Multimedia Cartography

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Second Edition

With 105 Figures

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Preface

William Cartwright, Michael P. Peterson and Georg Gartner

Multimedia Cartography Edition 2 has been produced as a 'companion' title to the First Edition. This book includes some of the chapters from the First Edition, with 26 new chapters. These cover dynamic map generation via the Internet, Internet Atlas publishing, 3D (realistic and non-realistic) and the application of games tools as geographical visualization realisation and presentation techniques. It also addresses the issues of accessibility, privacy & security and user-centred design.

This second edition of *Multimedia Cartography* includes updated applications areas that are Internet and mobile mapping-focussed. Since the release of Edition 1 in 1999 the focus of the delivery of Multimedia Cartography applications now includes the World Wide Web and mobile services, as well as discrete media. New chapters in the book reflect this. As per the first edition, this book has been written to provide foundation materials for those beginning in Multimedia Cartography production and design. It also provides chapters on current and developing applications that will interest academic and professionals alike. These chapters have been included to illustrate the broad-ranging applications that comprise Multimedia Cartography – discrete, distributed and Mobile. The book is pertinent to both the mapping sciences and related geographical fields.

The first section of the book covers the 'essential' elements of Multimedia Cartography. This section elaborates on the theoretical ideas about Multimedia Cartography and the essential elements that make it unique from computer-assisted cartography and visualization. The following section covers applications of Multimedia Cartography – discrete, distributed and mobile. In each of these areas theory, design concepts and production tools are covered. Several chapters focus on how multimedia is used to author the product and the design and production considerations that need to be addressed when undertaking production of these artefacts. This section provides examples of products delivered on CD-ROM, via the Internet, using Location Based Services (LBS), 3D, Virtual Reality and Computer Games tools. The final section looks at a number of issues that relate to Multimedia Cartography and the possible applications of this new rich media. The penultimate chapter addresses future directions and applications of Multimedia Cartography.

Like edition 1, this book has again been an international effort, with contributing authors from many countries, and editors based on three continents. Contributing authors are involved in Multimedia Cartography applications as practitioners, researchers and academics. The diverse nature of the backgrounds of the contributing authors and a global outlook about what Multimedia Cartography 'is' that they provide, gives a unique vehicle for conveying contemporary thinking and practice related to Multimedia Cartography.

We commend and value the efforts that contributing authors have made to this collaborative effort. We believe that the contents of the book provide a resource for those who are moving into Multimedia Cartography, as well as experienced readers. We hope that *Multimedia Cartography* Edition 2 becomes a valuable addition to your bookshelf.

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1 Multimedia Cartography

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1.1 Introduction

The term *'multimedia'* was once used to refer to a sequential display of slides with a recorded voice-over. The concepts of *interactive multimedia* and *hypermedia* were introduced to refer to media combined with an interactive linking structure. The meaning of *multimedia* has evolved and now subsumes these newer concepts. Multimedia uses different media to convey information as text, audio, graphics, animation, and video, all done interactively. This provides 'rich media' content. It also refers to computer data storage devices, especially those used to store multimedia content. Multimedia enhances user experience and makes it easier and faster to grasp information. Multimedia *is* interaction with multiple forms of media supported by the computer. The computer is both the tool of multimedia and its medium. Without means of creation or distribution, the current interactive form of multimedia would not exist. The World Wide Web, both static and mobile, has dramatically increased the audience and use of interactive multimedia products.

Multimedia Cartography evolved from a need to present geographical information in an intuitive manner. Multimedia Cartography is best defined through the metaphor of the world atlas that revered assemblage of maps in book form that has introduced people to the world for centuries. Displayed prominently in people's homes, or stored for reference in the library or school, the atlas has been a window to the world for millions of people. It is consulted when one needs to know where something is located or something about a region of the world. The atlas forms the basis for how people conceive the world in which they live.

The atlas also has a general audience. Its use does not require any particular expertise or motivation. It is not intended for the expert user or people from any particular educational background or for only a few, highly-trained individuals. Rather, it is an inclusive form of cartography that invites the user to explore the world through maps.

The traditional, printed atlas is not without its limitations. The maps lack interaction. It is not possible to change the scale of the maps or add detail. There is no provision to consult an underlying set of data. It is not possible to link features to other types of media, such as sound, pictures, or video. It is not possible to view cartographic animations that would depict the dynamic character of the world.

Interactive media is now commonplace and ubiquitous. Through the influence of the World Wide Web, users now expect a linking structure to be incorporated on any computer display. A display that is static is uninteresting and so it is with maps as well. The surface depiction is no longer sufficient. People want to “go into” the map, both spatially and conceptually. They want to explore at a deeper level. They want to put the pieces of information together themselves. These tendencies are not idle pursuits but can be attributed to the way we learn and structure knowledge. Interaction is the key to knowledge formation.

1.2 Visualizing geography

The general public use maps daily as a general information source, or as a tool to find specific locations when using a street directory or an atlas. They are bombarded with spatial information on television news reports, in newspapers and magazines and as part of computer packages for gaming, education and training. Technological developments have led to a wider range of different cartographic products that can be made faster and less expensively, and the interaction with visual displays in almost real-time. This has moved the emphasis from static to dynamic map use (Taylor, 1994), from discrete to distributed information provision, and from ‘wired’ access to ‘wireless’ access.

The ‘real’ geographical picture can be seen to be one that consists of many attributes. An efficient system for exploration would allow users to gain access to the ‘picture’ via a general, surface access mode or through a rigorous process of deep interrogation (Norman, 1993). At the ‘viewing end’ of the electronic mapping process users would be offered depiction methods which either painted a general information overview or else gave a very specific and precise graphic profile of essential user-defined geographical characteristics.

1.3 Access to geographical information

The spatial science professional is no longer the only one who should gain access to and present geographical information. Cartography has developed in two directions: the refinement of the means to represent natural points of reference; and the depiction of multiple phenomena. Therefore there exists the need to include more human-oriented elements in new media presentations and resources. There have been many comments about the needed evolution of current-day tools like GIS into one that will offer the required components for the next generation of user interaction, and it is suggested that this product should move from the 'technical elite' to the 'everyday user'. Commenting on GIS technology, Roe and Maidlow (1992) have noted that to date the vast majority of the emphasis has been placed on technical issues and that if it (GIS technology) is going to create value for the masses it is going to have to become more intuitive to use.

Many proposals have been made to rectify the shortfalls of digital mapping and GIS. Future systems were envisioned that incorporated image analysis and processing technology (Gallant, 1987); ones that included the cultural argument and information that highlighted human and social aspects, so as to reflect the basic goals of society (Chrisman, 1987); and new forms of data portrayal for the purpose of understanding, controlling and monitoring the multiple layers of space that make up the focus of human relationships (Müller, 1989). Other types of spatial data that were largely disregarded until fairly recently by the existing technology - photographs, free text, video images and sound, were seen in the future to play a greater role in decision-making than did all of traditional GIS (Lewis, 1991).

This technology-elaborated map could actually be many maps and provide access to information in ways dictated by the user. This would have the benefit of providing a map that is not just a picture of geographical reality, but also a search engine which, as well as giving access to geographical data and a means of data selection and display, also allows users to access further data and information plus a background on how things, data systems, data suppliers and facilitators, and mapping systems, and so on actually work. The geographically linked 'things' are a conglomerate of items, systems, processes and conventions.

1.4 A *Different* map

What multimedia offers is the ability to create a different map. By different map, what is meant is not merely something that is an 'electronic page turner', but a product which really extends the technology and allows for a different way of presenting geographic information to change geographical information access. A multimedia-based mapping product is seen as a real alternative to conventional mapping (including those maps now being produced electronically). Most electronically-produced are still not really that different to the maps produced when the printing press harnessed cartographers to think in terms of page sizes, print-derived specifications and products which had to be technically correct the very first time they came off the press. For example, topographic maps design, and the efficient uses to which these maps can be put, owes much to eighteenth century generals and nineteenth century engineers (Raper, 1996). They served their purpose as a tool for the accurate depiction of hills, roads, streams and other strategic terrain elements for military strategy, but the advent of the aircraft made the importance of high ground less prominent. Similarly, engineers required accurate, large-scale representations of landforms to enable the planning and conduction of their Victorian age buildings. The role that these types of maps were used for, and the depiction methods used, served particular functions. The ‘print mindset’ has been extended into some areas of automated mapping, GIS maps, applied computer graphics-generated maps (like those in contemporary printed products and those used as support devices for television news and weather services) and even to digital data stored on CD-ROM. Peterson (1995, p. 12) speaks of a ‘paper-thinking’ that still pervades how we think about maps and the process of producing them. The print mindset has ‘harnessed’ map designers to the idea that computer-generated maps should mimic printed maps (Cartwright, 1994).

Multimedia is intended to expand the channels of information available to the user. Users should then be able to thread their way through a database query in ways not anticipated by the system designers. Multimedia is an accessible tool, both practically and economically, even though it has been ‘hijacked’ by the 'glossy' nature of many multimedia products. But, if multimedia is viewed as multi-media, then its potential in the application of access and display interfaces to geographical information in a variety of ways can be seen. Multimedia offers a different way to view data that has been generated and stored by the many existing spatial resources packages.

In the real world some things can appear to be something that they are not. How things appear on the surface of an interactive multimedia product is not representative of what is happening with the human part of the interaction. Designers of multimedia geographical information products are undertaking work to ensure that the media allows for individual mental maps or virtual worlds to be composed and thus making available artifacts that allow geographical information and the real world to be better understood. Users must be encouraged to include their own experience in the ‘reading’ of the presented data. Multimedia allows the virtual world to be unfolded, scene by scene, where each unfolding offers a further unfolding.

1.5 Multimedia as an information interface

The traditional map form can be seen as a form of multimedia, whereby lines, colours, text, rendering, symbols, diagrams and carefully chosen content, were used to impart a 'story' about reality. Everyone is a product of their past training, and the limitations of the printed graphic map are still embedded in our thoughts and habits (Morrison, 1994). Those involved in the art and science of map-making should be content that these devices, paper or digital, accurately portray the phenomena that has been selected. However, the traditional delivery mediums cannot be viewed as an isolated entity in the digital electronic age, an age where arrays of information resources can be output in many different ways. This will restrict the possibilities for offering a package of information-enhanced map products. The multimedia revolution should be exploited to augment the capabilities of existing methods of geographical information processing (Groom and Kemp, 1995) and extend the use of the map as an isolated display device by adding extra data and information depiction methods. Interactive maps, using hot-spots and buttons to give access to the underlying data and metadata would allow for the map display to link to other information offering an enhanced spatial information resource.

Contemporary mapping, although providing timely and accurate products, may be still using formats which disallow them to be fully utilised. If one was to make a very general observation, the conclusion could be made that the formats and types of presentations used for the depiction of spatial data do not fully exploit the plethora of other information delivery devices in common usage. Telephones, television, faxes, computers, email, Web browsers, radio, newspapers, magazines, films and interactive mediums are all used to keep us informed in our own everyday lives. Maps can also adapt these other devices to enhance the communication of spatial information.

Tools like word processors and drawing programs are now commonplace. Users work with many tools on one computer and, increasingly, computer-based tools are used for communication with other people. Interactive systems are becoming gateways to communities and endless information spaces (Rijken, 1996). Hybrid tools, like the use of television for shopping and the use of metaphors to navigate through fairly complex data sets, have been developed. The choice of an ‘ideal’ tool is becoming complicated as we move from the simple one-user, one-device to computer-supported collaborative work and the design of interfaces for entire organisations (Rijken, 1996).

Maps themselves have been designed for purposes that are far more intimate than the plethora of uses to which contemporary maps are put. If the types of graphic representations provided with contemporary spatial information products are looked at critically it could be said that the depiction methods used are still not that dissimilar to those that have developed from the specifications provided by military and engineering authors. Multimedia offers the tools for depicting spatial information through the use of many media tools. To limit depictions afforded by multimedia to just maps and plans does not exploit the rich forms of media that are available. Multimedia allows many other ways of presenting data sets and the results of analysis.

Multimedia is a new form of visual and aural presentation and expression. As a new communication form it has taken on its own grammar and made its own rules. The grammar is developing and (script)writers are only beginning to master it. The rules are new and already being broken, as new forms of multimedia are explored and other means of exploiting this conveyor of ‘rich media’ are tried, tested and developed. Multimedia has much to offer users of GIS in improving access to data and facilitating displays of that data in formats most compatible with an individual user’s preferences for aiding their journey through a virtual world.

1.6 Visualizing Multimedia Cartography

Multimedia Cartography can be viewed as sphere that may moved by the user across and into a plane of geographical reality (see Figure 1). The Plane of Geographical Reality is composed of levels of abstraction. The user controls the sphere and can move down these levels. Moving the sphere across the surface affects a variety of other interrelated aspects of the display, such as scale and perspective. Critical in the use of multimedia

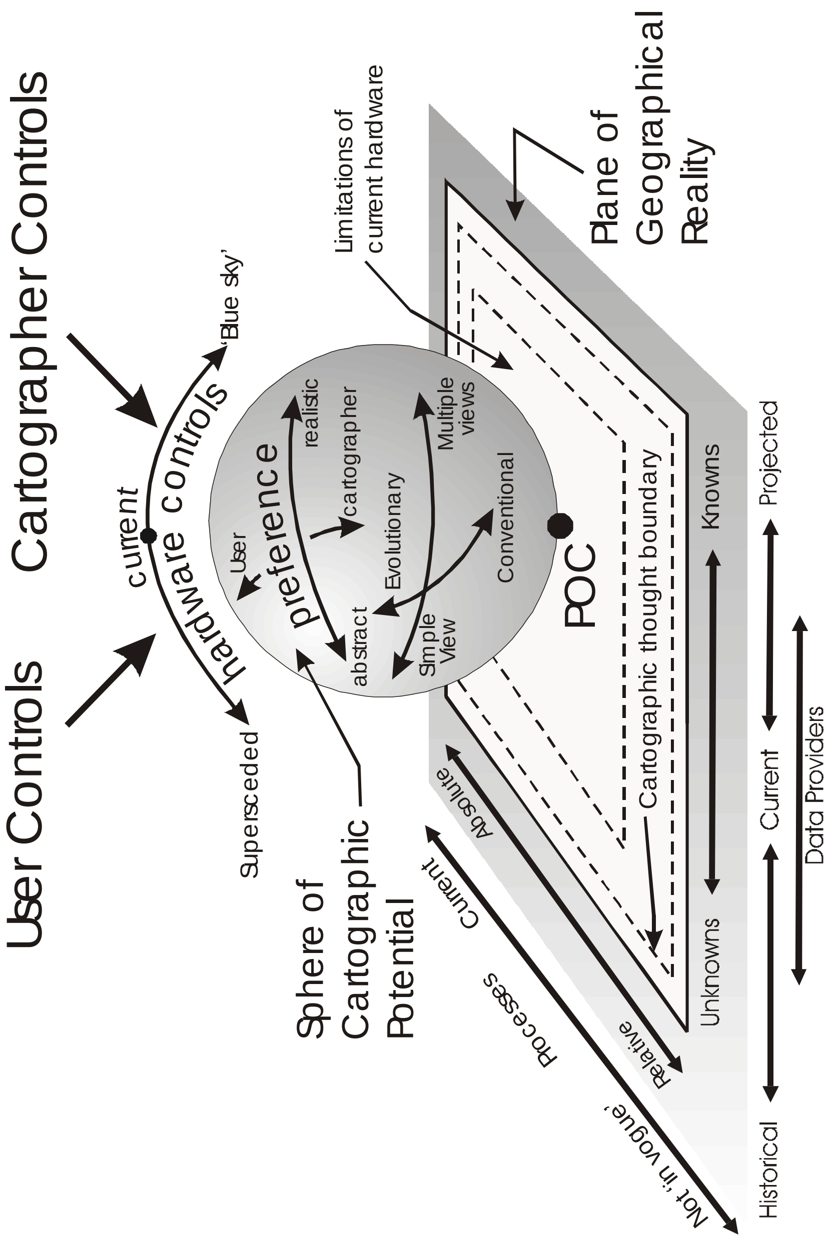

Fig. 1. The Sphere of Cartographic Potential and the Plane of Geographical Reality.

cartography is the Point Of Contact (POC) – the ‘ideal’ method for data/ information/ knowledge transfer/ understanding.

The POC is where the Sphere of Cartographic Potential (the best method of enabling the user to fully exploit a multimedia package according to cartographic allowances and hardware/software affordances) comes into contact with the Plane of Geographical Reality (the geographical ‘window’ through which the real world is viewed). The Sphere of Cartographic potential is controlled both by the user, who can choose a particular presentational method according to their ability and psychomotor skills, and the cartographer, who can apply their own biases or *depiction preferences* (and thus add *weight patches* to the Sphere and dictate, to some extent, its attitude and thus the relationship with the Plane of Geographical Reality.

The Sphere of Cartographic Potential is positioned according to controls that are within and outside of the sphere. The major external force are the hardware controls that can range from the need to use outdated equipment if, say, archival data located on a laserdisc needs to be viewed, to developing a product that needs ‘blue sky’ hardware that does not currently exist, or is cost exclusive, but will be available or economically accessible when a multimedia project is completed over some considerable time. The Sphere can be controlled by both user and cartographer to make display settings that will provide displays that range from the abstract to the realistic, from simple views to realistic views, and from the conventional to evolutionary displays.

The Plane of Geographical Reality is restricted by several factors. Firstly limitations of current hardware will disallow certain parts of the real world to be depicted. This limitation can be seen to be a movable feast and in the ever-changing scene that depicts today’s computer hardware industry, what is currently impossible can be tomorrow’s standard method of operation. The Cartographic Thought Boundary is the theoretical constraints of what could be depicted as can be conceived by cartographers. This perception of what can actually be done is a function of what is possible with contemporary cartographic visualization tools. The Plane of Geographical Reality is positioned also by the desire to view either relative or absolute information or whether knowns or unknowns (in terms of geographical information) need to be depicted. Processes that can be undertaken to take raw data and convert it into cartographic visualizations can be selected from the methods currently in use and even past methodologies that are not ‘in vogue’, but may be chosen to ensure that all possible procedural strategies are explored. Finally, what can sometimes override the best laid plans for delineating the Plane of Geographical Reality, the access to data, will affect its position and thus where the POC is made. Data providers can make available data to underwrite depictions of historical, current or projected scenarios.

1.7 About this book

Multimedia Cartography is complex and the factors influencing its design and operation many. Much experimental work has been undertaken to explore the possibilities that Multimedia Cartography offers. Lessons learnt from the application of this multimedia data depiction tool can be used to guide future enterprises in the display of geographical information.

This book includes a number of chapters from Edition 1, as the topics covered are still relevant for providing a complete ‘picture’ of what Multimedia Cartography is – discrete, distributed, mobile and ‘at location’ geographical information provision. Chapters that follow cover all of these areas of cartographic endeavour. It is a truly international effort, and it brings-together contributions from academics, researchers and producers.

The first section of the book provides the underpinning concepts of interactive multimedia and its application to cartography – ‘Multimedia Cartography’. Then multimedia atlas applications on CD-ROM and the Web are covered. This is followed by chapters on Virtual Environments and Virtual landscapes, and it includes an application on how this might be applied to cartographic education. Then chapters are provided on animation and dynamic maps. Chapters then cover the use of computer games technology for displaying geographical information in new ways. Mobile applications are discussed next, and the section provides chapters on research into this form of cartographic information provision as well as practical implementation. The Web, Web standards and Web applications then contribute to knowledge about how the Web can be best used as a geographical information conduit. Users are considered next, with chapters on usability and adaptability. The last section of the book examines future directions for Multimedia Cartography and then sumarises the book’s contributions.

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2 Development of Multimedia

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2.1 Introduction

Ideas take some time to develop, but once proven it may only be the progression of time and the development of techniques and technologies that convert strokes of genius to 'matter of fact' realities. For example the first fax was sent from Lyon to Paris in 1865, but it only become a widely used form of communication when advances in encoding technology and transmission matured and became economically viable almost 100 years later when Xerox sold its *Telecopier* in 1966 (Swerdlow, 1995).

The term multimedia didn't exist until the late 1970s. Views differ on what constitutes multimedia and, in the early developmental period, how it would mature. It is seen to be different to the film industry, the toy and games industries, the computer industry, the video industry, or any other pre-existing industry (Multimedia Digest, 1994). Multimedia involves the integration of computing, video and communications. It saw a convergence of previously discrete components of the entertainment industry. That is, large corporations which, in the past dealt exclusively with film, computing or communications, formed consortia or enveloped other media concerns to produce conglomerates with the ability to publish electronically, produce and distribute video and films, author computer packages and games and provide digital communication facilities worldwide.

From the general map using public's observation point, the mapping sciences community didn't really begin exploiting the possibilities of multimedia until the advent of optical discs, CD-ROM and the Internet. The mapping sciences have always adopted new technology for making their products more accurate, more quickly produced and produced in formats that were attuned to user expectations and requirements.

This chapter begins with an outline the development of multimedia from the first theoretical description of what was later to become known as hypertext to discrete interactive multimedia systems. Then it provides an overview of multimedia formats for delivering different spatial information delivery products. The chapter ‘stops’ at multimedia, and multimedia mapping products on discrete media. The following chapter by Peterson covers the Internet and Internet Cartography.

2.2 In the beginning ...

The beginning of today's global distributed interactive multimedia is attributed to the foresight and unique concepts of Vanaveer Bush, Professor in Electrical Engineering at MIT in the 1930s. After Pearl Harbour US President Roosevelt appointed Bush as Director of the Office of Scientific Research and Development (OSRD), a special agency that reported directly to the White House. Its charter was to organise research and scientific programmes to assist the US war effort. Amongst the programmes that fell under Bush's direction was the Manhattan Project.

In 1945 Bush wrote "As We May Think" in *The Atlantic Monthly* (1945) in which he proposed MEMEX, a multi-dimensional diary with links to all connected things. He envisaged a peripheral information machine that stored and retrieved information, plus the information owner's specific memories (hence MEMEX). Bush saw that this would work on an analogue computer delivering information via microfilm along with 'archived annotations'. The three main advantages that Bush saw with his theoretical machine were that it would:

- Greatly reduce information overload;
- Record intimate thoughts, or 'associated trails'; and
- Engender a family of thinking that could someday make possible human-machine consciousness (Zachary (1997, p. 158).

Even though Bush's ideas based his MEMEX system on an analogue computer was made redundant when ENIAC was perfected in 1946, his writings foreshadowed both the Personal Computer and the World Wide Web.

2.3 Pre-electronic multimedia

Before digital interactive multimedia became established and later ubiquitous cartography trialled other ‘multiple media’. Many innovative products did not use mainstream technologies. These included microfiche, motion film, video and videodisc. As a ‘primer’ to the use of interactive digital multimedia, an overview of these applications is provided.

2.3.1 Microfiche

Microformats were entertained as a medium for the storage of maps during the late seventies and early eighties. Exploratory work was carried out by a research team led by Massey (Massey, Poliness and O'Shea, 1985) who produced an 'Atlas' depicting the socio-economic structure of Australia on thirteen monochrome microfiche. Each microfiche featured one of Australia's capital cities, states and territories. This revolutionary product was jointly produced between the Geography Department at the University of Melbourne and Latrobe Comgraphics. The US Census produced colour microfiche depicting Census data that had been previously made available on colour paper maps. An excellent overview of the issues pertaining to the use of microfilm for map storage and archive that were discussed during this period was made in a paper by Lines (1982).

2.3.2 Motion film and interactive cinema

Film animation was first proposed as a method to depict the fourth dimension by Thrower in the late 50s and early 60s. Moellering (1980) produced the first animated map that depicted traffic accidents in Chicago. In Australia CAD-generated stills for animation were trialled by the National Capital Development Commission in Canberra to depict the impact of building the new Parliament House and how the vegetation would mature over time. Also, Massey (1986) produced an animated 16mm film that compressed climate data for Victorian Local Government Areas (LGAs) into one unit that allowed the user to gain an appreciation of the cyclic nature of drought and flood. More recently Web-delivered newspapers use animations to support their news items.

On a much larger scale the *HyperPlex* system (Sparciano, 1996), developed in the Vision and Modeling group at the Media laboratory, with the Interactive Cinema group at MIT, used interactive cinema (a combination of a large database, a big display screen and video browsing techniques) to provide navigation through a graphical virtual environment, providing users with visual cues to help them orient themselves.

2.3.3 Video

In 1927, Logie Baird gave the first demonstration of television. It took quite some time, until 1954 for the first regular broadcasts to be made. Developments in television accelerated due to the popularity of this communication medium. Even before the first transmissions to the public, a test colour broadcast had been made in (1950 and a VTR (Video Tape Recording) was demonstrated by Bing Crosby Enterprises in the US., with the first broadcast using videotape occurring in (1956. Once this had been perfected and 'time switching' - watching programmes at a time after the broadcast was made - sounded interesting to the general public, consumer demand led to Sony Corporation of Japan providing its first home VTR unit in 1963, an open reel ½" helical scan deck. Sony followed this with the videocassette (the ¾" *U-matic* (that remained a popular professional format well into the 1980s). The videotape scene became a little confused with the introduction of two formats - *Betamax* in 1975 and VHS in 1976 - and finally stabilised when *Betamax* fell out of favour with the public and was gracefully withdrawn from the marketplace. The dominance of television as a communication is highlighted by the fact that half of all television households in the US in 1988 had a VCR (VideoCassette Recorder) (The Media History Project, 1998). In 1992 the FCC in the US gave permission for telephone companies to offer video services, allowing for and opening up possibilities for cable home banking, shopping and movies. (Kindleberger, 1993).

Pre-Web dominance of information delivery thinking, the use of broadcast television that provided hyperlinks to other types of information was one possible scenario explored theoretically. Negroponte (1996) considered that one possible future scenario for allowing consumers to interact with information resources was hyperlinked television, whereby 'touching' an athlete’s image on a television screen will produce relevant statistics, or touching an actor reveals that his tie is on sale this week. This would involve embedding extra information from a central database into broadcast television signals. Television could react according to the information delivery designer’s intention when viewed under different circumstances. Negroponte saw *Java* contributing to the idea of hyperlinked television.

Television is where most members of the general public receive most of their information. Television, pre-dating the Internet, provided global coverage through the use of a number of interlinked satellites. Television was seen as a way in which information could be readily disseminated through the use of teletext in its many forms. Services like *Oracle*, *CEEFAX* and *Prestel* (*Viewdata*) in the United Kingdom, *Antiope* in France, *Prestel* and *Telidon* in Canada and *Viatel* in Australia were used to provide (relatively coarse) information that included text and simple graphics. Australia is covered by the Intelsat system. Much research on the use of television for weather mapping, perhaps the most widely-viewed television maps, has been undertaken by Carter (1997).

2.3.4 Videodisc

The first optical storage medium, videodisc, was demonstrated in Germany by Philips in 1972. This initial version was a playback-only laser disc. It was made publicly available in 1979 by Philips.

Videodiscs store analogue video signals and can be controlled by programs executed on a computer to which the videodisc is attached. Two types of videodisc exist - CAV (Constant Angular Velocity) used mainly for interactive applications and CLV (Constant Linear Velocity) that are used for applications like linear movies (Cotton and Oliver, 1994). The basic design parameters are to develop code in any of a number of programming languages, and then use commands to guide the laser reader in the videodisc player to specific frames. Each side of a 12” videodisc holds 52,000 frames. If video is required, the start frame, end frame, play rate (slow, normal and fast) and direction of play is specified. The analogue videodisc can contain stills, video and animation.

Some of the advantages of videodiscs are:

- compactness;
- high storage capacity;
- store and playback any form of image data, sound and computer-readable data;
- stores full colour and black and white images;
- stores high-resolution images;
- excellent image quality for stills or moving pictures;
- resistance to wear and tear;
- play does not wear disc;
- resistance to vibration;
- precise random access;
- low error rates;
- plays multiple discs on a single player;
- can be computer-controlled;
- extended play freeze frame;
- high data transfer rate;
- non-erasable;
- storage life more than 10 - 15 years;
- inexpensive hardware costs; and
- a large library of existing material.

However, there were seen to be several disadvantages (Duncan, 1992): they were expensive to create; they had incompatible formats; and copyright infringement of material to be stored on disc was of concern.

2.4 Hypertext

The most used form of hypermedia initially was hypertext. It allowed authors to produce seemingly unstructured texts that enabled readers to move through the publication at their own pace and to follow their own preferential reading pattern. The Hypertext model can be described as “a set of nodes connected together by undifferentiated links”, where the nodes can be abstractions made up from any kind of text or graphic information elements (Raper, 1991). ‘Electronic books’ produced using hypertext preserve the best features of paper documents, while adding rich, non-linear information structures (hypermedia) and interactive user-controlled illustrations (Reynolds and Derose, 1992). The idea of producing ‘Electronic Books’, using something like *HyperCard* (which didn’t exist until Apple introduced it in 1987) was first talked over 30 years ago by Andries van Dam, a pioneer in user interface languages.

Californian computer guru Ted Nelson transformed Bush's idea of associated trails and coined the term Hypertext in 1965 (Cotton and Oliver, 1994; Nelson, 1987) when the word was first used in a paper presented at the Annual Conference of the Association of Computing Machinery (ACM) (Nelson, 1965). Just two years later van Dam, then a Professor of Computer Science at Brown University, with his research associates, built the Hypertext Editing System (HES), which was implemented the next year in collaboration with Nelson. HES basically pioneered what is taken for granted with computers nowadays (things like What You See Is What You Get (WYSIWYG) (that debuted on the Xerox *Star*, the first computer offering a Graphic User Interface (GUI), from Xerox PARC in 1981), multiwindowing (sic) and seamless text) (Reynolds and Derose, 1992). Also in 1968 Engelbart began the Augmentation Research Center at the Stanford Research Institute (SRI) International and demonstrated NLS, an online Hypertext system (Rheingold, 1996; The Electronic Labrynth, 1998). With his concept of Hypertext Nelson published *Dream Machines* (1974) and he visualised and began to develop Xanadu (Reynolds and Derose, 1992; Nelson, 1990), which he then predicted would be ready by 1976. He also examined the implications in terms of the associative linking of facts and ideas and created prototypes (Raper, 1991). 1975 saw ZOG (now KMS), a distributed hypermedia system developed at Carnegie-Mellon University.
In 1981 Nelson was still developing his ideas for *Xanadu*, which he now saw as a central, pay per document, Hypertext data base encompassing all information (Nelson, 1981). Other Hypertext developments continued to occur. TELOS introduced *Filevision* in 1984, a hypermedia database for the Macintosh, which was released in the same year. In 1985 Norman

Meyrowitz and associates at Brown University conceived *Intermedia*, a hypermedia system that was described as a functional Hypermedia system. And, in 1986 OWL introduced Guide, the first widely available Hypertext browser. Developments in Hypertext became more formalised with the first Hypertext workshop (Hypertext '87) held in North Carolina, and ECHT, the European Conference on Hypertext, first took place in 1990.

Nelson produced a new edition of *Literary Machines* in 1987 and proposed delivery of a working Literary Machine for the following year. Nelson was supported in his developmental enterprise when AutoDesk took on *Xanadu* in 1989 as a project, but the company dropped it three years later (Sanders, 1987). Although Nelson's work has not yet come to fruition, his innovation and ground-breaking ideas were recognised in November 1993 when he spoke as Guest of Honour at the November Hypertext Conference in Seattle, USA.

The technology and theoretical structures developed in the 1970s and 1980s and second-generation systems appeared and were further advanced with access to inexpensive computer memory, making it possible for Bush’s and Nelson’s ideas to be implemented.

2.5 Hypermedia and Multimedia

2.5.1 Hypermedia

Hypermedia is the extension of Hypertext through the use of multimedia (graphs, sound, animation and video) (Jiang *et al.*, 1995). It is a communications medium created by the convergence of computer and video technologies and it describes the whole spectrum of new interactive media spanning telecommunications, High Definition Television, interactive cable television, videogames and multimedia. Hypermedia incorporates text, sound and graphics. Hyperdocuments could also include things like tastes, odours and tactile sensations (Conklin, 1987), items that are along the lines of those included in Kraak and van Driel’s (1997) explanation of hyper-terminology.

In 1968 Nicholas Negroponte formed the Architecture Machine Group at MIT (Negroponete, 1995a). This was a laboratory/think tank that researched radical new approaches to human-computer interfaces. This was later to become the Media Lab. In 1976 the Architecture Machine Group devised the notion of a Spatial Data Management System, a seminal step in the development of multimedia, for the Defense Advanced Research Projects Agency. It was to be a 'Multiple media' system that was given the name 'Dataland'. Negroponte and Bolt developed a demonstration room equipped with an instrumented Eames chair, a wall-size colour display, and octophonic sound. Users sitting in the chair could ‘fly’ over Dataland as if it were a landscape, touching down on calculators, electronic books or maps (Leutwyler, 1995). Bolt undertook more development work and produced SDMS II in (1980.

2.5.2 Multimedia

In 1985 Negroponte and Wiesner opened the MIT Media Lab. Negroponte, who became the Director of the Lab, promoted the raison d’etre for work done in that laboratory as being to take both human interface and artificial intelligence research in new directions. This idea was marketed to the broadcasting, publishing, and computer industries as the convergence of the sensory richness of video, the information depth of publishing, and the intrinsic interactivity of computers. He said that the digital age had four very powerful qualities that will result in its ultimate triumph: decentralising, globalising, harmonising, and empowering (Negroponte, 1995c).
Apple also took a keen interest in the use of multimedia, especially for educational applications. In 1990 the Apple Multimedia Laboratory was formed by Hooper-Woolsey. The following year it produced its first product, *Visual Almanac*, a classroom multimedia kiosk. During this period many multimedia platforms appeared from Apple, Commodore, Amiga, MicroSoft, IBM and Lotus (*Australian Multimedia*, 1992).

In 1992 a 12-corporation coalition - 'First Cities' was formed to deliver what was described as *real* multimedia services. The companies came from the computing, communications and media fields. It was their intention to develop a US infrastructure to develop applications in multimedia conferencing, shopping services on-demand, distance learning and healthcare. This was the first concentrated effort to properly establish and implement a true multimedia industry (AudioVisual International, 1993a). Looking at the companies involved - Microelectronics & Computer Technology Corp., Apple Computer, Kaleida Labs (Apple/IBM) and Tandem Computer from the computing industry; Bellcore, Southwestern Bell, US West and Corning from the communications area; and Eastman Kodak and North American Philips from the media supply arena, the amount of interest in multimedia at the time can be gauged. Another consortium was formed in Europe to develop the links between multimedia and teleconferencing, the Multimedia Communications Community of Interest (MCCI) in France. Its members are France Telecom, Deutsche Telekom, Northern

Telecom, Telstra Corporation, IBM and INTEL (Audio Visual International, 1993b).

Macromedia (formerly Macromind) *Director* became a de-facto standard for multimedia authors, replacing the quickly-discarded device-independent scripting language, *Script X* from Kaleida Labs (a joint venture begun in 1991 between Apple and IBM (Pournelle, 1993; Brown, 1995)).

Initially, ‘full functional multimedia’ was seen to be composed of three elements (Pixel Vision, 1991):

- Natural presentation of information through text, graphics, audio, images, animation and full-motion video;
- Non-linear intuitive navigation through applications for access to information on demand; and
- Touch-screen animation.

But the development of optical disk storage, effective product authoring tools, communications systems and innovative approaches to publishing with this new medium promoted the development of a ‘multimedia’ that extended beyond just these three elements.

2.5.3 Discrete Multimedia – CD-ROM *et al.*

Discrete multimedia is products made available through the use of isolated computers regardless of whether they are desktop, notebook or Personal Digital Assistant (PDA). The packages made available are stored in digital form on disk drive, optical disk, videodisc or computer tape. It formed the core for multimedia development prior to the development of complementary distributed products.

The Compact Disc, more commonly referred to as the CD, was jointly developed by Sony of Japan and Philips of The Netherlands in 1982. CD-ROM proved a most popular medium, unit costs fell yearly and market penetration always increased. Optical discs allow the recording of information in such a way that it can be read by a beam of light. Formats are CD-ROM, WORM (Write Once Read Many), rewritable CDs (CD-R or CD-RW), CD+ or enhanced CD (combines a music CD with CD-ROM data), Digital Video - Interactive (DV-I) Sony's Minidisc, DVD-ROM, DVD-R and DVD-RAM (the rewritable DVD format).

CD-ROM is a read only technology that can store a minimum of 540 MB of data; has a 5 1/4" diameter, it is removable; cost is fairly low; easy to distribute; standards exist and the media are well established; and networking is possible. Philips and Sony continually worked on their CD-ROM Colour Book Standards, which complement ISO 9660. Other discrete developments explored the possibilities of using blue-green and blue lasers instead of the standard red lasers to maximise the amount of information stored on any one optical disc (Liebman, 1998).

The world of publishing embraced multimedia using mainly CD-ROM as an alternative to paper. Book abstracts, bibliographic references and encyclopedias, like *Compton's Interactive Multimedia Encyclopedia* and *Encyclopedia Britannica* (now available as a hybrid CD-ROM Web-supported product), have been published on optical storage media. *VERBUM Interactive*, a CD-ROM based product, was the world's first fully integrated multimedia magazine. Produced in August 1981 as a co-production of *VERBUM* magazine, MOOV design and GTE ImagiTrek, this project used a point-and-click interface to lead the user through an array of text, sound, graphics, animations, product demonstrations, talking agents and music (Uhler *et al.*, 1993).

The entertainment industry was quick to use the medium for publishing. Perhaps the first acclaimed music CD-ROM was Peter Gabriel's *Explora 1*, (Australian Macworld, 1994; Australian Multimedia, 1994b), which included interactive applications as well as the music content. *A HARD DAY'S NIGHT* was the first full-length movie to be translated into Hypertext and distributed on an interactive CD. It was released in 1993 by the Voyager Company (Jacobs, 1998), an early innovator in both videodisc and CD-ROM, This work was built around the Beatles 1960's film "*A Hard Day's Night*". It contains ninety minutes of *QuickTime* movie, full original script with author Richard Lester's annotations, a short interview with Lester, the full "Running Jumping Standing Still" film he made with Peter Sellers, the US theatrical trailer and 1982 release prologue, critical essays, and a photo gallery. It is interactive and gives a full search on words and music titles. Users can jump anywhere in the ninety minutes of *QuickTime* movie (Australian Multimedia, 1994a). Unfortunately very few copies of the CD-ROM exist; as it was quickly removed from sale after the validity of publishing the film on another medium, without appropriate copyright clearances, was questioned. The Voyager Company also produced the much-acclaimed interactive book, *Puppet Motel* by Laurie Anderson.

2.5.4 DVD

CD-ROM was overtaken by DVD-ROM during late (1995 and early 1996 (NewMedia, 1995b; Advanced Imaging, 1995, 1996; Green, 1996; Lynch, 1996, Ely, 1996, Fritz, 1996) and some titles previously published on CD-ROM were re-issued on DVD-ROM (Hamit, 1996). The format was first introduced in (1995 as a ‘compromise’ format between the Sony/Philips and Toshiba/Time consortia. Bonding two single-sided discs or making double-sided discs produces the medium. It offers 133 minutes of digital video, 9.4 Gb digital data on a 2-sided disk or 8.7 Gb on a single double-layered side, and 17 Gb on a 2-sided double-layer disc. They are backwardly compatible with audio CDs and CD-ROMs. In order to be backwardly compatible many drives incorporate two lasers at different wavelengths. For example the Hitachi GF-1050 used a 560nm laser for DVDs and a 780nm laser for CDs (Yates, 1998). The new format had such an impact on the multimedia industry that it was predicted in late 1997 that within 6 months of its release that products using this format would amount for 40 per cent of production (The Age,1997b). DVD-R and DVD-RAM drives (DVD-RAM is the rewritable DVD technology that stores 2.6 Gb of data per disk side) were available in late (1996, but prices excluded them, initially, from the mass market (Waring, 1997). As DVD-ROMs store about 40 times as much as a CD-ROM. Ely (1996) saw this format as the first ‘truly (discrete) multimedia’ format.

DV-D players were also made in their portable variation. In December 1997 Samsung released a 900-gram P-Theatre (Barker, 1997) and soon after, in January 1998 Matsushita released its L10, at 910 grams (The Age, 1998). Different versions of the optical disc storage medium continued to be developed, like Divx, an optical disc that expires after two days. It was designed for rental movies. Divx machines can read standard DVD, but DVD machines cannot read Divx (Wired, 1998). Many multimedia ‘purists’ like movie buffs still prefer the 12” laserdisc to its smaller counterpart, but this new format has been forecast to eventually make the laserdisc obsolete (Cochrane, 1997). But, DVD offers 500 lines of resolution compared to a 425 line resolution for an NTSC format laserdiscs (The Age, 1997a) and it was praised for its quality that exceeded the laserdisc (Hunt, 1997).

2.5.5 Games machines

A fairly recent phenomenon is the upsurge of the availability and impact of games consoles. From their beginnings as arcade games, they later migrated into homes via PCs and then linked to televisions, and finally as stand-alone devices. Gaming, computer games, games consoles and the games industry are now part of everyday life. A decade ago the games industry was worth somewhere between US$8 billion (Elrich, 1996) and US$11 billion (Storey, 1996). Now it is estimated to be around US$27 billion per year (3AW radio news, 17/5/05, reporting from the E3 conference in Los Angeles). Current games consoles are powerful - they provide a multi-task machine – for example the recently-released Microsoft *Xbox 360* provides players with the ability to display the games on a 16:9-ratio wide screen, it has a wireless controller, can it be used online to play collaborative games (Bullard, 2005). Console revenues have improved compared to PCs. In 2005 PCs sold were worth US$3.6 billion, while games consoles netted US$7.9 billion. Projected PC growth to 2007 is US$4.3 billion, and games consoles US$10.4 billion (Clickz.com, 2004).

Cartography has seen these devices as potential platforms for geographical information. Devices like the portable, powerful and Web-enabled PlayStation Portable (PSP) from the Sony Corporation of Japan offer the potential for portable multimedia cartographic information delivery.

2.6 Hypermaps

Laurini and Millert-Raffort (1990) first introduced the term 'hypermap'. Hypermaps are seen as a unique way of using multimedia with GIS (Wallin (1990, Laurini and Millert-Raffort (1990). The hypermap is an interactive, digitised multimedia map that allows users to zoom and find locations using a hyperlinked gazetteer (Cotton and Oliver, 1994). Geographic access is provided via coordinate-based access in which by clicking a point or a region on a map can retrieve all information relating to that point. A similar concept, the 'HyperGeo model', was described by Corporel (1995) as a dynamic map created by user queries. The package favoured experimented users, but required a good mastery of syntax to be successful (Dbouk, 1995).

Much interest was centred on the production of electronic atlases during the late 1980s and early 1990s, mainly due to the availability of Apple's *HyperCard* software developed for the Macintosh computer and released in 1987 (Raveneau *et al.*, 1991). According to Raveneau *et al.* (1991) several factors contributed to the development of electronic atlases:

- The development of inexpensive and powerful microcomputers;
- The creation of geographic databases that may contain either digital base maps or spatially referenced thematic data;
- A renewal in the field of conception and production of instructional atlases, as well as the communication of geographic information in general;
- The integration of geographic information within computerised information systems; and

- The diffusion of the hypertext concept and its translation into such software as *HyperCard* facilities and the application of structured geographic information to an electronic atlas.

An early cartographic product was the *Glasgow Online* digital atlas, which operated around a hypermedia spatial interface (Raper, 1991). HyperCard products also came from the Department of Geography at l'Universitié Laval (Québec City, Canada) - *La Francophonie nord-américaine á la carte* (North American French-speaking communities á la carte) and *Mines et minéraux á la carte* (Mines and Minerals á la carte) (Raveneau *et al.*, 1991). The dynamic structure of *La Francophonie nord-américaine á la carte* provided access via ten navigation buttons - instructions, impression, stop, region, localisation, origin, a brief description and a flag icon of the local French community. Also of note is *HYPERSNIGE* (Camara and Gomes, 1991), which included Portugal's national, regional and sub-regional maps and information, and, Parson's *Covent Garden* area prototype (Parson, 1994a, 1994b, 1995). Parson's project presented users with a 'through the window' view of the market via a 3-D perspective view. Users could navigate around the package using conventional cursor controls and mouse clicks on directional arrows.

2.7 Multimedia and maps

2.7.1 Initial projects

What has been called the first multimedia mapping project was the *Aspen Movie Map Project*, devised and undertaken by the MIT Architecture Machine Group in 1978 (Negroponte, 1995b). This groundbreaking package used videodiscs, controlled by computers, to allow the user to 'drive' down corridors or streets of Aspen, Colorado. Every street and turn was filmed in both directions, with photographs taken every three metres. By putting the straight street segments on one videodisc and the curves on the other, an artificial seamless driving experience was made available. It used two screens - a vertical screen for video and a horizontal one showing a street map of Aspen. Users could point to a spot on the map and jump to that spot, enter buildings, see archival photographs, undertake guided tours and leave a trail like Ariande's thread. Military contractors built working prototypes for the field, for use in assisting the protection of airports and embassies against terrorism. A follow-up, 'The Movie Manual' was for maintenance and repair (Eindhoven Tech. Univ., 1998).

2.7.2 Videodiscs and Cartography

Videodisc mapping offered a low cost map display background, providing many of the information coordination functions of a GIS (Aubrey, 1992). They were seen to be a viable alternative to vector/raster-based GIS until a more populated digital database was available and to be quicker to get complete map coverage than digital data (Bilodeau, 1994). The program controls the display of frames and access to a database that may reside on the controlling computer or be embedded on the actual videodisc. Programs could be developed as generic code, which could then be used to control other videodiscs produced to similar guidelines.

Video laserdiscs became a standardised product through NATO where a specification (STANAG 7035) was set for the Defense Mapping Agency (DMA) database. The Canadian Department of National Defence (DND) introduced videodisc mapping in (1987 and over 40 mapping systems were installed (Bilodeau, 1994). Products containing topographical maps at scales of 1:1,000,000 and 1:500,000 have been used for large scale planning, briefing and command and control purposes (Aubrey, 1992). It became the interim geographical information package of preference for the Canadian Forces due to its large storage capacity and rapid retrieval (Bilodeau and Cyr, 1992; Bilodeau, 1994). Also, the National Search and Rescue Secretariat (NSRS) adopted videodisc technology in 1988 as a relatively economic means of vessel location in search and rescue operations.

Other videodiscs projects were the Canadian Energy, Mines and Resources prototype, *Canada on Video Disk*, produced in 1987 (Duncan, 1992), a videodisc to teach map reading skills (Cartensen and Cox, 1988); and the *Queenscliff* prototype videodisc 1987 (Cartwright, 1989a, 1989b). The first real popular mapping application of videodiscs was the *Domesday* project, the innovative multimedia ‘picture’ of Britain in the 1980s (Goddard and Armstrong, 1986; Openshaw and Mounsey, 1986, 1987; Atkins, 1986; Openshaw *et al*., 1986, Owen *et al*. (1986; Rhind and Mounsey, 1986, Rhind *et al*., 1988, Mounsey, 1988, Rhind and Openshaw, 1987). It was jointly produced by the BBC (British Broadcasting Commission), Acorn Computers and Philips to commemorate the 900th anniversary of William the Conqueror's tally book. This double *laservision* videodisc system was driven by a BBC computer and incorporated the software on the disc itself. The *Domesday* videodisc engine was later employed to operate other BBC *laservision* products. Rhind and Openshaw (1987) said of their *Domesday* videodisc that, even though the product was revolutionary, the system offered limited analytical capability, it could not be updated regularly, the database was limited the *Domesday* videodiscs only stored data on Great Britain) and there was the possibility of the misuse of data in combination through analyses carried out by unskilled users. Limited as they were, and constrained by underdeveloped user interfaces and interrogation routines, interactive videodisc products heralded the future of the application of hypermedia to the spatial sciences.

2.7.3 Cartographic products on CD-ROM

Initially, the potential of the large storage capacity of CD-ROMs for distribution of geographical information fostered interest in publishing digital maps (Rystedt, 1987; Siekierska and Palko, 1986). Products like the *Digital Chart of the World* (DCW) and the *World Vector Shoreline* (Lauer, 1991) were some of the first products to exploit this storage medium.

Discrete atlas products were quite quickly produced and publications include the Dorling Kindersley *World Reference Atlas*; MicroSoft *Encarta*; Mindscape's *World Atlas 5* (New Media,, 1995); *The Territorial Evolution of Canada* interactive multimedia map-pack that developed from an experimental prototype atlas as part of the National Atlas of Canada program in the Geographical Sciences Division, Survey and mapping Branch, Department of Energy and Resources (Siekierska and Palko, 1986; Armenakis, 1992, 1993) (this is discussed in Chapter 13 of the book); the *National Atlas Information System of the Netherlands* (Koop and Ormeling, 1990); *The Swedish National PC-Atlas* (Arnberg, 1990, Wastenson and Arnberg, 1997, Ögren, 1997); the Chinese Population Censuses and Electric Maps of Population (Taylor, 1996); and the *National Geographic Society's Picture Atlas Of the World* on CD-ROM.

An interesting example of a CD-ROM application was *Autoroute Plus*, one of a number of products developed by the NextBase company, and built around the same engine (Sargeant, 1994). It covered the whole of the U.K. The original maps (both scanned and digital) originated from the Ordnance Survey and can be reduced to 1:250,000. It included a database editor with search features; giving access to 30,000 placenames in the U.K. Nextbase also produced a street directory of London, also using the same engine. The advantage of this product was that layers of information could be turned on and off, enabling information to be made available when required, thus enhancing what could be immediately viewed - an apparent electronic version of a paper street directory

In the US DeLorme published a *Mac*/*Windows* CD-ROM, *Street Atlas USA*, containing every street in the US, as well as names for every city, town, street, geographic feature and prominent building (New Media, 1995). Other road map products were the Geosystems/Delorme *AAA Trip Planner* and *Global Explorer* and *Map Expert* (Kruh, 1995), US digital road atlases by Microsoft (*Automap Road Atlas*) and Rand McNally (*Trip-Maker*), and at a ‘local’ level portraying town maps as well - Microsoft’s *Automap Streets* and Rand McNally’s *Streetfinder* (Booth (1996).

Travel guides published on CD-ROM included the titles *Lets Go* (a CD-ROM of their USA guide), Frommer (*Travel Companion*, containing 25 cities in the USA), Co-mInfo (Moscow Kremlin CD Guide), Superbase (*Getaway to Australia: an electronic book*) (Kruh, 1995), Expert Software (*Expert CD-ROM Travel Planner Gold*) Deep River Publishing (*Everywhere USA Travel Guide*) (Akscyn et al., 1994) and DeLorme (*Map’n’go*) (New Media (1995); *the Great Cities of the World*, a multimedia travel guide of Bombay, Cairo, London, Los Angeles, Moscow, New York, Paris, Rio de Janeiro, Sydney and Tokyo (vol. 1) and Berlin, Buenos Aires, Chicago, Jerusalem, Johannesburg, Rome, San Francisco, Seoul, Singapore and Toronto (vol. 2) (Diehl, 1992).

Multimedia maps have also been used to extend the impact of exhibitions. The CD-ROM, *The Image of the World: An interactive exploration of ten historic world maps*, was developed as part of *The Earth and the Heavens: the art of the mapmaker*, an exhibition held in the British Library in 1995. It contains historical images of ten world maps, dating from the 13th to the late 20th centuries. Access to the maps is initially made through the introductory screen, which depicts small map icons that act as hot spots to other more detailed information about the maps.

2.7.4 Games, maps and gameplay

Computer games initially began as discrete applications, delivered on floppy disks, then CD-ROM. Later the trend in computer games was towards the development of multi-player games for the Internet, provided by cooperative ventures between gaming networks and Internet service providers (Tanner, 1997). Generally, geography-related games have been designed as either home platform or entertainment applications.

Early geographically-related games delivered on discrete media used multimedia and hypermedia technologies. For example, the USGS's *GeoMedia* was used to teach upper elementary students in the USA geographical concepts. Hypermedia techniques allowed students to make associative links between graphics, text, animation and sound. Animations showed earth science processes such as plate tectonics and the water cycle and an ‘understanding maps’ section explains the use of maps (GIS World, 1993).

A cartographic game, *Magellan* (Taylor, 1994), was launched in late 1993, and it operated as an interactive ‘touchtalk’ globe that can be used as either a computer game or as an educational tool. ‘Virtual keypads’ could be added to the interface, allowing responses to touch that gave taped audio information on each country. Another computer game, *Where in the World is Carmen Sandiego?* taught geography whilst users were playing a mystery solving game.

Kuhn (1992) saw that, for mapping and GIS applications, play allows developers to emphasise creativity and encourage ‘trying-out’ and that video games ideas that included strong spatial components could be useful. He stated that: “… it seems tempting to further explore this kind of paradigm for GIS applications. In some sense, a GIS is like a toy world - a model of reality simplified to the point where users can play with it”(p. 98).

The contemporary use of gaming and games engines is explored in the chapter by Champion elsewhere in this book. Also, the chapter by Germanchis provides information on how to ‘build’ a games-delivered cartographic application. The chapter from Pulsiver and Caquard and another by Axford *et al.* discusses the potential that games machines offer for delivering geographical information to support more conventional mapping methods.

2.8 From packaged media to distributed media

There are presently three commonly used types of communication systems - the telephone for voice, cable and transmission signals for television programming and computer networks for data. There has been a digital convergence of communications equipment, office machines, domestic equipment and personal entertainment items. This has been brought about by all of the elements talking the same electronic language and the digitising of pictures, sounds and video (Computer Age, 1995). Zahler, co-director of the Center for Arts and Technology, at Connecticut College, New London, supports convergence and has stated:

> *“I think convergence is a good thing because what comes with convergence is simplicity ... It lets every individual find what they want, when they want it, and use it however they like” (Computer Age(1995, p. 26).*

Things like the hype of marketing and the Internet in the mid-nineties was viewed with some with skepticism - some seeing the predictions made about the information superhighway very closely paralleling the predictions made in the (1950s about atomic energy (Elliott, 1995).

Video approaches or computer approaches? During discussions at the beginning of the 1990s about where discrete multimedia would progress to, Hartigan (1993) from Philips Professional Interactive Media Systems saw a debate between video and computer developers of multimedia. Film/video developers would argue that a movie should not be stopped or interrupted, whilst those from the computer side see programs which include moving images and those things like finesse of colour, contrast and composition are a waste of time. He said:

"Are we really facing, in Multimedia, 'the image that ate the computer industry' - or 'the data that ate the video industry' ".

There would be a need to establish standards for advanced data interchange and system integration, agents will be needed to anticipate users' needs and computers will be able to write computer code. Apple predicted this in 1987 with their futuristic *Knowledge Navigator* (Sculley, 1989).

Writers like Negroponte (1995a) saw all kinds of package media slowly dying out. This was predicted for two reasons: the approaching ‘costless’ bandwidth, allowing almost a limitless distribution system on the Internet; and solid state memory catching-up to the capacity of CDs, giving the prospect of massive data storage at minimal cost. As with the predicted demise of paper products, the future demise of discrete multimedia was predicted as well. On-line publishing was seen as the ‘next phase’ of electronic publishing, one that would superscede optical storage media. Most observers saw that CD-ROM had a limited life, but it would still be quite a number of years before networks with sufficient bandwidth were available to adequately handle multimedia (Multi Media Digest, 1994). Louis Rosetto, the founder of *Wired*, called CD-ROMs the ‘Beta of the ‘90s’, referring to the now-defunct *Betamax* video. Negroponte (1995a, p. 68) agreed with him and said that:

“It is certainly correct that, in the long term, multimedia will be predominantly an on-line phenomenon.”

By the mid 1990s the Internet had ‘matured’ and spread, information was being made available and browser software was wide-spread. The next communication medium was waiting in the wings, one that revolutionised the way in which maps were designed and delivered. This was distributed multimedia. Distributed multimedia uses communication resources to link computers locally or internationally. Multimedia packages are delivered either using intranets, computers linked internally, say in agencies or corporations using the standard access methods of all distributed multimedia, or through the use of the Internet, whereby the World Wide Web with appropriate ‘browsers’ and ‘plug-ins’ is used to access hyperlinked multimedia resources. The further development of interactive multimedia Cartography using the Internet is covered in the following chapter.

2.9 Conclusion

This Chapter outlined the development of the ideas and 'tools' necessary to allow publishers, including cartographers, to produce maps using interactive multimedia. Other delivery mechanisms were described, from microfiche to computer games, as alternative media for geographic information delivery. The distribution of these products is effected by the use of discrete media like CD-ROM or videodisc or through the use of the Internet or Intranets. Typical products developed using multimedia and hypermedias were outlined and the profiles of the different types of titles produced for the different new media types have been described.

Map producers and map users alike should revel in what multimedia offers. Multimedia is the matchmaker between the logical world of computers and the abstract world of video. Cartographers, already attuned to dealing with multimedia in terms of atlases and mapping packages that contain a plethora of map tools, are well placed to exploit the medium. It offers the cartographer the means of dynamic displays, high interaction and direct access to the database. The challenge for map designers and producers is to use multimedia, in its broadest sense, as a new tool for cartography.

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3 The Internet and Multimedia Cartography

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3.1 Introduction

Although the Internet has been in existence in some form since 1969, only since the mid-1990's, with the widespread use of the World Wide Web, has the Internet became a major medium for cartography. Within a matter of years, millions of maps were being delivered to users through this new medium, and cartography was freed of its dependence on a physical medium for the exchange of geographical information. The image search option in most search engines makes it possible to quickly find a large number of maps in the GIF, JPEG and PNG raster formats. Although many are of poor quality and some are even illegible, static maps in the raster format persist despite the availability of more advanced and interactive products. The ease with which such static maps can be placed on the Web and how quickly they can be found still makes such maps a mainstay for the Internet map user. This chapter examines the Internet phenomenon, particularly the current status of the Internet, Internet map use, and contemporary research related to maps and the Internet.

3.2 Internet development

From its beginnings in 1969 up until the mid-1990s, the Internet was used almost solely by academic research scientists and the military. Besides being restricted to specific users, the system was difficult to use. The simple process of sending and receiving files required memorizing arcane text commands. At the beginning of the 1990s, in a research laboratory in Switzerland, Tim Berners-Lee created the hypertext Internet links that formed the basis of the World Wide Web. But, the initial version consisted only of text. Making the Web mainstream would take until the middle of the decade and require the implementation of a graphical browser. The first such browser was made freely available on March 14, 1993 and called Mosaic. The program was written by Marc Andreesen and Eric Bina at the University of Illinois' National Center for Supercomputer Applications (NCSA). They introduced the program as a "consistent and easy-to-use hypermedia-based interface into a wide variety of information sources." The concept, Andreessen says, "was just there, waiting for somebody to actually do it."

NCSA Mosaic enjoyed almost immediate success. Within weeks it was the browser of choice for the majority of Internet users. More Mosaic users meant a bigger Web audience. The bigger audiences spurred the creation of new content, which in turn further increased the audience on the Web and the demand for Mosaic. Not everyone was pleased with Mosaic. Tim Berners-Lee, who designed the Web only a few years before, lashed out at Andreesen at a public meeting by telling him that adding images to the Web was going to bring in a flood of new users who would do things like post photos of nude women. Andreesen later admitted that Berners-Lee was right on both counts.

The success of Mosaic led to the release of a re-written and faster commercial version called Netscape in October of 1994. It became the pre-eminent 'browser' software until rivaled by Microsoft's *Internet Explorer* when it was introduced in 1996, leading to the "browser war" of the late 1990s. Standards were developed for HyperText Mark-up Language (HTML) by the WWW Consortium (W3C). Further work led to a standard for Dynamic HyperText Mark-up Language (DHTML for Netscape) and dHTML (for Microsoft), VRML (Virtual Reality Mark-up Language) authoring (Murie 1996), XML and a variety of derivatives – including Scaleable Vector Graphics (SVG).

At the end of 1994 there were only 13 million users of the Internet. By late 1995 this number had risen to 23 million, plus an additional 12 million using electronic mail of various kinds (Parker 1995). The Web grew one home page every four seconds and doubled every 40 days. It had over 40 million users worldwide in early 1996 (van Niekerk 1996). There were only 200 million Internet users at year-end 1998. It grew to 533 million at year-end 2001. The figure was 935 million in 2004 and. reached 1 billion sometime during 2005. In terms of Web servers, the Internet grew from 130 in 1993 to an estimated 660,000 in early 1997 (Peterson 1997) and by late 1998 servers numbered over a staggering 3.5 million (The Netcraft Web Server Survey 1998). It is clear that the Internet and its use have grown very quickly and now represents the major form of information distribution for a large portion of the world's population.

3.3 Maps and the Internet

The development of map distribution through the Internet was affected by general trends that influence the spread and adoption of the technology. Three major eras in the development of the Internet can be identified that influenced the development of the Internet as a medium for cartography. In the first stage, the distribution of maps via the Internet was a novelty with no specific purpose other than to demonstrate that maps could be quickly distributed in this way. In the second stage, beginning in about 1997, the Web emerged as a major form of delivery for certain types of maps, particularly for interactive street maps. In the current third stage, various forms of user input to maps, including *community mapping*, are being developed. The continued development of the Internet for map delivery is dependent on solving specific problems. Solutions to these problems are both technical and philosophical and will have a major influence on how cartography as a whole develops in the future.

Formal research in cartography related to the Internet began in about 1995. The North American Cartographic Information Society (NACIS) dedicated its annual meeting to the Internet in 1996. The international dimension to this research was aided by the creation of the ICA *Maps and the Internet* Commission in 1999. Meetings of this international body were held in 2000, 2001, and 2002, 2003, 2004, 2005, in the United States, China, Germany, South Africa, Japan, and Spain respectively. These meetings have addressed issues of Internet map use and Internet map delivery. These areas of research are represented in the 2003 publication *Maps and the Internet*, a publication of the International Cartographic Association. The purpose here is to outline each of these areas and present the major focus of each. We first examine the growth of the Internet and the growth of Internet map use.

3.4 Internet use and Internet Map Use

The development of map distribution through the Web is largely dependent on the growth and expansion of the Internet as a medium of communication. According to the Computer Industry Almanac (2004), there are 935 million Internet users or nearly 16% of the world's population (see Table 1). This is up from 533 million Internet users worldwide at year-end 2001 which at that time represented only 8.7% of the world's population (see Table 2). There were only 200 million Internet users at year-end 1998. It is expected that this figure will reach 1 billion by mid-2005 and

1.46 billion by 2007. Most of the current 935 million Internet users, are located in the top 15 countries (see Table 1). The major growth in the use of the Internet is coming from the East and South Asia, Latin America, and Eastern Europe. India is now ranked 5th in terms of the share of world Internet users. In 2001, India was not even in the top 15. The rate of usage and growth in usage is remarkable considering the complexity of the required computing and communications infrastructure.

The growth in the use of wireless Internet via cell phones is especially strong. The wireless Internet share is currently 16% or 85 million people. This is expected to rise to 42% in 2004 and 57% in 2007. This means that by 2007, there will be 829 million users of wireless Internet. The number of wired Internet users will only be 632 million – an increase of only 184 million. These figures indicate that most of the growth in the use of the Internet will come from the wireless sector. However, it is likely that a wireless Internet user will also use a wired network.

Table 1. Top 15 nations in Internet use at year-end 2004. The last column indicates the percent of the world total. Data for some countries are not available.

0Rank	Nation	Internet Users 2004 (millions)	1Share of World Users
1	United States	186	19.86%
2	China	100	10.68%
3	Japan	78	8.35%
4	Germany	42	4.48%
5	India	37	3.96%
6	UK	33	3.54%
7	South Korea	32	3.39%
8	Italy	26	2.73%
9	France	25	2.72%
10	Brazil	22	2.39%
11	Russia	21	2.27%
12	Canada	20	2.19%
13	Mexico	14	1.49%
14	Spain	13	1.44%
15	Australia	13	1.39%

Source: Computer Industry Almanac (2004)

Table 2. Top 15 nations in Internet use at year-end 2001. The last column indicates the percent of the world total. Data for some countries are not available.

2Rank	Nation	Internet Users 2001 (millions)	3Share of World Users
1	United States	149	41.92%
2	China	33.7	9.48%
3	UK	33	9.29%
4	Germany	26	7.32%
5	Japan	22	6.19%
6	South Korea	16.7	4.70%
7	Canada	14.2	4.00%
8	Italy	11	3.10%
9	France	11	3.10%
10	Russia	7.5	2.11%
11	Spain	7	1.97%
12	Netherlands	6.8	1.91%
13	Taiwan	6.4	1.80%
14	Brazil	6.1	1.72%
15	Australia	5	1.41%

Source: Computer Industry Almanac (2001)

Another trend in Internet usage is the return of a browser war. All of the major browsers, especially Microsoft's Internet Explorer, are losing ground to upstart Firefox which now accounts for nearly a fourth of all web browser activity (see Table 3). Firefox is viewed as a faster, trimmer Web browser that isn't subject to the crashes and security gaps that afflict the market-leading Microsoft Internet Explorer. Table 4 shows the market share of each operating system.

Table 3. Browser market share in the last four months of 2005. Explorer is losing market share to Firefox.

2005	IE 6	IE 5	Ffox	Moz	NN 7	O 8	O 7
December	61.5%	6.5%	24.0%	2.7%	0.4%	1.3%	0.2%
November	62.7%	6.2%	23.6%	2.8%	0.4%	1.3%	0.2%
October	67.5%	6.0%	19.6%	2.6%	0.4%	1.2%	0.2%
September	69.8%	5.7%	18.0%	2.5%	0.4%	1.0%	0.2%

IE	Internet Explorer
Ffox	Firefox (identified as Mozilla before 2005)
Moz	Mozilla
O	Opera
NN	Netscape

Source: http://www.w3schools.com/browsers/browsers_stats.asp

Table 4. Operating system market share in the last months of 2005.

2005	Win XP	W2000	Win 98	Win NT	Win .NET	Linux	Mac
December	71.6%	13.6%	2.6%	0.3%	1.7%	3.2%	3.3%
November	71.0%	14.6%	2.7%	0.4%	1.7%	3.3%	3.3%
October	70.2%	15.0%	2.8%	0.4%	1.6%	3.3%	3.2%
September	69.2%	15.8%	3.2%	0.5%	1.7%	3.3%	3.1%
December	71.6%	13.6%	2.6%	0.3%	1.7%	3.2%	3.3%
Source: http://www.w3schools.com/browsers/browsers_stats.asp							

An interesting aspect of Internet use is the disparity in the number of male and female users, particularly in certain countries. In 2000, male-female ratio ranged from 94:6 in Middle East to 78:22 in Asia, 75:25 in Western Europe, 62:38 in Latin America, and finally 50:50 in USA (Dholakia, et.al, 2003). Updated data are presented in Table 5. In many European countries, local telephone calls are metered. This means that the home user of the Internet would pay a telephone fee for every minute of connection time. This cost structure would limit home use of the Internet, which may affect women more than men.

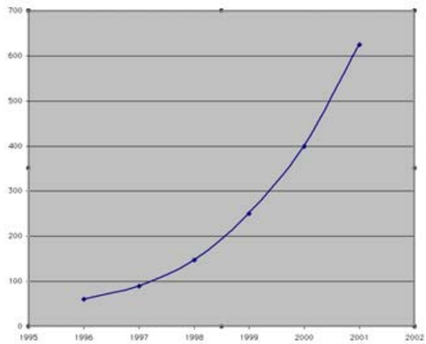
Table 5. Internet use gender differences by country ranked by disparity in male usage.

Internet Users by Gender		
Country	**Male %**	**Female %**
Germany	63.4	36.6
France	61.9	38.1
Italy	60.9	39.1
Spain	60.9	39.1
Belgium	60.6	39.4
Netherlands	59.8	40.2
Brazil	59.7	40.3
Switzerland	58.7	41.3
Japan	58.4	41.4
Austria	58.1	41.9
Norway	58.0	42.1
UK	57.2	42.8
Israel	57.1	42.9
Hong Kong	56.6	43.4
Singapore	56.5	43.5
Denmark	55.9	44.1
Taiwan	55.8	44.2
Ireland	54.8	45.2

Sweden	54.8	45.2
South Korea	54.4	45.7
Mexico	54.0	46.0
Finland	53.9	46.1
New Zealand	52.5	47.5
Australia	51.6	48.4
Canada	49.0	51.0
United States	47.3	52.2

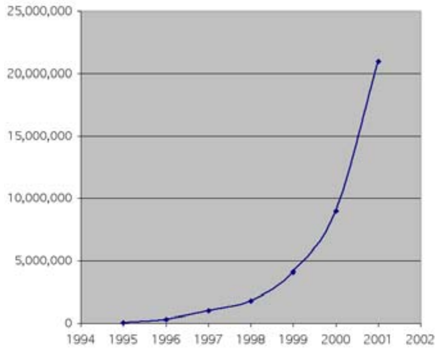
Source: Nielsen/NetRatings, 2003.

The number of maps that are distributed through the Web was tracked at four major sites since 1997 (Peterson 2003a). The results indicate that usage grew rapidly, particularly at commercial sites. Figure 1 presents a comparison of the growth in Internet use vs. the growth of Internet map use through 2001. Both growth rates are strongly exponential. It is probably not surprising that the growth in the use of maps through the Internet is exceeding the growth rate for the Internet itself. It is far more difficult for a non-Internet user to get the initial equipment and Internet connection to become an Internet user than it is to get an existing Internet user to access maps through the Internet. It is interesting that people have adapted so easily to using maps through the Internet and that the growth the usage is expanding at such an exponential rate.



Growth in the Use of the Internet in the number of new users per year.

$e^{0.45}$



Growth in Internet Map Use in Number of Maps Distributed per Day

$e^{0.80}$

Fig 1. A comparison between the growth of the Internet and the growth of Internet map use. Both growth rates are exponential. Internet map use is growing at a faster rate, approximated by an exponent of $e^{0.80}$, where e is the base of the natural logarithms.

3.5 Research in Internet Cartography

The Maps and the Internet commission of the International Cartographic Association have identified a number of areas of research. These areas are:

Internet Map Use – The purpose of this research is to investigate the growth in the use of the Internet, the growth in Internet map use, methods of Internet map use, and approaches of improving Internet map use.

Internet Map Delivery – The purpose here is to find better methods of transmitting maps through the Internet. Research involves exploring new Internet protocols and graphic file formats for cartographic applications.

Internet Multimedia Mapping –This area of research attempts to integrate multimedia elements with maps and make them available in an efficient and educational manner through the Internet.

Internet Mobile Mapping – This direction examines the use of mobile phones for map delivery and display. The major challenges are to reduce the map to a small display and update the map relative to the position of the user.

3.6 Theory to support Internet Cartography

3.6.1 Dimensions of internet map use

A number of chapters in the Maps and the Internet (Peterson 2003) volume address different aspects of Internet map use. Krygier and Peoples (2003) describe the integration of the Internet in a college-level course to create a basic geographic information literacy. The course attempts to engage “students (who are mostly non-geography majors) in active learning about mapping, but also critical thinking about the nature of maps and mapping sites on the WWW (World Wide Web), a skill that is more necessary than ever.” (Krygier & Peoples, p. 17).

Richmond and Keller (2003) explore Internet maps and their use in web-based tourism destination marketing. They examine 181 “maps within 40 official national tourism destination websites” (p.77). They conclude that the “designers of tourism websites need to put more thought into the location of maps within their sites” (p. 94) because the maps are often very hard to find.

Mooney and Winstanley (2003) look at the publishing of public transportation maps and the cognitive processes involved in understanding these maps within the medium of the Web browser. They found that "computer generated route maps often disregard many of the techniques and principles that guide cartographers" (p. 306). Among other things, they argue that transportation maps need to be more up-to-date because over a given day many changes occur on a public transportation network. The Internet can help deliver more current transportation maps to the Internet map user.

Monmonier (2003) examines how online maps are being used to invade privacy. He points out that: "Web cartography" is especially valuable—and potentially threatening—because it not only greatly expands the audience of potential watchers (Peterson, 2000) but also allows for unprecedented customization of maps that describe local crime patterns, warn of traffic congestion and inclement weather, disclose housing values, or - thanks to the Global Positioning System (GPS) and the new marketplace for "location-based services" - track wayward pets, aging parents, errant teenagers, or unreliable employees" (p. 98). He concludes that: "As society and government work through the significance of locational privacy and decide what legal limitations, if any, are appropriate and permissible, the debate will turn to possible restrictions on Internet cartography, which many consider invasive because of the increased accessibility of information about where we live, the size and condition of our homes and real property, and the quality and safety of our neighborhoods" (p. 111).

3.6.2 Internet map delivery

The purpose of this line of research is to find better and more efficient ways of distributing maps through the Internet. This work is influenced by the open source movement that seeks to maintain a body of software through a combined effort of numerous, independent individuals.

Herzog (2003) describes the freely available Mapresso software for choropleth and cartogram mapping. He points out that the "World Wide Web offers cartography an ideal platform for making communication with maps more feasible" (p. 117). He argues that cartography "has not taken sufficient advantage of the Internet" (p. 129). He concludes by arguing for a different model for how software is developed for Internet mapping:

> Considering a broader model of cartographic development on the Internet, small applets, as the one presented here, could be the result of a common effort of different actors in this area – from writers of the code for basic utility classes and for applets and related products to compilers of the geodata and finally to Web publishers with special thematic concerns. Such a community would help to exploit the constantly increasing techni-

cal opportunities for the diffusion of cartographic products and ideas (p. 129).

Neumann and Winter (2003) describe the advantages of a vector format called SVG. Andrienko, et.al. (2003) relate the experience of developing and evaluating an open source GIS program. Zazlavsky (2003) looks at the cartographic potential of XML, a new mark-up language for the Web.

Elzakker, et.al, (2003) review worldwide progress in the dissemination of census data in the form of maps. Elzakker, et.al, (2003) state that the advantages of web mapping "may be summarized under the headings of accessibility and actuality. Accessibility means convenience in accessing data anytime and from anywhere (as long as there is Internet access). Actuality refers to the potential of making the data available to the user immediately after their collection" (p. 58). In their review, 126 national statistical organizations (NSO's) were identified and analyzed. They point out that if "NSOs (National Statistical Organisations) wish to enable further possibilities to interact with maps, some kind of *mapping application* is needed that dynamically constructs maps out of the available data according to the user's specifications" (Elzakker, et.al, 2003, p. 74). Many possibilities are available, some open source, that would make this possible.

Cartwright (2003) "addresses the new area of Web mapping and covers why maps delivered through the Web are different, what constitutes effective Web map design, and the criteria by which they should be evaluated." (p. 35). He concludes that: "Proper design and evaluation procedures are essential if usable Web-delivered geovisualizations are to be provided and effectively exploited" (Cartwright 2003, p. 55).

Andrienko, et al. (2003) develop and test a general purpose GIS program called CommonGIS. The objective is to incorporate exploratory data analysis with online maps. CommonGIS is implemented in the Java language and can be used in two ways: as an applet running in a standard Java-enabled Web browser and as a local application, after being installed on a user's computer.

Jiang (2003) examines the potential of developing an analytical online cartography. He argues that "more and more users would like to query maps or geographic information for various purposes" (p. 147). Seeing limitations in the server-client model, he sees the potential of P2P for developing and distributing Geographic Information Services (GIServices).

Li (2003) examines point-to-point protocols (P2P) that are used for the exchange of music files and movies. He shows how a "node-hub P2P system enables individual users to form a cartographic data network where cartographic data are packaged, published, registered, searched, and transported over the Internet" (p. 159).

Zazlavsky (2003) introduces XML and outlines its potential for online cartography. Through an application called AxioMap, he shows how data and instructions can be downloaded and processed on a local computer. He concludes by pointing out that XML makes it possible to perform many spatial data integration and dynamic mapping tasks that could not be addressed before (p. 194).

Newmann and Winter (2003) describe the advantages of Scalable Vector Graphics (SVG), a vector graphics standard based on XML. They describe it as the first "vendor neutral vector graphics standard that integrates vector graphics, raster graphics, text, scripting, interactivity and animation while also being fully extensible, open to metadata and internationalization" (p. 217). They argue that SVG will reach its full potential when it is fully integrated with other XML standards (p. 218).

Lehto (2003) views the Web as a new publishing platform, similar to traditional print media. The challenge is to publish maps in multiple formats. He describes a mechanism for transforming XML-encoded data, the Extensible Stylesheet Language Transformation (XSLT) specification, and explains its use as a tool to provide multi-purpose publishing functionality for the Web and the Mobile Internet-based spatial services (p. 221).

Tsou (2003) envisions software agents that reside on the Internet and handle map related functions, such as map design. He argues that: "Software agent-based communication mechanisms can facilitate the dynamic integration of geospatial data, GIS programs, and cartographic rules and knowledge bases in distributed network environments (p. 242).

Torguson & Blinnikov (2003) show that an online atlas can be made by combining the efforts of students and Internet data sources. The project brought students from several different classes together to work in a team-building work experience (p. 312).

3.6.3 Internet multimedia mapping

A particular form of map delivery research attempts to exploit the potential of the Internet for combining multimedia content with maps. For example, Hu (2003) describes the creation of a web-based multimedia GIS. According to Hu, "web-based multimedia GIS is based upon interactions between three components: 1) a web-based GIS application developed to manipulate digital maps; 2) a web-based interactive multimedia application designed to manipulate multimedia information including hypertext, hyperlinks, graphics, photographs, digital video and sound; and 3) a mechanism linking the web-based GIS application and the interactive multimedia application" (p. 336). He argues that the "integrated multimedia-GIS approach provides a multi-sensory learning environment" (p. 341)

Caquard (2003) evaluates the potential of Internet maps to serve a role in a public participation decision-making setting. He argues that the dynamic maps that he studied are better suited to improve public participationby reducing the influence of the mapmaker and supporting the user's participation in the map-making process (p. 355).

Cammack (2003) uses a sense of virtual reality immersion with a map so the map-reader can experience the complexity of the virtual reality scene and abstraction of the map at the same time. He explains that spatial information can be represented in an extremely abstract or nearly realistic way (p. 361) and that there is a relationship between the level of abstraction and map use. "One aspect of this relationship is that spatial representations at different levels of abstraction can have the same map use" (p. 361). He proceeds to develop a multimedia-map environment using QuickTime VR that helps users understand water quality issues in a particular drainage basin.

Schwertley (2003) also uses QuickTime VR to create an online virtual landscape of a small city in Iowa. The individual virtual reality scenes are linked to a map and to each other. He concludes that "QuickTime VR can enhance spatial understanding and provide a better sense of place by combining virtual realitywith geographical information in the form of maps" (p. 381).

Giordano (2003) describes an application to distribute historical maps through the Internet with a GIS. As he states, the study "exemplifies the difficulties of using geographic information technologies with historical data (p. 321). His study showed that it is possible to integrate the traditional tools of GIS with computer cartography and multimedia. Together, "they provide a formidable suite of tools. The geographic query capabilities of the GIS, coupled with cartographic animations, images, pictures, and videos that can help a researcher gain additional insights into the study of historical databases. On a negative note, however, the integration must be done totally from scratch. Today's GIS is too immature to integrate multimedia applications" (p. 331).

Fuhrmann (2003) examines use of a geovirtual environment to support wayfinding. The research looks at how an egocentric frame of reference is best extended for navigation purposes with an exocentric map view and whether adding such a frame of reference significantly reduces navigation and wayfinding problems within the virtual environment.

Ottoson (2003) looks at the use of the Internet for three dimensional visualization, mostly in reference to the Virtual Reality Modeling Language (VRML). The advantage of VRML files is that they can be downloaded and executed on a standalone computer but the format has suffered from a lack of a widely available plug-in. He concludes that there are a large number of 3-D map applications particularly with small mobile devices.

3.6.4 Internet mobile mapping

Gartner (2003) defines mobile mapping as an extension of Internet mapping through the distribution of cartographic presentation forms via wireless air data transfer interfaces and mobile devices. One potential application of this technology is Location Based Services (LBS) in which the location of the map user is identified. He sees the use of multimedia as both a “necessity in the context of small displays and special usage conditions of mobile users and a benefit for the cartographic information transmission (p. 392).

Wintges (2003) tackles map design issues on a PDA display. The purpose of this his research is to design a “satisfactory user interface and a method for navigation and interaction with a personal digital assistant” (p. 397). In the PDA user interface that he proposes, to “compensate for the absence of scrolling and to guarantee the largest display area possible, pop-up menus and information frames which fall back on a structured layer-model were integrated” (p. 402).

Interest in mobile mapping has led to a series of conferences held at the Technical University o Vienna in Austria. These meetings, entitled *LBS and Telecartography* have helped define this new area of study.

3.6.5 Theoretical development

Taylor (2003) argues that the increasing use of maps and the Internet requires a new paradigm for cartography. He proposes the concept of Cybercartography which he defines as: “The organization, presentation, analysis and communication of spatially referenced information on a wide variety of topics of interest and use to society in an interactive, dynamic, multimedia, multisensory and multidisciplinary format” (p. 406).

Brodersen (2003) attempts modeling the visualization of Internet maps. He argues that despite “the changes in the process of geo-communication through Internet maps, communication is still the purpose” (p. 434). The “content of a communication is media-independent” and the ultimate aim is that the map affords the user the possibility of *quickly* and *safely* getting *correct* answers to *relevant questions*.

Peterson (2003) identifies the four paradigms that have guided cartography over the past half-century that have had an influence on the development of cartographic research related to the Internet. These four paradigms include cartographic communication, analytical cartography, cartographic visualization, and maps as power. For example, the latter paradigm argues that “the technological dimension of cartography has managed to overwhelmingly dominate the discourse in the field” (p. 443). It was pointed out by Harley “that under the influence of the computer, cartographers are more interested in technological questions rather than in the social consequences of what they represent” (p. 443).

3.7 Summary and suggestions

Cartography has always been subject to changes in technology. The particular change in the way maps are delivered to map user that began about a decade ago can be seen as a revolution. We are still adjusting to this rapid change. The research that is summarized here reflects this adaptation to a new medium. Clearly, there is much research yet to accomplish before the use of the Internet can be mastered by cartographers.

The *Maps and the Internet* commission of ICA has taken a leading role in spurring discussion and research about this new medium. Additional international efforts need to be focused on encouraging individual map suppliers and government agencies to take a greater role in improving the creation and use of maps through the Internet.

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4 Development of Multimedia - Mobile and Ubiquitous

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4.1 Introduction

Telecommunication infrastructure (mobile network), positioning methods, mobile in- and output devices and multimedia cartographic information systems are prerequisites for developing applications, which incorporate the user's position as a variable of an information system. Integrating geo-spatial information into such a system, normally cartographic presentation forms are involved. Thus, the resulting system can be called a 'map-based location based service' (LBS). This chapter discusses the elements of a map-based LBS, outlines main research topics and describes some experiences in the context of conceptual design and developing map-based LBS.

This chapter deals with location-based services and maps. It analyses the basic elements such as positioning, information modelling and presentation as the main fields of research, and the state of the art of currently used location-based systems. It presents selected research experiences such as the potential of cartographic presentation forms, positioning of active landmarks, modelling and visualization of guiding and navigation for pedestrians. TeleCartography is the distribution of cartographic presentation forms via wireless data transfer interfaces and mobile devices.

4.2 Elements of Cartographic LBS

A system can be called a Location Based Service (LBS), when the position of a mobile device – and therefore the position of the user - is somehow part of an information system. The derivable types of applications in this context can be stated as heterogeneous and include simple and text-based applications, which use the 'cell' (unique identification of the cell of a telecommunication network) for a rough positioning ("Which petrol stations are there around me?") to map-based multimedia applications including routing functionalities. In this context, different names for the context of telecommunication infrastructure, location-based applications and cartography are used. Beneath 'mobile cartography', 'ubiquitious cartography' the author proposes the term 'TeleCartography', to be understand as issues involved by the distribution of cartographic presentation forms via wireless data transfer interfaces and mobile devices

Independent from the level of complexity of the system architecture every map-based LBS needs some basic elements to handle the main tasks of positioning, data modelling and information presentation.

4.2.1 Positioning

The determination of the position of a mobile in/output device is a direct requirement for every system to be called LBS. Positioning has to be adequate to the service in terms of a dependent relationship and adapted to the tasks. For various applications the necessary level of accuracy needed can be served by the cell-ID of a telecommunication network and the thus derivable position, which gives an accuracy of positioning between 50 and 100 meters in urban areas (see Retscher 2002). For navigation purposes – in particular in the context of pedestrian navigation – the accuracy demands increases to values of at least 25 meters and less (Retscher 2002, Gartner & Uhlirz 2001). For indoor navigation, the requirements for the position determination are even more increased (Gartner et al. 2003).

Various methods of positioning are available for different levels of accuracy:

- satellite-based positioning,
- positioning by radio network,
- alternative methods,
- combinations.

Nowadays for outdoor navigation, satellite-positioning technologies (GPS) are most commonly employed. GPS provides accuracies on the few meters to 10 m level in standalone mode or sub-meter to few meter levels in differential mode (DGPS). If an insufficient number of satellites is available for a short period of time due to obstructions, then in a conventional approach observations of additional sensors are employed to bridge the loss of lock of satellite signals. This is particularly necessary for areas where the satellite signals are blocked like indoor or underground environments, or generally urban areas.

Deriving information from parameters of a radio network – coordinate cell or base station information – is a further method, but immanently restricted by the cell dimensions. Measuring methods using elapsed time of signals in combination with cell identification, time synchronisation or differences of elapsed time can improve positioning (Retscher 2002).

Alternative methods or improvements of already existing methods are shown by Zlatanova and Verbree (2003). They propose ‘user tracking’ in combination with ‘Augmented Reality’ (AR) to improve positioning in bad conditions (indoor/underground). Kopczynski (2003) describes an approach of using simplified topological relations to determine positions by sketch maps (sketch based input).

4.2.2 Modelling and Presentation of Information

The possibility of transmitting and visualising geospatial information in the context of a determined position is primarily restricted by the limitations of the used mobile device. The basic conditions of the cartographic communication process have to be fulfilled in any way, also when using map-based LBS: The cartographic model has to be clearly perceivable while it is permanently scale-dependent and has to present the task-dependent appropriate geometric and semantic information.

This fact in combination with restrictions in size and format of current mobile devices leads to different levels of solutions for presenting information within map-based LBS:

- Cartographic presentation forms without specific adaptations;
- Cartographic presentation forms adapted to specific requirements of screen display;
- New and adapted cartographic presentation forms; and
- Multimedia add-ons, replacements and alternative presentation forms.

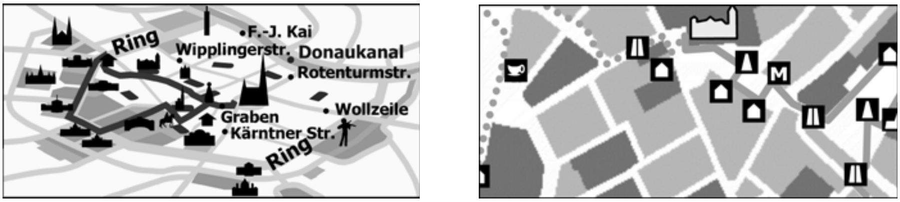

Fig. 1. ‘Look and Feel’ of the *Lol@*-Service

Rules and guidelines have been developed recently to adapt cartographic presentations to the specific requirements of screen displays (Neudeck 2001). A lively discussion about new and special guidelines for map graphics regarding the very restrictive conditions of TeleCartography and mobile internet has brought up various suggestions and proposals (see Reichenbacher 2003, Gartner and Uhlirz 2001). In this discussion the main focus is laid on questions of graphical modelling, visualizations, or generally on questions of usability and application navigation (Meng 2002). First experiences and results have been made e.g. with the prototyping Universal Mobile Telecommunications System (UMTS) application *Local Location Assistant* (*Lol@*) (Gartner & Uhlirz 2001).

Fig 2. Multimedia Content of the *Lol@* Service**.**

Common rules or standards for cartographic presentations on screen displays are not defined yet, due to the permanently changing determining factors. Display size and resolution of state-of-the-art devices are permanently increasing and colour depth is no longer a restricting factor. Parameters of external conditions during the use of the application (weather, daylight) are hard to model. The needs of an interactive system have to be incorporated into the conception of the user interface, which includes soft keys as well as functionalities for various multimedia elements. As a general approach for including the various parameters within a model of map-based LBS the concept of ‘adaptation’ (in terms of user-dependent adaptation of a cartographic communication process) has been brought up (Reichenbacher 2003). The concept is to describe links or mutual dependencies between various parameters and the results are connected to impacts to the data modelling and cartographic visualization. Furthermore, new cartographic presentation forms especially designed for restricted and small screen displays have been developed (see e.g. ‘focus-map’ by Klippel 2003).

For the presentation of geospatial information within LBS and on small displays additional multimedia elements and alternative presentation forms may become potential improvements. Methods of ‘Augmented Reality’ (AR) link cartographic presentation forms (e.g. 3D graphic) to a user’s view of reality, e.g. at applications like navigation systems. Cartographic AR-applications try to create a more intuitive user interface (Reitmayr and Schmalstieg 2003). Kolbe (2003) proposes a combined concept of augmented videos, which realises positioning and information transfer by means of video.

4.2.3 Users and Adaptation

Experiences in LBS developments have led to various suggestions for a more user-adequate system conception. Modelling parameters in the context of the ‘user’ and the ‘usage situation’ are seen as fundaments of more user-adequate attempts, which can be summarized as ‘concepts of adaptation’.

The adaptation of cartographic visualisations in this context can be understood as e.g. the automatic selection of adequate scales, algorithms for adequate symbolization, or even the change to text-only output of information in case of inadequate graphic potentials of an output device. Adaptation to the user is for the time being limited to user profiles, selected in advance from a list or entered manually by the user himself to influence the graphical presentation (size of lettering, used colours) or to provide predefined map elements. Adaptation of the visualisation to the situation is including the actual day time (day/night) or considers the actual velocity of the user (this type of adaptation is realised in some actual versions of navigation software like *TomTom*, which adapts automatically the map scale to the current velocity).

Various forms of adaptation are summarised by Reichenbacher (2003) as ‘context-adapted Geovisualisation’, where definitions of methods and algorithms to derive adequate cartographic presentation forms from influencing parameters for various output devices and different users in different situations are aimed at. This approach is challenging not only technical developments but also the questions of how to identify, define and model the main influencing parameters (e.g. ‘user’, ‘user situation’). First attempts of empirical studies in this context have been made (Radoczky 2003), while experiences of implementations are rare.

4.3 Infrastructure Developments: Towards ubiquitous environments

The development of technologies like telecommunication infrastructures, wireless networks, radio frequency identification or innovative displays like electronic paper can all be seen as parts of developing a ubiquitous environment, where location-based services and ubiquitous cartographic applications can be applied.

4.3.1 National telecommunication infrastructure

In Europe, the first generation of mobile telephones appeared in the mid 1970’s in Scandinavia and was based on analogue techniques. The second generation of mobile handheld devices brought digital transfer technologies as the ‘Global System for Mobile Communications’ (GSM) and made the wireless phones a mass market phenomenon. Today, multiple standards are used in worldwide mobile communications. Different standards serve different applications with different levels of mobility, capability, and service area (paging systems, cordless telephone, wireless local loop, private mobile radio, cellular systems, and mobile satellite systems). Many standards are used only in one country or region, and most are incompatible. GSM is the most successful family of cellular standards, supporting some 250 million of the world’s 450 million cellular subscribers with international roaming in approximately 140 countries and 400 networks.

When ‘Wireless application protocol’ (WAP) started some years ago it was for the first time ever that mobile devices have restricted access to the Internet and content that was prepared especially for the use on mobile clients with small displays. Although it does not allow the provision of graphics other than in a very basic presentation, it has been used for first attempts. With 3rd generation technology UMTS it is possible to give continuous access to most of the internet sites, graphical presentations included.

The new so called ‘3rd Generation’ (3G) of mobile phones features not only an IP-based technology but allows also for the first time so called 'rich calls' transferring several user data streams simultaneously. This is also often referred to as 'multimedia calls'. It was a question of data transfer rates which did not allow other than voice calls up to now. But users and developers of wireless devices always had the idea not only to transmit 'simple' voice calls but also all other forms of digital data. The new technologies as 'Global Packet Radio Switch' (GPRS) and the latest, on air since 2001, 'Universal Mobile Transmission System' (UMTS) seem to make this idea become true for first time in mobile communication. This will be possible only with the transmission rates proposed for the third generation of mobile devices as UMTS will be. The difference in speed between GSM and UMTS can be given by factor 50, in rare cases up to a factor of 200. This is a factor of 6 compared to ISDN and enables video transmission as well as audio files. Because UMTS technology enables the transfer of many different data formats in fast growing transmission rates, the development of complete new and attractive applications is initiated. Still, there are only very few ideas, prototypes and even less running applications trying to take advantage of the UMTS possibilities. But due to telecommunication companies this market will grow up and is currently highly focused in research and development.

4.3.2 Electronic Paper

'Electronic paper', or e-paper, is a technology that allows the text on a piece of paper to be re-written. The 'paper' is actually made of organic electronics that use conductive plastic which contains tiny balls that respond to an electric charge, changing the page in much the same way that pixels change on a computer monitor.

Electronic paper was developed in order to overcome some of the limitations of computer monitors. For example, the backlighting of monitors is hard on the human eye, whereas electronic paper reflects light just like normal paper. It is easier to read at an angle than flat screen monitors. As it is made of plastic, electronic paper has the potential to be flexible. It is light and potentially inexpensive.

Electronic paper was first developed in the 1970s at Xerox's Palo Alto Research Center. The first electronic paper, called 'Gyricon', consisted of tiny, statically charged balls that were black on one side and white on the other. The 'text' of the paper was altered by the presence of an electric field, which turned the balls up or down.

In the 1990s another type of electronic paper used tiny microcapsules filled with electrically charged white particles suspended in a coloured oil. In early versions, the underlying circuitry controls whether the white particles were at the top of the capsule (so it looked white to the viewer) or at the bottom of the capsule (so the viewer saw the colour of the oil). This was essentially a reintroduction of the well-known 'electrophoretic display technology', but the use of microcapsules allowed the display to be used on flexible plastic sheets instead of glass.

There are many approaches to electronic paper, with many companies developing technology in this area. Other technologies being applied to electronic paper include modifications of liquid crystal displays, electrochromic displays, and the electronic equivalent of an Etch-A-Sketch.

It is obvious, that developments like the combination of wireless networks with such electronic paper devices are of high interest for cartography. The potential of displaying any maps via wireless interfaces on electronic paper devices offers especially innovative map use possibilities. It can be expected, that innovative cartographic applications will be triggered.

In summary it can be stated, that various infrastructure and technology developments are taken place currently. These developments include innovations in terms of new in/output devices, interfaces and telecommunication technologies and can be seen of high interest for cartographic communication processes. As an early field of applications in this context navigation systems are under development currently. In the following chapter some selected aspects will be analyzed.

4.4 Navigation Systems as possible applications of LBS

Guiding instructions for pedestrian navigation consist of geospatially related information. The main elements of guiding instructions for supporting pedestrian navigation are usually resulting from a general routing model, where routing functions and, optionally, guiding functions along predefined routes can be executed. The main elements derivable from such routing models include starting point, target point, decision points, distances and route graphs. In order to communicate the resulting elements they have to be combined and translated into 'communicative guiding instructions'. Such a translation has to be seen in the context of the problem of matching a guiding instruction with the reality by the guided person, which is dependent on various influencing parameters, including:

- the user's task/situation;
- the skills of the guided person;
- the 'quality' of the instruction in terms of semantic, geometric, temporarily correctness or usability;

- the ‘potential’ of the communication mode to transmit the information needed by the client; and
- the technical restrictions of output devices.

As a research project of the Vienna Telecommunication Research Centre with the Technical University of Vienna, the development of a prototype of a location-based service for a UMTS environment has been done. The application *Lol@*, a guided tour through Vienna’s 1st district was designed as a service for foreign tourists. The user is guided along a predefined route or due to individual input to some of the most interesting places in Vienna’s city centre, where he can get multimedia (audio and visual) information about the tourist attractions via the Internet portal of the service. The application requires a wireless handheld as input/output device. In order to be able to develop a location based service in a UMTS environment, the project has to deal with four main parts: specifications of technical prerequisites as well as conceptual and method development for localization, positioning and routing, application development and application implementation. The result (cp. Gartner and Uhlirz 2001) is based on the objective to develop a running prototype and therefore lacks usability testing and the testing of additional questions concerning the ‘cartographic’ communication process, including presentation forms, interface, interactivity tools and design issues.

The objectives of further projects have to be seen as closely adding on / taking advantage of the results of the project *Lol@*. This is seen in the context of applying methodology derived from multimedia cartography research on the transmission of guiding instructions. All this is based on the theory, described in Cartwright et al. (1999), that Multimedia cartography offers various methods and forms of communicating geospatially related information with different potential of information transmission and user interactivity (Gartner and Uhlirz 2001). In this context projects are currently carried out at the Department of Cartography and Geo-Media Techniques of TU Vienna, including issues like the:

- Specification of the applicability of various presentation forms. In this context Reichl (2003) has set up an empirical test with different presentation forms of guiding instructions for pedestrian navigation. Different user ‘types’ like tourists, locals or business persons have been tested by using different presentation forms including maps, text-visual, text-acoustic, photos, animations with additionally different variables in terms of usability conditions like day/night etc. The result can be interpreted in a way, that in the context of pedestrian situations the presentation form ‘map’ plays the most important role also when only small displays are available (Reichl 2003, p.75).

- Derivation of route information into guiding instructions in various presentation forms. The output of a routing algorithm consists of metrical and topological information (edges and nodes). This information has to be communicated by using various presentation forms, dependent on user specifications and device restrictions (Klippel 2003). In order to derive semantically acceptable presentations of routing information in various presentation forms, derivation algorithms for various presentation forms (textual, cartographical, acoustic, images) have to be specified. The analysis of the quality and validity of the derived route presentations can be done by comparing metrical and semantic parameters.
- Integration of ubiquitous environments by using active landmarks. The evaluation of integrating landmarks in a multimedia supported cartographic communication process within the context of pedestrian navigation is guided by the hypothesis, that the applying of landmark information on geospatial communication processes is an improvement in terms of the efficiency of information transmission. In the context of pedestrian navigation the appropriate presentation form is dependent on the particular user situations, the user skills and the specification of the user characteristics. It is assumed, that the appropriate form of communicating geospatial guiding instructions will include primarily graphical coding and abstracting, but also other kind of information transmission methods. The special focus on the role of active and/or passive landmarks and their derivation possibilities enables the analysis of more user-centred systems.
- Use of ‘Augmented Reality’ (AR). This can be seen as a form of virtual reality / computer animation, where information is derived into visual displays, e.g. glasses. Whilst in virtual reality applications users ‘move’ through virtual spaces, the user of augmented reality applications move in real spaces. The perception of the reality is additionally overlapped by different layers of information. The main advantage of augmented reality applications in terms of guiding system could be seen in the fact, that all necessary information is displayed in the visual system of the user. The interpretation and comparison of maps with real situations need a lot of ‘mental processing’, including the ‘decoding’ of map objects, the identification of objects in reality and/or maps, the reverse coding of real situation into the ‘abstracted’ graphical representation of the reality. As AR applications need a number of preconditions like precise positioning, precise movement measuring and precise measuring of viewing directions, the availability of ‘running’ systems cannot be expected in the near future.

Fig. 3. Pedestrian Navigation Service TU Vienna – Screenshot (Gartner et al 2003)

4.5 Conclusion

In this chapter the major aspects of conceptualising map-based LBS were discussed: integrative positioning, context-adapted data modelling and multimedia route communication. As a result the pre-requisites for positioning, data modelling and information communication are analyzed. Determining innovations in technologies are described. Findings and results from research projects, accomplished at the University of Technology Vienna, have been presented. Results have been discussed, that lead to further developments and questions concerning the integration of positioning sensors, handing over positions seamless between indoor and outdoor navigation, modelling context-dependent communication forms for route information communication and to enable and to enhance map-based LBS, pedestrian navigation systems in particular.

It can be expected, that further innovations (e.g. e-paper, wireless networks and data transfer standards) will offer additional possibilities to develop new forms of cartographic systems, either for guiding purposes or for collaborative decision support systems or cartographic information systems.

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5 Elements of Multimedia Cartography

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5.1 Introduction

The communication of spatial information in the form of maps is in the midst of a revolution. The origins of this dramatic change can be largely traced to the mid-1980s and the introduction of iconic interfaces on computers that made their use both easier and more widespread. For cartography, this new interface made interaction in the display of maps feasible. Previous to this, computers had been used primarily to help in the process of producing maps on paper. Advances in data storage (CD-ROM / DVD) and the Internet (World Wide Web) during the late 1980's and 1990's contributed to a second wave of cartographic development in the area of multimedia.

It is difficult to overstate the importance of this new medium for cartography. Our conceptions of the world and our actions within it are largely controlled by the depictions that we see. We approach the world with information acquired through models of reality in the form of maps. But, past models have not served us well. Maps on paper could only depict a static and unchanging world and the mental representations that we derived from them limited our interactions with reality. Worst of all, these models could not be used, or used effectively, by most people – leaving a large segment of the population essentially map illiterate.

This chapter examines the meaning of Multimedia Cartography and identifies a set of underlying principles that form the basis of the paradigm. Multimedia Cartography is first viewed in relation to a continuing struggle to represent reality in a meaningful way. Then, the ideas of Kuhn and others are explored that deal with the concept of a paradigm and paradigm shift. Finally, the elements of Multimedia Cartography paradigm are characterised with five basic principles. The overall purpose is to understand the broader meaning of Multimedia Cartography to the development of cartography.

5.2 The Meaning of Multimedia Cartography

5.2.1 Maps, Lies and Abstraction

Multimedia Cartography is based on the compelling notion that combining maps with other media (text, pictures, video, etc.) will lead to more realistic representations of the world. This notion is in contrast to the deeply ingrained idea in cartography that abstraction is the ultimate goal, and that, to some extent; the more abstract the map, the better it works as a functional representation of reality. Indeed, what is the purpose of cartography if it is not to make abstractions of the world that are more useful than looking at reality itself?

Abstraction is a form of lying and artists have long realised that lying through abstraction is art. In *The Decay of Lying*, Oscar Wilde (1913) claims: "The only form of lying that is absolutely beyond reproach is lying for its own sake, and the highest development of this is … Lying in Art." Picasso is quoted to have said that "Art is a lie which makes us realise the truth" and Muehrcke (1978, p. 15) comments that the same can be said of maps. Abstraction in maps is a useful and necessary form of lying.

Artists recognise that different media can be used to create different forms of expression. The differences between static and interactive media has been noted for centuries. Plato, in commenting on a painting, says:

It is the same with written words: they seem to talk to you as though they were intelligent, but if you ask them anything about what they say, from a desire to be instructed, they go on telling you the same thing forever. (Plato's Phaedrus, p. 158)

What Plato is saying is that the quest for truth must be "a joint effort between two minds, the mind of the teacher (or guide) and disciple, whose love for one another is rooted in their common love of truth, beauty, and goodness" (Hackforth 1952, p. 10).

Interactive multimedia may also be seen as a search for "truth, beauty, and goodness." Like a conversation, the interactivity allows lies to be examined, albeit with other lies that may or may not be as insightful as the first. The process is one of discovery as the observer becomes more critical of the information that is presented to them. The same process occurs in a conversation as we "converge" upon a common understanding through a dialog. Plato goes on to say that:

And once a thing is put in writing, the composition, whatever it may be, drifts all over the place, getting into the hands not only of those who understand it, but equally of those who have no business with it, it doesn't know how to address the right people, and not address the wrong. And when it is ill-treated and unfairly abused it always needs its parent to come to its help, being unable to help or defend itself. (Plato's Phaedrus, p. 158)

Plato is referring to the written word, but the same can be said of the printed map. It also cannot adapt itself to the user. In contrast, the "multimedia map" can be constructed in several layers, each addressing the needs of different users. In addition, the multimedia map author, like a parent, can "come to its help," and make the information more understandable and less misleading to an individual user.

5.2.2 Maps and Amusement

Another important aspect of interactive media is enjoyment. People seem to learn things more quickly when the learning process is fun. While "fun" has negative connotations especially in educated circles, 'fun' is essentially an emotion that may be associated with concepts like awareness, excitement, and joy. There is often a physical response, a release and relaxation that accompanies the intense experience of "knowing." Some people experience these sensations when examining a map or an atlas on paper. The feeling can be made more intense and brought to a wider audience through interactive multimedia.

Postman cautions, however, that:

Our politics, religion, news, athletics, education, and commerce have been transformed into congenial adjuncts of show business, largely without protest or even much popular notice. The result is that we are a people on the verge of amusing ourselves to death. (Postman 1986)

Indeed, our lives may be a constant search for amusement. Maps are part of our lives and have a role in amusement as well. They will likely never be as thrilling as a roller coaster ride, but there is a sense of joy when we understand something about the world for the first time – and there is much of the world to learn "for the first time." Multimedia Cartography can contribute to the joy of this discovery.

5.3 The Paradigm of Multimedia Cartography

Multimedia Cartography represents a fundamental change for cartography, analogous to a revolution. In *The Structure of Scientific Revolutions,* Thomas Kuhn (1962) employs the concept of a paradigm to refer to revolutions that inspired such inventions and “unexpected discoveries” as the printing press and electricity.

Scientific revolutions are tradition-shattering complements to the tradition-bound activity of normal science... Major turning points in scientific development are associated with [such] names [as] Copernicus, Newton, Lavoisier, Einstein and Darwin. More clearly than most other episodes in the history of at least the physical sciences, these display what all scientific revolutions are about. Each of them necessitated the community's rejection of one time-honoured scientific theory in favor of another incompatible with it. Each produced a consequent shift in the problems available for scientific scrutiny and in the standards by which the profession determined what should count as a admissible problem or as a legitimate problem-solution. And each transformed the scientific imagination in ways that we will ultimately need to describe as a transformation of the world within which scientific work was done (Kuhn, p. 6).

In Kuhn’s view, no reconciliation of opposing paradigms can be made by some higher authority because each represents both the construct of observation and the higher authority of explanation. The new viewpoint, embodying the paradigm change, wins by gaining the consent of the relevant community. After the paradigm changes, important new lines of work are guided by a new set of generalisations. A paradigm, then, is a widespread, commonly-held set of convictions that takes the form of a firm belief although it’s fundamental elements are not testable in the framework of a hypothesis. While not testable, the tenants of the paradigm are taken to be true by people who would otherwise rely on more rigorous methods to separate fact from fiction. In this sense, the paradigm rests on a “faith” that is similar to that of religion.

Kuhn is describing here a specifically scientific – rather than media-related – paradigmatic shift. However, he goes onto to argue that: “Historians of literature, of music, of the arts, of political development, and of many other human activities have long described their subjects in the same way” (Kuhn, p. 208). Kuhn believes that the process of discovery is not cumulative but cyclical – interrupted and rearranged by new discoveries. “To the extent that this book portrays scientific development as a series of tradition-bound periods punctuated by non-cumulative breaks, its theses are undoubtedly of wide applicability” (Kuhn, p. 209).

Griscom (1996) argues that the concept of a paradigm is germane to changes in communication technology. Marshall McLuhan’s media theory (McLuhan 1967), for example, embraces the Kuhnian notion that human experience will qualitatively evolve under the influence of a new medium. Similar to changes brought by technology, Kuhn’s paradigm shift is a rapid, discontinuous change, in contrast to the traditional view of a slow, step-by-step progression.

The frightening aspect of Kuhn's theory of the paradigm is that, like a revolution, a paradigm shift obviates all prior work. In cartography, this would mean that all work in relation to the print medium – essentially everything we know about maps and their construction – would have to be thrown out. This knowledge would simply not be valid any more. Further, by keeping any of it, we would be corrupting our ability to use the new medium.

Griscom (1996), while embracing the concept of a paradigm shift in communication technology, rejects this basic tenet of Kuhn's theory. "Whereas Kuhn describes the eradication of past scientific methods as "incompatible" with – and therefore negated by – the new one, revolutions in media do not "prove wrong" the value of its predecessor, but reposition it." While digital technology is expanding the potential and perceptual scope of humanity, the message of the print medium is not obsolete or untenable, but re-positioned within a broader understanding of reality.

Whether Multimedia Cartography "proves wrong" the previous methods of representation in cartography should not be a major concern. Certainly, there are advantages to representations of reality that use the more portable medium of paper (at least more portable for now). The important point is that Multimedia Cartography is a search for better ways to represent the spatial reality, and that search is somehow predicated on the notion that existing methods are inadequate. It may also be true that there is little that we have learned from print cartography that can be transferred to Multimedia Cartography. In the following sections, each of the five elements of Multimedia Cartography is examined with respect to the concept of a paradigm and the notion that cartography is within a paradigm shift.

5.4 Elements of the Multimedia Cartography Paradigm

Five basic principles can be identified that form the basis of work in Multimedia Cartography. The first of these principles deals with the general inadequacy of maps on paper to represent and convey the spatial environment, especially its multifaceted and dynamic character. The second concerns problems associated with the distribution of maps on paper, both the expense of their production and dissemination. The third deals with differences in map use among individuals, and the troubling but generally accepted notion in cartography that a large percentage of the population do not use maps on paper or cannot use these maps effectively. The fourth principle concerns the intrinsic value of multimedia and the firmly held belief that adding multimedia elements to maps leads to improved information and knowledge transfer. The fifth concerns a general, moral obligation that cartographers have to communicate spatial information in an effective manner to as large an audience as possible. Together, these principles guide and motivate the efforts in Multimedia Cartography.

5.5.1 Inadequacy of the Paper Medium

Paper has two major advantages for cartography over the computer: 1) it is easier to carry, and 2) the medium can support a higher spatial resolution (i.e., display more dots per unit area). In addition, paper may have a greater longevity than electronic media – although both would be less than clay tables on which the first known maps were discovered. Implicit with Multimedia Cartography, however, is the notion that maps on paper cannot adequately represent or communicate the spatial environment. In other words, while paper offers major advantages to cartography, it cannot compete with interactive media in addressing the essence of cartography – the representation and communication of the spatial world.

5.5.2 Problems Associated with Distributing Maps on Paper

Putting maps in front of people is the most important aspect of their use. It wasn't until a little over 500 years ago that humans discovered a way to accurately and quickly duplicate maps. As late as the mid-1400's, all maps were still painstakingly reproduced by hand, so there were very few maps in existence. Beginning in the latter part of the Renaissance, maps began to be printed in Europe. The development of printing meant that maps could be easily reproduced while being faithful to the original. It also meant that more people had the opportunity to see and use maps.

The impact of printing on mapping has a good analogy in the present transition to the distribution of maps through computer networks. Like the printing of maps, computer networks have increased the distribution of maps. Printing made it possible to produce thousands of identical maps in a short amount of time. The Internet has made it possible to simultaneously "print" and distribute thousands of maps every second.

In addition, maps on computer networks are delivered in a fraction of the time required to distribute maps on paper. A single network request for a map supersedes the former time-consuming map printing and distribution processes. A process that is analogous to the printing and shipping of maps is done on the Internet in a matter of seconds. Like printing, the Internet, and specifically the World Wide Web, redefines how maps are made and used. They tend to be interactive – often allowing the user to change the perspective, the projection, or the level of detail. They tend also to be more up-to-date. Weather maps, for example, are posted on a hourly basis. Finally, maps are used differently than before. They are accessed through a hyperlinking structure that makes it possible to engage the map user on a higher-level than what is possible with a map on paper (Peterson 1997).

5.5.3 Problems in Map Use

One of the major problems associated with maps is that of map use. Many people have difficulty using maps even within highly educated populations. It has been estimated that more than half of the educated population do not have a basic competency with maps. The reasons for this are not well understood. Some see the problem related to a lack of education specific to map use while others say it is the maps themselves and, more specifically, the medium of paper that is used for their display. But, the result of the map use problem is clear: A large segment of the population have poorly formed mental representations of their local environment and especially the space beyond their direct experience.

A solution to this problem may be interactive multimedia. No longer restricted to the single view offered by maps on paper, the map user is encouraged to explore alternative methods of representation – different views that help shape the user's perspective of the world. The "views" that are presented to people go beyond those offered by the maps in atlases. The maps are more current and targeted to specific users. They can also be more interactive and incorporate animation. The exposure to interactive maps may also lead to better map use skills and both improve and increase the use of maps on paper.

5.5.4 The Intrinsic Value of Multimedia

The fourth principle of Multimedia Cartography that is identified here concerns the intrinsic value of multimedia and the firmly-held belief multimedia leads to improved information and knowledge transfer. Hoogeveen (1997, p. 151) argues that "a strong paradigmatic belief can be noted in the benevolent effects of multimedia for a wide variety of application domains." In many studies the improved learning effectiveness of multimedia in comparison to non-multimedia courses is presumed (Conklin, 1987; Morariu, 1988; Hooper Woolsey, 1991; Marmolin, 1991). Hoogeveen goes on to argue that the true experimental foundation of such assumptions and beliefs is incomplete and often weak (Janda, 1992), and a coherent theoretic basis explaining why multimedia is supposed to work, taking into account the experimental findings, has not yet been established.

A number of studies have been cited to demonstrate that multimedia is not an effective means in improving information and knowledge transfer. For example, Nielsen (1990) reviews a comparative study of Wilkinson and Robinshaw regarding error frequencies of subjects in two test conditions: proof-reading from screen and proof-reading from paper. In the first ten minutes of the experiment, subjects had about the same error rates in the two conditions (25% vs. 22%), but after proof-reading for 50 minutes, the subjects using computer screens did significantly worse with an error rate of 39% vs. 25% for paper. Nielsen concluded from this experiment that users become tired fairly quickly when reading from the current generation of computer screens. According to Nielsen, it is only possible to achieve the same reading speed when the computer screen is high-resolution and uses anti-aliased proportional fonts. It may also be concluded that text needs to be augmented with multimedia elements to achieve the same information and knowledge transfer.

Another example of decreased information and knowledge transfer concerning multimedia involves synthetic speech. It is widely recognised that synthetic speech has a relatively bad quality compared to natural speech and researchers have found that synthetic speech hinders verbal learning (Hapeshi & Jones, 1992). A further argument against interactive multimedia is that of Price (1995) who found that students were more *satisfied* with the passive medium of video than with interactive electronic distance education. However, the quality of the information transfer was not tested.

There are also numerous studies that suggest that multimedia improves information and knowledge transfer. Hapeshi & Jones (1992) note that the presence of moving images can serve to enhance comprehension and learning of spoken material. Marmie & Healy (1995) showed that interactivity improved retention. Fendrich et al. (1995) found the same effects for recognition memory. The importance of congruence, the degree to which different media are used redundantly to express the same ideas, has been demonstrated in several experiments. Marmolin (1991) points to the congruent effect of colour and sound. Bradley & Henderson (1995) report the perceived benefits of a voice-over. Hayes, Kelly & Mandell (1986) found that recall of a visual and auditory presentation was more accurate than only an auditory presentation.

If we follow the arguments of Gibson (1966, 1979), the acquisition of information is an active process. According to Gibson, we do not hear, we listen; we do not see, we look around (Peterson, 1994). Based on this argument, more active environments will lead to better learning environments. Users should be able to explore natural multimedia information in an active way. Marmolin (1991) notes that neither the author of the information or its designer should decide how the information should be processed. Rather, the user should be in control.

5.5.5 The Moral Obligation of Cartographic Communication

Underlying a great deal of research in cartography, especially in recent years, is the idea that we should attempt to improve maps as a form of visualisation for expert map users. Implicit in this argument is that most people don't need maps because they don't perform any kind of spatial analysis. Cartographic research, it is argued, should therefore be oriented toward those few that can actually benefit from this work.

This view, although widely held, is simply inexcusable. Maps help us to understand the world and can provide information to make important decisions. This function of maps is especially important in a democracy where all should participate in the variety of democratic processes. It should also be noted that this "maps for the few" attitude is furthered by Geographic Information Systems that can only be operated by a few, trained individuals. If such systems exist that are only meant for the few then it is naturally easier to put maps in this context as well.

Of course, there are now many efforts outside of cartography to get "maps out," so to speak. Systems for Public Participation GIS are ways to bring interactive map use to a larger audience. Multimedia Cartography has a major role to play in this overall effort.

5.5 Conclusion

Cartography is in the process of change. Like all technological developments, the computer makes our work both easier and more difficult – and multimedia cartography is not *easy*. How must cartography react to these changes? We have to begin using new definitions in cartography. The word "map," for example, should perhaps be redefined to refer to an interactive map display. If the presentation of the information is not controlled by the user - it's not a map. If there is no interaction - it's not a map. If there is no potential for animation - it's not a map. We may eventually realise that what we call maps today are simply static map elements - as much a piece of the puzzle as a single symbol on a map.

It is an exciting time for cartography. We have in Multimedia a new medium. A medium that can lead to a new relationship between maps and people, and ultimately people and the world. But, we have a lot of work ahead of us to make the new medium *work* for cartography.

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6 Designing Suitable Cartographic Multimedia Presentations

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6.1 Introduction

For cartography the predominant medium to present spatial information has been the map. Cartographers have developed suitable methods and theories for map construction and map use. New developments like multimedia presentations or mobile mapping, however, go far beyond a single map. They are highly interactive systems where cartographers and map users can envision geographic information using different media, like sound, video or animation, according to their particular purpose and interest. Multimedia cartography, therefore, requires methods and theoretical principles which concern not only the map but also other media.

The recent developments of multimedia techniques offer a wide range of hard- and software equipment that enables cartographers and map users to create and use cartographic multimedia presentations. To apply the powerful technique in a suitable way it is necessary to choose and combine media which best support the purpose of a multimedia presentation. This chapter focuses on two topics which are fundamental for suitable media application and combination: the function of media and the medium as an artefact. The question addressed is: to what purpose should a particular medium be put and what medium best suits this purpose?

6.2 Media functions and media as artefact

The importance of map functions was emphasised by Papay (1973), Ogrissek (1987) and Freitag (1993) because functions determine both the content and design of a map. In cartographic multimedia presentations attention also needs to be given to the functions that a particular medium has to fulfil, because the function controls the choice of media and how it should be combined with other media.

Functions of media in a cartographic multimedia presentation can be considered from different points of view:

- the function a medium has to fulfil in the perception of information;
- the function a medium has to fulfil in knowledge generation; and
- the function a medium has to fulfil according to the purpose of communication.

The suitability of media to present particular information, for example animations to show processes or diagrams to show relations between values, will not be discussed here as it is widely covered in literature (Schröder 1985; Schnotz 1994; Borchert 1996; Dransch 1997).

A further aspect which determines the choice of media as well as media combination is the task that supported by a multimedia presentation. Media have to be regarded as artefacts which are used to reach a specific goal. For that reason the task and its related activities are of great importance, too, when designing multimedia presentations.

6.3 Functions of media in information perception

A common opinion in the field of multimedia application is that as more media are applied and thus more senses involved, a better presentation results and thus aids the perception of information. This adoption is based on a paper by Dale (1946) where he points out the intensity of information processing according to different forms of information acquisition. A typical breaking up might be hearing causes 20%, seeing 30 %, and hearing and seeing 50% contributing to information acquisition. This ‘summation theory’ was criticised by other researchers (Dwyer 1978; Weidenmann 1995a) and it cannot be naively translated directly to multimedia as acoustic information presentation effects 20%, pictorial information presentation effects 30%, acoustic and pictorial information presentation effects 50% of information acquisition. Multimedia presentations often overwhelm the user as they are constructed according to summation theory and not according to conclusions from perception and cognitive research.

Human perception and cognition are restricted by several constraints (Paivio 1969; Neisser 1974; Kosslyn 1980). In the context of multimedia, particular attention must be given to limited capacity of short-term memory and the overabundance of single senses. Human short-term memory has the ability to retain only a few information units (four to seven units) simultaneously. In the case of information overload short-term memory information process is insufficient. It has been shown that information processing can be improved if information is repeated or elaborated upon and if perception is directed. Information should also be divided into separate visual and acoustic media to relieve single senses.

Considering this perception view, media may have the following functions in cartographic multimedia presentations:

Function of avoiding an overload of information

Media that have to serve this function must prevent information overload. Information overload can occur especially with dynamic media like cartographic animation and video. Text used as an additional medium can avoid the overabundance of dynamic media because it can name presented information and prepare a user for that information (Lurija 1992). The text should be directed to a second sense organ and be presented in an acoustic form to relieve the visual senses from perceptual overload.

Function of increasing important information

Media which have to emphasise important information must repeat and elaborate a particular piece of information. In cartographic multimedia presentations different media like maps, pictures, text and sound can be combined to show various aspects of a spatial object or phenomenon and, in that way, they can increase and accentuate information.

Function of directing perception

Media that have to fulfil this function must direct perception. They have to guide the users' interest and direct their attention to significant information. Written or spoken text like ”compare”, ”take note of” or ”look at first” may help to exploit maps, pictures or cartographic animations.

6.4 Functions of media in knowledge generation

6.4.1 Cognitive approach

According to constructivist theory, knowledge is not objective and cannot be transmitted from one person to another. Knowledge is something very individual which is generated in a personal cognitive process and depends highly on a person's pre-knowledge and on the form and context of its presentation. Pre-knowledge acts as a filter which directs perception as well as enabling the interpretation of new information (Neisser 1974; Antes and Mann 1984; MacEachren 1991). The more pre-knowledge that exists the more new information is activated, and thus more filters can be brought into use, leading to a more comprehensive knowledge processing activity. Presentation form and context also affect the structure of knowledge (Howard 1983). Different presentations give different insights into a phenomenon. They guide the creation of various schemata or mental models, and in this way they support the generation of multifarious knowledge structures.

Cartographic multimedia presentations should offer a generous palette of various media plus flexible media combinations to support the user. This must be characterised by the users' personal pre-knowledge and competence in comprehensive knowledge generation. This is especially true for cartographic multimedia presentations provided via the Internet because they often lack a defined user group. Media may have the following functions in this context:

Function of activating pre-knowledge

Media that have to activate pre-knowledge must present familiar information. They have to support the organisation of new knowledge in such a way that they offer points of contact from existing knowledge to new information. In cartography maps of strange areas are often combined with maps of familiar regions to allow users comparing the new with the familiar. Another example is sound of a particular time period or spatial area that can associate known and unknown information. Not only maps and sound but all media can fulfil this function.

Function of multiple presentations

Media which have to support multiple presentations must show information in various forms to offer the user different decoding schemata. They should display information in several abstraction levels, in different graphical presentations or in acoustic and visual form. All media are able to contribute to this function.

6.4.2 Approach of Erkenntnis theory

A further contemplation to knowledge creation comes from Erkenntnis theory (Keller 1990). This theory is based on the concept that knowledge creation occurs in a hierarchical sequence in different steps of appreciation: *experience*, the direct observation or action in the real world; *abstraction*, the generalisation of information obtained through experience; and *knowledge transfer to the real world*, the setting of knowledge obtained through abstraction in relation to the real world, for example for prediction or planning.

The concept of Erkenntnis theory was transferred to cartography and related to map construction (in the sense of map modelling) and map use by Sališcev (1975), Berlijant (1979), and Ogrissek (1987). According to this approach maps are differentiated according to their different levels of knowledge generation. First level maps show information obtained by direct observation, second level maps show transformed information and third level maps give recommendations for acting in the real world. This diversification can be also transferred to other media. Pictures or natural sound for example are first level media, maps or animations are second level media and a simulation is a third level medium. According to their levels of knowledge generation, media can support the different steps of appreciation - experience, abstraction and knowledge transfer to the real world.

In the field of computer visualization the idea exists that the more realistic a presentation is, the more helpful it is in information presentation. Therefore much research work has been undertaken to develop methods and techniques for creating more realistic presentations. Realistic presentations, however, are, according to Erkenntnis theory, suitable only for certain levels of knowledge generation. Other levels require a higher level of abstraction. In a cartographic multimedia presentation we have to decide which levels of knowledge generation are for support and which media are suitable to be included to show the information. In this context media may have following functions:

Function of supporting direct observation

Media for direct observation have to act as a substitute for the real world. They have to give a vivid impression of a spatial object or phenomenon. 2D-pictures, 3D-hologramms, video, animation in the form of realistic simulation or virtual realities and natural sound can be applied for that function.

Function of supporting abstraction

Media that have to support abstraction must present information in a processed and transformed way. They must be able to convey general concepts that go beyond individual situations. Maps, abstract animations, diagrams, and formal sound used for data exploration are suitable media in this context.

Function of supporting knowledge transfer to the real world

Media that have to support knowledge transfer to the real world should be able to show the effect of human interaction on the environment. They must be able to integrate existing and conceived objects. Suitable media are maps for prediction, virtual realities for decision making in planning and visual and acoustic simulations. An example of this is the simulation of the noise of planned objects like roads or airports.

6.4.3 Didactic approach

A third aspect in knowledge generation comes from didactic research. Didactic science investigates the processes of teaching and learning. A subdivision in didactic science is the didactic of media that focuses on media applications in the teaching and learning process. Issues of research here are the role of media in instruction and the functions of media in the learning process (Schulmeister 2001, Issing and Klimsa 2002).

Cartographic communication (as a dialogue or a monologue) can be regarded as a learning process in which spatial knowledge is created. Therefore principles of media application developed in the didactic can be transferred to cartographic communication and cartographic multimedia presentations.

Didactic science mentions different functions of media in the learning process (Strittmatter and Mauel 1995; Weidenmann 1995b). Some of these functions are significant for cartographic communication and will be elaborated here. They are the informing functions of demonstration, setting in context and construction, and the directing function of motivation.

Function of demonstration

Media for demonstration should help a user to get a suitable ‘picture’ of a phenomenon. For this task pictures, videos, realistic graphic representations and animations as well as virtual realities are suitable. Audio can give a vivid impression about noise and its spatial distribution. Media for demonstration are particularly useful and necessary for people without great knowledge about the topic being presented. (This function correlates closely with the function of supporting immediate observation in Erkenntnis theory).

Function of setting in context

Media that have this function should help a user to set information into a greater context. All media that can give a spatial overview or a thematic integration are suitable for this function. Examples are the traditional overview maps that present a wide spatial area, video that shows the neighbourhood of a spatial object or object group, or sound used to present the typical sound of a particular area or time period.

Function of construction

Media with the function of construction should help the user to create complex mental models. Mental models are constructions of pictorial and propositional knowledge about information units and their relationships. Media for this purpose have to inform about concepts, elements and their relationships. The creation of mental models is highly influenced by applied media. Pictures or realistic presentations are not suitable in this context. On the contrary, this function requires abstract media that show prepared information like text, maps, diagrams, graphs, abstract animations or formal sound. Media for this purpose have to initially give an overview of the complete information structure and subsequently they have to inform about detail.

Function of motivation

Media with motivational function should arouse the user’s interest and attention. Knowledge acquisition depends highly on a user’s motivation. Motivation can be produced by attraction and by moving and changing media. Therefore attractive pictures, dynamic media like animation and video and sound are best suited for this purpose.

6.5 Functions of media according to the purpose of communication

Functions of media (especially of maps) related to the purpose of communication are a particular point of interest in cartography (Board 1967; Papay 1973; Freitag 1993). The function of a map determines its efficiency in a distinct application and it affects its content, its design and its scale. According to Papay (1973) the primary determinant of a map’s function are the users' requirements and interest, their knowledge about the presented subject and their experience in map reading. Later, Freitag (1993) distinguished several functions of maps. In multimedia cartography these functions have to be considered in the context of all available media. The functions are:

Cognitive function

"This function encompasses all processes and operations which generate and enhance spatial knowledge. All processes of ... map analysis, ... transformations, generalisations, animations, etc. should be listed here, if possible in a sequence of operations leading from near reality models to very abstract models of space" (Freitag 1993, p. 4). All media may support this function. Pictures, video, realistic animations like virtual realities or simulations, and natural sound can give a realistic impression of a spatial phenomenon. Maps, abstract animations, and artificial sound are able to present abstract models. The application and combination of different media depends on the users' competence. The higher the competence, the more abstract media can be.

Communication function

"The communication function (including demonstration function) encompasses all processes and operations of spatial knowledge transfer from a map maker to a map user" (Freitag 1993, p. 4). This function can also be performed by all media mentioned in the context of cognitive function. The application of media for communication has to be directed by the users' competence and by the different levels of appreciation distinguished in Erkenntnis theory.

Decision support function

"Decision support function encompasses all processes and operations which -based on evaluation of spatial phenomenon – result in spatial decisions and spatial actions." (Freitag 1993, p.4). Sub functions are navigation, spatial planning and persuasion.

Navigation

Navigation requires media that direct a users' way finding. Route maps or text for example as spoken instruction in a travel pilot may suit this function. Animations in the form of virtual realities and fly- or walkthroughs in combination with landmarks or an overview map might be another possibility. The efficiency of these animated presentations has not investigated comprehensively thus far. Spatial planning demands media that can present existing and conceived objects. Maps, animations, visual and acoustic simulations and virtual realities are suitable media for this function. Persuasion requires media to present information according to a particular interest on one hand or that touch emotions on the other. Suitable media are maps, pictures, video, animation and sound.

Social function

"Social function encompasses all processes and operations which result not in spatial but in social behaviour and actions" (Freitag 1993, p. 4). Examples are media as cultural or prestigious objects as well as media as tools with social power exercised through the access or denial of access of spatial information. The social function can be performed by all media.

6.6 Media as artefacts

Beside this more cognitive and communication oriented functions of media a further aspect has to be considered when choosing media and media combination in multimedia presentations. It is the task which has to be fulfilled, and the goal that has to be reached. A multimedia presentation is not just an information product it is also an artefact that has to support a person to achieve a certain task (Dransch 2001, 2002). Therefore, a cartographic multimedia presentation also has to be designed according to the requirements of the task. Presently, tasks have become more important in cartography. Recent developments in mobile and ubiquitous computing focus on the context in which a cartographic representation is used; beside location the task is a major component of context. A good basis for this task-oriented approach is Activity Theory which offers a suitable framework to model and characterise tasks (Nardi 1996).

A task can be described by different components:

- a goal which has to be reached;
- a sequence of activities (or actions) that has to be performed to achieve the goal;
- an actor in a certain role; and
- rules that have to be considered during the activity.

For cartographic multimedia presentation all these components are of importance. If cartographic presentations are regarded as artefacts it is necessary to know the activities they should support. In a cartographic context two types of activities exist: activities related to the real world, e.g. navigation, and activities related to the cartographic presentation, e.g. detecting location A and B, and finding the best route between them on a map. Both are connected and must be regarded for choosing useful media. A good overview of real world and map activities is given in Heidmann (1999) and Reichenbacher (2004).

The actor and his/her role also influence multimedia design. The map users and their characteristics like age, culture, interest and knowledge have to be considered as well as aspects of perception and cognition. From the perspective of tasks and artefacts a further point is of interest when describing the user or in this case the actor. Activity theory postulates: “You are what you do”. According to this, the activity strongly affects the user/actor and characterises him or her. Bearing this in mind, cartographic multimedia presentations should be designed not only for the information processing user but also for *active users* e.g. “children undertaking learning or ‘spatial data explorers’ or ‘spatial navigators’.

Finally, a task-oriented approach has to deal with the rules that are in operation with a certain task. It has to be proven, if the rules can be shown in the multimedia presentation. For example when planning a gas pipeline the acting person has to conform to different rules, e.g. keeping a minimum distance to another pipeline. The minimum distance could be visualized to support the acting person.

A task and its related activities can be seen as the superior criterion when designing a suitable cartographic multimedia presentation. The activity determines which processes are to support and therefore, which media should be selected and combined. Figure 1 depicts this relationship and gives an overview about the different map functions.

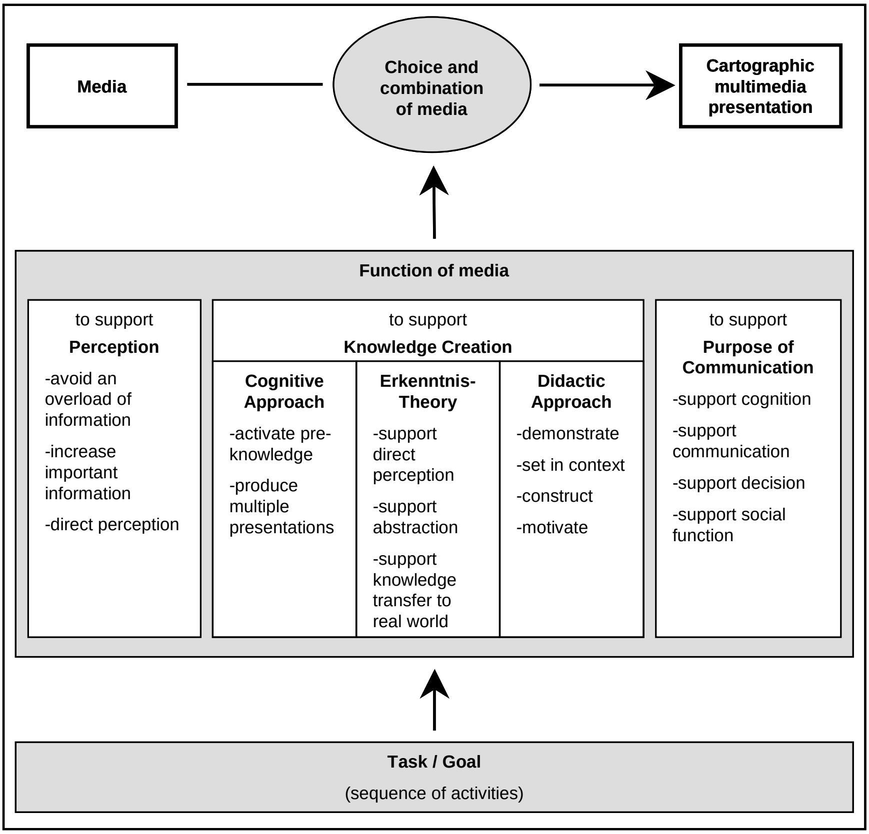

Fig. 1. Task and media function as influencing factors for cartographic multimedia presentations

6.7 Conclusion

The literature of multimedia points out repeatedly that not only the technical dimension of multimedia but also its application dimension needs to be considered. Only the application context accomplishes multimedia *techniques* to real multimedia *systems*. Klimsa (1995) mentions that not any arbitrary combination of media can be labelled as a multimedia system; only the combination of multimedia techniques, application context, and functionality can define actual multimedia systems.

This chapter's discussion of the functions of media and the artefact perspective in cartographic multimedia presentations has been undertaken to contribute to the strengthening of the application dimension of cartographic multimedia presentations. The media functions provided and the task-oriented aspects outlined should help in selecting and combining media in such a way that cartographic multimedia presentations are regarded as more than just a summation of individual media. This approach can contribute a useful application of multimedia to cartography. This is essential if multimedia is used as more than just entertainment and it supports the presentation and exploration of spatial data.

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7 Design of Multimedia Mapping Products

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7.1 Introduction

Design is a complex process. The design of a conventional map-based product involves the cartographic abstraction (Muehrcke 1978) processes of dimensional transformation (scaling and projection), selection and generalisation and various graphic and structural design processes including symbolisation, visual composition, figure-ground and hierarchical organisation and content arrangement (Bertin 1967; Dent 1993; Keates 1973; MacEachren 1995; Robinson *et al.* 1995; Wood 1968). Conventionally, this process also involves a number of compromises due to design constraints such as map scale, presentation format, area coverage and the degree of geographical complexity required in a map-based product. This complex process is made more complex in a multimedia environment by the addition of a greater number of design constraints, a greater and more varied quantity of media with which to work, and the incorporation of tools to enable users to interact directly with maps and map-based information. This chapter aims to simplify this complex process by discussing an approach to designing multimedia map-based products.

The approach to designing multimedia map-based products discussed in this chapter is equally applicable to both discrete (e.g., CD-ROM) and distributed (e.g., WWW) mediums of presentation. At the same time it should be recognised that given the current technological limitations associated with presenting and providing access to content via the WWW (i.e., limited bandwidth and modem speed), much of the design approach discussed in this chapter is far more easily achieved when using discrete media for distribution.

This chapter focuses on the design of discrete multimedia map-based products that communicate spatial, thematic and temporal information about the geographical environment by exploiting maps as the primary, yet not exclusive, source of information. The concept of the map has been extended in more recent years and is approaching a stage of re-evolvement with technologies such as virtual reality and research into visualisation promising new ways of representing information. Despite this, currently the map, as conventionally defined, remains the primary tool for the presentation of spatially definable content, particularly from a publication perspective. It is recognised that this focus on maps as they are more conventionally defined, as graphical representations, and on multimedia map design as an extension of existing map design techniques, is perhaps an interim approach.

7.1.1 Concepts of Map-Based Access

Map-based access enables users to access multimedia content relative to spatial locations via map symbols that have been defined as 'hotspots'. It is important to make a distinction between two types of map-based access:

1. Map-based access in which maps are used as 'Content Organisers'. As content organisers, maps visually organise content using a spatial metaphor. Multimedia content is not designed to aid in the decoding and interpretation of maps, rather, maps are used to arrange content in an easily accessible manner. This type of map-based access is intuitive for information systems for such applications as tourism (Mogorovich *et al*. 1992; Panagopoulou *et al*. 1994; Schewe 1993). Map-based access has also been used to organise content that is not conventionally spatial in nature (Hodges and Sasnett 1993). In fact, as a content organiser, map-based access has emerged as a relatively common means of access in multimedia products and web-based sites.
2. Map-based access in which multimedia content is intended to support and enhance map decoding and interpretation. This type of map-based access is less common but it is anticipated that this will change. This is particularly so given the interest of cartographic researchers in finding new ways to use animation, digital and multimedia techniques to increase the ease with which users use maps.

7.1.2 Presentation and Structure Characteristics of the Multimedia Environment

Multimedia products and print-based products use distinctly different information presentation and information structure techniques given the characteristics of each environment of use. Multimedia mapping products are dynamic, interactive, associatively accessed, modifiable and functional products that use a synthesis of audio and visual media for cartographic representation. Product design must take into account the requirement to seamlessly integrate multiple media and to enable direct user interaction with information. Product design must also incorporate the use of dynamic and responsive environments of display and increased functionality enabling analytical and manipulation capabilities. Information structure in a multimedia environment is influenced by the limitations imposed by a computer screen display environment. Restrictions in screen display size and resolution require that manageable chunks of information are used. Since random and associative access are possible, consideration must be given to the manner in which content is arranged in organisational structures, and the way in which access mechanisms are provided. In addition, meaningful relationships between content must be constructed based on information, rather than media, content. This chapter discusses a design approach in accordance with these new information presentation and structure requirements.

7.1.2.1 The Hypermedia Paradigm

The ‘hypermedia paradigm’ (Maurer and Tomek 1990) refers to the application of the principles of hypermedia to computer applications or product construction. The concept of hypermedia is generally used to refer to the associative linking of chunks of information in large, active, networked systems such as the WWW (Maurer 1993; Parsaye *et al*. 1989). However, its underlying principles are also appropriate for the structure of information in multimedia products that do not necessarily represent large, active databases, and do not always enable entirely flexible access to content (Apple Inc. 1994; Parsaye *et al.*1989). Such products use the ‘hypermedia paradigm’ rather than the fully-fledged definition of hypermedia.

Hypermedia is an important concept in terms of the structuring of multimedia information. In a hypermedia environment, information is structured as a series of nodes (modules of information) that are connected according to active contextual relationships (associative links). These modules are usually, but not exclusively, complete pieces of information that can be viewed independently of other information (Ambron and Hooper 1988; Jonassen 1989; Shneiderman and Kearsley 1989). Landow (1991) contends that the very existence of links in hypermedia products and systems conditions the user to expect purposeful relationships between connected information. Based on this contention, the spatial environment of access created by using a map as an interface component, conditions the user to expect a purposeful relationship between the map point of access and the information displayed. As such, the hypermedia paradigm is integral to the concept of map-based access.

7.2 Components and Design of Multimedia Map-Based Products

This section provides a brief overview of the main components of multimedia map-based products that are structured according to the hypermedia paradigm. In this chapter, the term 'object' is used to refer to a node in the hypermedia environment of a multimedia map-based product. More correctly, and as part of wider research undertaken by the author of this chapter, the term refers to a node in an object-oriented product construction environment (Miller 1996). The multimedia map-based product is comprised of three primary components:

1. the Graphical User Interface (GUI);
2. a content-set; and
3. object links.

Although each of these components is briefly defined, the focus of this chapter will be on the GUI.

7.2.1 The Multimedia Map-Based Product GUI

The success of a multimedia product is determined primarily by its Graphical User Interface (GUI) (Apple Comp. Inc. 1994). Although content, the contexts within which content is used and the associations between content are also determining factors (Blum 1995), it is the GUI that enables product functionality, navigation and the visual display of content to be realised. The GUI is particularly important in multimedia map-based products given the use of map-based access and the fact that in many instances multimedia content and functionality is intended to support the map content. The multimedia map-based product GUI is comprised of two components: the map object (a responsive display construct that is the primary means of product control and provides direct spatial access to product content); and marginalia objects (referring to those objects that exist outside the bounds of the map object that incorporate display, access, navigation and interaction tools).

Every graphic presentation employs visual hierarchies that aim to guide the viewer's eye across the display in a manner fitting to the content (McCleary 1981). The multimedia map-based product GUI requires a clear visual hierarchy in order to separate its component parts, both visually and conceptually. This can be achieved via the use of structured display viewers, a window or an area of the screen display that is distinct from all other areas (Blum 1995) and/or the use of graphic design variables such as colour. In fact, colour is becoming a ‘pseudo-standard’ for creating distinction between different components and content of multimedia and web-based products (Sather *et al*. 1997).

7.2.1.1 The Map as a Display and Product Control Construct

The map object is the key component of the multimedia map-based product and functions as both a product control and display construct. The map object is a composite object composed of a conceptual framework (‘map object model’) and a number of visual representations of this framework (‘map object displays’). Each map object is defined according to a distinct spatial coverage with its component 'map object model' storing a number of combinations of attribute values according to theme, timeframe and scale. Each combination of attribute values is associated with a ‘map object display.’ In order to construct a multimedia map-based product, each component map object display must represent an individual map (pre-created, dynamically generated or a combination of the two) whose design has been optimised according to a specific theme, timeframe and scale.

In the multimedia map-based product, every object has a relationship with the map object and the map object controls how each object is displayed and behaves. It acts as the product control construct, determining object behaviour in response to user interaction and controlling the relationships between objects in the product. As a visual display construct, the map object uses a ‘symbol-oriented’ structure (see Sect. 7.2.1.2) and a hierarchical arrangement of content to emphasise spatial locations, distributions and relationships. The symbol-oriented structure of the map object enables controlled access to multimedia content to enable the decoding and interpretation of the map object. All access is controlled by the map object relative to a specific spatial context governed by the spatial attributes of individual symbol objects and map object theme and timeframe. The map object and its associated components are displayed in Fig. 7.1.

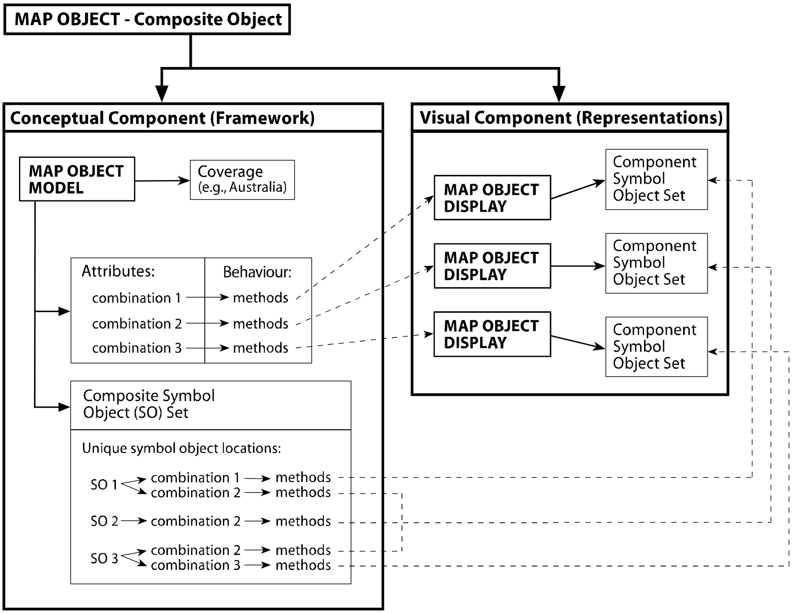

Fig. 1. The Map Object: The relationship between the 'map object model' and the component 'map object displays'.

'Scale-Sets'. Multimedia map-based products are publication quality products whose map content is optimised for display at a specific scale. Generalisation, symbolisation and other design components are specific to a certain scale in both conventional and multimedia map-based products. To avoid destroying map design components, it is not sufficient to merely enlarge or reduce a single map object display in a multimedia product. In order to ensure the map object is optimised for display at all the scales at which it may be displayed, it is necessary to create 'scale-sets' with each map in the scale-set optimised for viewing within a specific 'scale-range'. A 'scale-range' refers to the range of scales at which a map can be optimally displayed (Arnberg 1993).

Coverage Maps. Map object view and map object coverage are distinctly different in a multimedia map-based product. Kuhn (1991) defines view as the visual field that contains what a user sees at a specific point in time. Therefore, map object view refers to the portion of the map object coverage displayed at a point in time. In comparison, the map object coverage refers to the extent of the spatial information contained in the map object. In most instances this will exceed the available map object view area due to the current limitations associated with the environment of display (VDU display and resolution) (Wood 1993).

The synoptic effect is inherent to all conventional map-based products where maps can be viewed in their entirety and compared directly with other maps. The multimedia map-based product can not maintain this synoptic overview in the map object without increasing levels of generalisation in order to maintain legibility, which in many instances renders the map object content largely unusable. The lack of synopticity can be minimised by the use of a coverage map and a flexible map object viewer. To enable the user to locate the map object view with respect to the map object coverage, it is necessary to employ the use of a map that acts as a positional indicator. This is referred to as the coverage map. In addition, in order to provide a flexible map object viewer it must be possible to display multiple views of the map object coverage to enable regional and thematic comparisons.

7.2.1.2 Symbol Objects

Associated with each map object is a composite symbol object set. Each symbol object in this set has a unique location, and a number of associated structures and behaviours depending upon the map object attribute values of theme, timeframe and scale. Each map object display is also comprised of a set of symbols referred to as the component symbol object set, however, these are only visual in nature. The behaviour of each symbol in the map object display is controlled by its corresponding symbol in the composite symbol object set according to the attribute values of the map object. As such, each unique symbol object location has associated with it a number of different visual representations and behaviours according to theme, timeframe and scale (see Fig. 1).

Symbol objects in a map object display are of two types:

1. First Order Symbols – symbol objects that have a direct relevance to the map object theme. Symbols of this type have multimedia content associated with them that is intended to aid in decoding and/or interpretation. Controlled access is provided to this content via the map object. First order symbol objects represent the most visually and intellectually dominant symbol objects.
2. Second Order Symbols – symbol objects that contribute to the overall spatial structure of the map object. They provide the spatial framework necessary for the decoding and/or interpretation of the first order symbology. Whilst second order symbols are defined as objects

and may be responsive to user interaction, they do not have any associated content to which they provide access.

When integrated, first and second order symbol objects create spatial structure via visual hierarchies in the same way as the conventional map.

The visual role of symbology in a multimedia map-based product corresponds to that of the conventional map, however, while symbology in a conventional map is static and a means of display only, in a multimedia product symbology has extended functionality. Each symbol object is responsive to user interaction. In addition, each first order symbol object has associated multimedia content, that may or may not be intended to enhance map object decoding and interpretation. The associated multimedia content is arranged according to an organisational structure (see 7.2.3) based on the map object attributes of theme and timeframe and the specific symbol object location within a coverage. Each first order symbol object represents the parent node in an associative network to which other nodes are cross-referenced.

Each 'map object model' and its associated symbol object set is defined by the attribute of coverage, however, it is the attributes of theme, timeframe and scale that determine the specific visual structure and behaviour of symbol objects that are visible to a user. Each symbol object has an associated state and behaviour. Two mechanisms are used to enable symbol objects to function in the map object:

1. Display Mechanisms – these mechanisms control the visual appearance of a symbol object in response to user interaction and enable the incorporation of ‘self-describing’ symbols.
2. Access Mechanisms – these mechanisms are exclusively associated with first order symbol objects and control the access of multimedia content relative to unique symbol object locations.

Both mechanisms enable the incorporation of ‘user-notification stimuli’.

Self-Describing Symbols – The Embedded Legend. According to Blum (1995), icons in user interfaces, particularly multimedia interfaces, are not intuitive to every user. In many instances, the same can be said of map symbols. Most maps contain symbology that requires explanation in order to enable decoding and interpretation. Conventionally this has been provided by a legend, part of the map marginalia, requiring a visual comparison with the map content in order to decode the symbology (Robinson *et al*. 1995). In a multimedia map-based product, the symbol-oriented structure of the map object makes possible the concept of ‘self-describing’ symbol objects.

A ‘self-describing’ symbol provides its own descriptive information. As such, each symbol object in the map object has a unique legend associated with it. This legend is a component of the symbol object structure and remains hidden until exposed, if required, by the user. A ‘self-describing’ symbol also alleviates many of the problems associated with the limitations of computer screens as display devices for high resolution map data by enabling identification information to be displayed as needed rather than persistently. The activation of ‘self-describing’ symbols when using a multimedia map-based product can be the result of setting a mode of display (Armenakis 1993). Alternatively, ‘self-describing’ symbols can be an integral and persistent part of symbol object structure (Miller 1996). For example, descriptive information can be accessed by simply moving a mouse cursor over a symbol.

Self-describing symbol objects and the multimedia environment provide an opportunity to increase the detail and specificity of legend material accessible from individual symbol objects. For example, since a symbol object is self-describing, its legend content may be slightly different to that of another symbol object of the same graphic appearance. Therefore, legend content is spatially as well as thematically specific.

User Notification Stimuli. A user notification signal is an aural or visual signal, such as a change in symbol object colour or intensity (brightness). According to Lynch (1994), signals or ‘cues’ are necessary to provide feedback to users and are fundamental design features of graphical user interfaces. A key multimedia component is the ability to enable the dynamic presentation of content. Since symbol objects are dynamic and responsive to user interaction, each symbol object in the multimedia map-based product, encapsulates within its internal structure the ability to provide user notification for the purpose of indicating:

- the presence of an access mechanism or the status of a symbol; and
- a spatial relationship between itself and an information object.

A number of standard multimedia interface techniques have emerged as a means of indicating the presence of embedded content, or an access mechanism. Of these, cursor modifications are the most universally employed means of indicating the existence of ‘hidden’ information in multimedia products (Blum 1995; Michon 1992). Cursor modifications can be further extended to indicate the type of information that can be accessed (Blum 1995). For example, this may involve using a camera icon to indicate the presence of a photograph when moving a mouse cursor over a symbol object.

Modifications to symbol object appearance can be used to indicate both the presence of an access mechanism and a spatial reference between a symbol object and an information object. A direct manipulation interface is one that supports visibility of the object of interest (Shneiderman 1987). Since the multimedia map-based product represents a direct manipulation interface, it is necessary to ensure that symbol objects that have the users attention have greater visibility. This can be achieved by manipulating the conventional visual variables of the symbol object and/or via the use of dynamic visual variables (DiBiase *et al.* 1992; Köbben and Yaman 1995). Several cartographic multimedia products utilise user notification signals. Jiang *et al.* (1995) refer to the use of 'blinking' to attract user attention. Armenakis (1993) alludes to the use of user notification signals with respect to the *1:50,000 Topographic Map Application* in which 'double-clicking' on a road (for example) causes the road to be highlighted and information provided. Ishizaki and Lokuge (1995) refer to the use of opacity and transparency to create hierarchical relationships between symbols in maps based on a context.

User notification stimuli are an inherent component of symbol object structure and are visual and/or aural in nature. From a visual perspective, recent research on dynamic visual variables (Köbben and Yaman 1995; Wang and Ormeling 1996) can be applied to the construction of user notification stimuli. From an aural perspective, cartographic research on sound variables (Krygier 1994), and more generic research on sounds in the user interface (Blattner 1993), suggest that when combined with visual responses, sound can be effectively used as a means of user notification.

7.2.1.3 Marginalia – A Concept Extended

The concept of marginalia is extended in a multimedia map-based product. Conventionally, marginalia refers to information (graphical, image or textual) that exists outside the spatial bounds of a map and whose primary role is to aid in the decoding and interpretation of that map. In the multimedia map-based product, map marginalia shares the same primary aim, however, it is more varied and requires additional capabilities to support the decoding and interpretation of the map object. The multimedia map-based product contains three types of marginalia: spatial, manipulation and navigation marginalia.

Spatial Marginalia. Spatial marginalia are visually dynamic objects that are seamlessly and actively linked to the map object and may include scale, direction, geographic location and legend information. Being actively linked to the map object, any change in, for example, map scale or coverage is reflected in the spatial marginalia while it is also possible for the user to change the scale, orientation and map object view via the direct use of spatial marginalia. Despite the incorporation of 'self-describing' symbols, a legend should also be available on request for purposes where symbol object comparisons are necessary to facilitate interpretation.

Manipulation Marginalia. Manipulation marginalia enable direct interaction with the attributes of the map object. Many of these tools prompt a change in the values of map object attributes causing the map object display to respond accordingly. According to Asche and Herrmann (1994), interactive maps should provide zoom and scale controls to enable direct user interaction. Fundamental manipulation marginalia should also include panning functionality, view modification and, depending on the product, layer manipulation and search functions.

Navigation Marginalia. The standard multimedia product contains some sort of reference to the overall product content usually via content listings consisting of subject or theme headings. This provides the upper level structure of the product as well as a means of providing an overview of product content. In the multimedia map-based product, navigation marginalia function as a content overview that is displayed in conjunction with the map object as a component of the GUI. Coverage, theme and timeframe selectors, or navigators, should be persistently available as 'buttons', icons or pull-down menu structures to enable a user to change the attribute values (coverage, theme and timeframe) of the map object and therefore the current map object display. The attribute values of the coverage navigator are persistent within the product GUI since the range of coverages available does not change. In comparison, the map object attribute values of theme and timeframe are non-persistent. Different themes may be related to different coverages and different timeframes may be related to different themes. As such the theme and timeframe navigators are active. A sub-theme navigator may also be incorporated; this is controlled by the attribute value of theme and represents a means of content access (in addition to symbol object access to content). This enables the rapid access of specific information of interest, however, it is important that a spatial context is maintained by ensuring the spatial locations, distributions and relationships to which content relate are always visible within the map object itself (see Miller 1996 for a more detailed coverage). Depending upon the required functionality of the product, search tools should also be incorporated to assist user navigation and access.

7.2.2 The Multimedia Content-Set

The multimedia content-set refers to the content objects contained within the multimedia map-based product such as maps, photos, text, video and sound. A multimedia MBIP content-set is comprised of four types of content objects which have distinctly different roles:

- Direct Spatial Objects – referring primarily to map object displays and to other maps used as locality indicators and to illustrate spatial concepts or distributions;
- Information Objects – referring to the multimedia content used to assist in map object decoding and interpretation. Every information object has a spatial context;
- Functional Objects – referring to the visual objects used in the multimedia MBIP GUI. These include marginalia objects and other standard multimedia interface objects; and
- Aesthetic Objects – used only as a means of increasing the aesthetic appeal of a product.

7.2.3 Object Links and Organisational Structures

Object links are used to define relationships between symbol objects and information objects and between individual information objects. There are various types of object links, also referred to as associative links (Bielawski and Lewand 1991; Parsaye *et al.* 1989; Woodhead 1991). Miller (1996) discusses an approach to classifying links and thereby the relationships between information objects and the map object.

Organisational structure refers to both the ‘concept structure’ and ‘content order’ of information objects (Sikillian 1995). Concept structures connect objects according to a common semantic category and in a multimedia map-based product are used to create associations based on spatial context. Concept order refers to the order in which objects are accessed or the arrangement of objects. Therefore, organisational structure refers to the types of information objects to which a symbol object is referenced and the order in which these are presented during content access. Each symbol object in the map object has an associated set of information objects arranged in an organisational structure according to map object theme and timeframe and the unique location of the symbol object. Conceptually, a symbol object with a specific map object location may have a number of organisational structures associated with it according to different map object attribute values.

The organisational structures used in multimedia map-based products are highly structured in nature in order to guide access and user interaction (Asche and Herrmann 1994; Ormeling 1993), however, this does depend upon the requirements of the product. Generally, the aim is to convey a thematic and/or temporal structure, based on a spatial context, between linked symbol objects and information objects (Miller 1996).

7.3 Conclusion

Multimedia is a potentially powerful tool for geographical representation. It enables a greater quantity of a more diverse range of media to be used to increase the potential for the communication of spatial information. It also enables an interactive, dynamic environment in which a user can explore, manipulate and transform spatial information. This ability to incorporate such a wide range of media into map-based products can have a tendency to focus the cartographer's attention on issues other than map design. Map design still remains a primary means of spatial communication in a multimedia environment, particularly in the multimedia map-based product environment discussed in this chapter. Despite the potential that interactive three-dimensional spatial environments, virtual worlds, and the more immersive environments of virtual reality offer for representing spatially definable content (Jacobson 1994; Koop 1995), it can be surmised that the two-dimensional map, whether in hard-copy or multimedia format, will remain a dominant means of spatial representation given its ability to provide a succinct summary of spatial patterns and relationships within a coverage. It is at the development of multimedia products whose primary content is the two-dimensional map that this chapter is aimed. This represents a sub-set of the ever increasing field of multimedia cartographic design.

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8 Map Concepts in Multimedia Products

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8.1 Introduction

This chapter provides some insight into the theoretical issues that relate to the design and production of cartographic multimedia products. The concepts related to Multimedia Cartography are largely derived from cartography itself. Therefore, we will first look at the general contributions of cartographic products (maps and atlases) before we look at the specific cartographic concepts of multimedia products. The latter can be subdivided into 'meta' concepts used for accessing the information contained in the products (navigation, access), and concepts where maps are the means for exploration or information transfer. Consequently we will consider the role played by maps:

- as organisers of the multimedia products;
- as container of links to other multimedia elements;
- as interface to the geographical database; and
- as vehicles for interaction.

Subsequently, the conditions for proper interaction will be discussed.

It is always relevant to realise what concepts the procedures one follows are based on - if only to check whether one has a sufficiently good reason to deviate from them. The concepts described here make us understand why specific approaches have been taken when dealing with maps in multimedia products. If we want maps or atlases to play their expected role in a multimedia environment, we should see that the conditions to play that role are met, and that the (cartographic) interfaces needed are in place. Only then can we ensure proper interaction with the data, and that is what a multimedia approach is all about.

8.2 General Map- and Atlas-related Concepts

Maps as models of spatial reality

Maps serve as scale models of spatial or geographical reality. Because they are rendered to a specific scale, maps provide overviews that are otherwise beyond one's ability to conceive. As these overviews are made to serve specific purposes (game hunting, tax gathering, inventorying resources) these models are also selections of the various possible information layers, containing only the information thought to be relevant for a specific objective.

Maps as providers of spatial insight

What is the advantage of a multimedia atlas? In the first place they provide answers to specific questions. Maps inventorize, and therefore they can answer a question like:What is there? Maps suggest explanations because they show the proximity and interrelationships between the objects depicted. Therefore, they help in answering the question: Why is that there? Because they are generalisations and selections from all the possible data that could have been rendered, maps are able to show overviews. So they would answer the question: Where is that? And, as an answer to that question, spatial patterns can be interpreted from the map.

The number of these map-based questions can be expanded exponentially when we combine maps in an atlas. Besides asking what is there, we can also ask what more is there? Such a combination would allow us to 'mine' different data sets in order to find multiple attributes for the same location. These various data sets have all been processed in the same way, in order to have their level of generalisation, and therefore their patterns, comparable at a specific resolution set by the user. So the users would be able to ask for example: What phenomena have the same distribution pattern over this area?

Users would ask all these questions because it would allow them to anticipate spatial phenomena when planning a trip. It would allow them to plan for specific conditions set by climate, altitude, etc. Users would be able to make themselves familiar with the local situation. Few map users can mentally transform the abstract contour-based map images into a fly-through rendering. Analogous to the training of pilots in flight simulators, we can provide this kind of virtual environment as well. That will allow people to visualise space through our multimedia atlases. The armchair travellers of today, in the future can truly become immersed in their multimedia atlases.

Maps as spatial organisers

The map, or its ensemble as an atlas, can act as an organiser of the multimedia product. Atlases consisted of explanatory texts, photographs, graphics, schemes and diagrams even before the digital age, that added sound and video. Because the map defines the area covered, it thereby provides geographical linkage to this set of disparate elements, and holds them together.

There are other means, besides maps, for providing linkages between a variety of datasets. Toponyms can be used, for example, but these geographical names have an unfortunate tendency of referring to different areas over time. Australia would be no problem for this century, but how would the toponym ‘Germany’ be used? Does this name refer to the extent of the area designated by this name before 1918, or before 1939, or before 1989 or after? Geographical names would at least also require a temporal indication in order to make sure of the geographical area referred to. So the map would be a superior spatial organiser, even more so where graphics and logo's are more powerful than alphanumeric cues.

Their role as spatial models, as tools for providing spatial insight and as spatial organisers are traditional strong points of maps and atlases. Now, we add to these, the new potential of the digital environment:

Maps as tools for accessing information elements

Amongst the cartographic concepts that are specific for multimedia products, there are those that relate to exploration and/or information transfer from the maps and those that relate to the role maps play in accessing non-cartographic information elements contained in the multimedia product. We will start here with the latter:

Maps as navigation tools for the multimedia product

The ability of maps to provide overviews and show spatial relationships can also be transferred to other dimensions, for instance to Cyberspace (Jiang and Ormeling 1997). Within multimedia products, the structure of the various elements that together compose the product can be made clear to the user through maps, providing a better understanding of the product. At the same time, this can be used as a way to show users their current position in the product (Where am I in the multimedia atlas, what are my possibilities for navigation from my present position?).

An example of such a map is given in Fig. 1. Here the user has accessed an agricultural map (Banana production) of a specific area (South Asia) in an electronic atlas. As is shown on this map, he can directly access:

a) a map with the same theme for an adjacent area (such as Southwest Asia, East Asia);

b) maps for the same area (South Asia) with different themes (such as coconut production, rice production);

c) a geographical map or a physical map of the same area;

d) zoom out to a world map with the same theme (Banana production).

Such navigation possibilities immediately set the conditions or requirements for the maps that can be accessed. If two maps with the same theme are accessed in sequence, the class boundaries they have in their legends should be similar, as well as the tints rendering these classes, in order to be able to make fruitful comparisons. After all, this is what atlases are for.

Maps as interface to the geographical database

By clicking map elements, the geographical data behind the map may be accessed, such as population numbers or geographical names, for locations or areas, geographical names or (traffic) volumes for linear features, spot heights, co-ordinates, distances, surface areas and even local time for a specific spot, the latter provided the user's real time and co-ordinates have been entered.

The most important contribution of the electronic environment to cartography is that the storage and display functions of maps could be separated. Maps could be customised, visualising only those items that were important for answering a specific question. In traditional cartography, maps had both a storage and communication function. In digital cartography, the map is that visualisation of data from the database that is appropriate for answering a specific question.

Of course, displaying maps on a computer monitor is not ideal. The size of the map is restricted and it therefore does not provide an overview. So, it is a sheer necessity to be able to do away, if even temporarily, with those map elements one does not need at a particular moment. The legend need pop up only when needed, and the same goes for the scale, source data, and all other marginal information. It is not only valid for the elements from the traditional map's margin, but also for the map elements proper: the various layers that together constitute the map can be turned on or off, according to the map user's needs. So we have been able to overcome the restrictions imposed by display of maps on monitor screens by customising the map information and by manipulating the marginal information, only visualising and accessing it when really needed.

In a traditional production process,the office of the atlas editor contained the database with demographic, economic and toponymic data. He would have an image bank as well for his illustrated editions. From this database, the various attributes of the map elements were taken, classified, categorised and symbolised. In an electronic environment it became possible to transfer this database to the product, allowing the user to access it directly instead of going through the editor. The exact population numbers (for example 337,000) of settlements would be available instead of a categorised attribute value (between 250,000 and 500,000 inh.) indicated by a symbol. The geographical names contained in a search engine would allow the user to access a map version where the name entered would be displayed at the largest 'scale'. At the same time it could also store the name's pronunciation and other relevant attribute information.

Maps as multimedia interfaces

The maps in multimedia cartographic products provide - through their hotspots - the actual links to the other multimedia elements, and thereby enable users to access them. The maps are the most obvious carriers of these hotspots as these would immediately indicate the geographical positions (locations, linear objects or areas) the other multimedia elements (texts, diagrams, images, drawings, schemes, videos, sound tracks, etc) refer to.

Maps as vehicles for interaction

Finally, maps can, in this digital environment, play additional roles to those in analogue cartography:

Maps as interface to the cartographic database

In principle, by scrolling and zooming every wished-for area can be accessed at every scale. So, as any frame required could be visualised, each geographical site and situation can be understood. Geographical stepchildren no longer exist. For example middle eastern countries like Lebanon and Israel are such stepchildren: they lie in the margin of the map of Europe as well as of the map of Asia in our traditional school atlases.

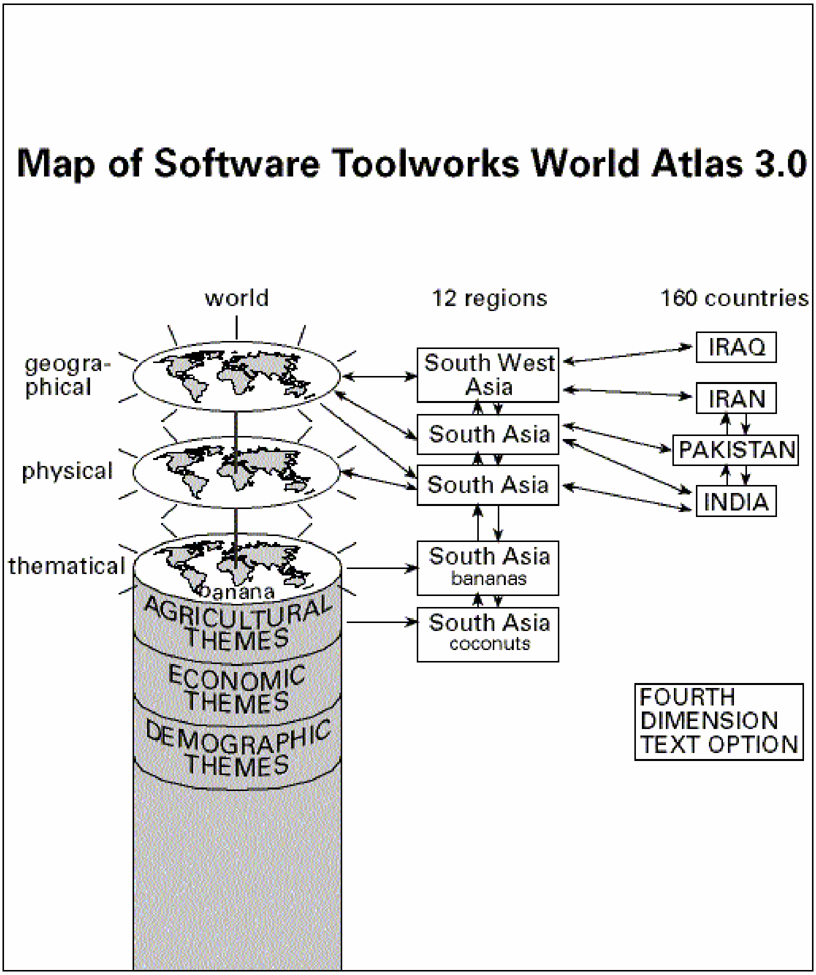

Fig. 1. Map of the navigation possibilities of the Software Toolworks World Atlas 3.0 (Ormeling 1993)

Maps as tools for scientific visualisation

Through maps, cartographers try to transfer images of reality that are as close as possible to the 'true situation'. One single image here could easily be biased, and they come closer to the actual situation by manipulating classification schemes (the number of classes and the classification types), the colours assigned to classes, representation modes, and aggregation levels. It has been said that it is unethical to provide only a single view of specific data (Monmonier 1991). Analogue atlases, with their lack of space, could not escape from the restriction of only providing single views. With multimedia atlases, we are able to break free and provide as many views as we want.

A good example of breaking away from the traditional static cartography is the prototype of the digital Swiss National Atlas (see chapter 9). It contains a digital terrain model (DTM) that allows users to state vertical exaggeration, angles and direction of view and even the time of day and the season. Before this, we were forced to have the relief illuminated from the Northwest, and because of the names rendered, were forced to look northwards. In this new digital representation, one can actually plan the panorama one is going to see at a specific point (provided the weather does not spoil it). Names, when asked for, would follow the orientation rather than be set at a single angle.

Conditions for interaction

Around this conceptual framework provided by maps, other conceptual issues that are to be taken into account in order to set proper conditions for interaction are: modalities, narratives, task situations, and carriers or medium types. Their interrelationships are suggested by Van der Schans (1997) as (see Figure 2):

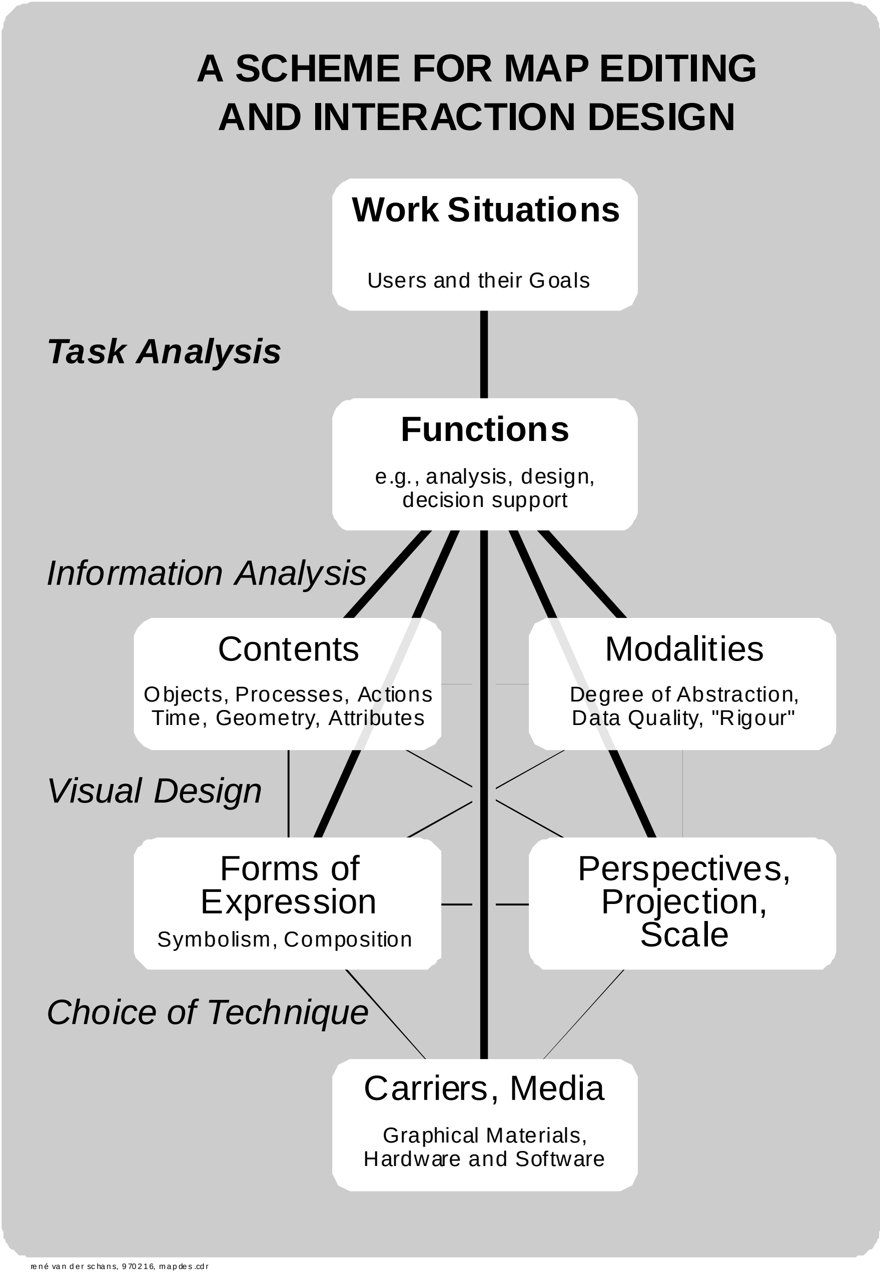

Fig. 2. A scheme for map editing and interaction design, by R. van der Schans (1997).

Users of multimedia atlases can be beginners or be advanced, casual or expert, intermittent or frequent. They can be computer novices or experts and be more or less knowledgeable about the domain depicted (Nielsen 1993). On the basis of the goals users would have when accessing our products, specific work situations should be envisaged. Whould they access the maps or other information elements in the multimedia product to answer any of the questions indicated in the section above (on maps as providers of spatial insight), or even the more complex ones? We can envisage GIS-like situations where questions might involve finding the area where five or six different conditions apply. The goal would be to find those designated areas, visually isolate them from the base map, and transport their outlines to maps with other themes in order to find additional attribute values.

This would be a decision support function that is linked to an extended analysis function. The map, as interface, can have other functions to perform, such as navigation, management, education, reference, recreation or propaganda. Each of these functions would require a specific selection of information layers from the database, a specific degree of generalisation and a specific design. Maps designed for propaganda would render a certain geographical situation or relationship different from a more neutral rendering on a map with a reference function.

The contents to be incorporated are set by the strategy/objective of the multimedia product. The material to be incorporated should allow for a homogeneous coverage answering the conditions that have been set, with a comparable level of generalisation, collected within a comparable timeframe, and with a comparable data quality. In a multimedia product, users would expect the data quality to be homogeneous. If this is not the case, this should somehow be indicated.

Modality as rendered in Figure 2 can be defined as being conscious of the relationship with reality (Van der Schans 1997, Hoye 1997). In physical planning, for instance, a geographical situation can be rendered as it is now, as it should be or as it possibly will be within a given number of years (temporal modality). Modalities can refer to the legal character of planning measures: whether a situation is prescribed by law, or whether more latitude is given. It can refer to geographical modalities: the site of a new building/settlement could be exactly indicated or it could merely refer to a smaller or larger prescribed area. Cartographic modalities could be efficiency of the visualisation (Bertin, 1981), redundancy, perceptibility, accuracy and - for the multimedia product as a whole - its synergy (Maybury and Wahlster 1998): "one channel of communication can help refine imprecision, modify the meaning and/or resolve ambiguities in another."

Perspective, as indicated in Figure 2, can be defined as a conscious orientation to other users (Van der Schans 1997, Simpson 1993). It is our objective to convey information to the users, but in order to let them better understand it, they have to know our standpoint: an American multimedia product meant for the American market will show the world from an American perspective, with the U.S. as a yardstick with which to measure other areas. The product will be focused on those aspects that Americans are thought to be interested in, and it will be based on the peculiarities of their educational system (which seems to be interested in things like: "Which state in the US is first in hog production, or has the highest crime rate?"). When aware of producer's perspectives like this, it will be easier to evaluate the information contained in the multimedia product.

Carriers, of course, will determine the specialisation of the subject matter. Look, for instance, at the National Atlas of Germany that is now being produced (Atlas Bundesrepublik Deutschland 1997) in an analogue version, on CD-ROM, and on the Internet (this is discussed in another chapter in this book by Lambrecht). As seems to be the case at this point (Mayr and Lambrecht, forthcoming; see also the latter’s chapter in this book) it is the role of the printed version of the national atlas to interest users in the subject matter and to incite them to use the CD-ROM version, which will be more complete regarding data and possibilities of combining datasets and will allow users to change classifications and legend colours. As opposed to the CD-ROM version, the Internet version will primarily serve to update the material.

8.3 Conclusion

Iterations are not shown in the model depicted in Figure 2, but they are necessary, as all these aspects influence each other. What we want to express would influence the choice of the carrier. But, as indicated with the example of the National Atlas of Germany, the choice of carrier in turn influences the contents. It is a complex environment of construction, in which we will only be able to produce relevant multimedia products when we are able to differentiate between and take into account the various roles played by the maps involved.

As indicated above, these roles are (1) to make the overall multimedia product function properly and (2) to allow users to interact in a relevant way with the cartographic part of the product. While playing the first role, maps function as spatial organizers, as navigation tools and as interfaces to the geographical database contained in the product. Their second role allows users to adapt the maps contained to their requirements, generate the cartographic images they want and manipulate them in such a way that new insight might be gained.

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9 Territorial Evolution of Canada - An Interactive Multimedia Cartographic Presentation

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9.1 Introduction

The numerous changes to boundaries within Canada, which occurred between 1867 and 1949, are difficult to display in classical map forms. A major advantage of electronic mapping over conventional cartographic presentations is the capability to present time-dependent phenomena by the use of animation. The first version of an animated Territorial Evolution map was produced within the Electronic Atlas of Canada prototype system called MARK 2 (Siekierska and Palko 1987; Siekierska 1990; Siekierska and Taylor 1991). A desktop version of the electronic Territorial Evolution map was produced as a stand-alone multimedia mini-atlas first displayed at the 'Canada House' exhibition, which was organized to celebrate the 125 anniversary of Canadian confederation, in 1992. A modified bilingual version of this product was released on a CD-ROM for use by schools and by the general public (Siekierska 1998).

Territorial Evolution consists of a series of Canadian maps at important times in the evolution of the Canadian Confederation with the ability to animate these maps through time. For the purposes of the multimedia version, still and animated graphics or images, text, sound, and video information were included, as well as provincial maps. A hypermedia information management method that connects various types of media in a non-sequential mode was incorporated. The user can access information in a flexible nonlinear fashion by moving from one part of the presentation to another, as long as the associative links mechanism has been created. The links are equivalent to an indexing schema and the established relationships between objects allow browsing within the same object or navigating between multimedia objects containing related information.

This chapter provides a brief description of the main characteristics, information content, cartographic representation, and technical issues of the

CD-ROM and the Internet version of the Territorial Evolution of Canada map. The *Territorial Evolution of Canada* - a multimedia presentation, is one of the earliest examples of cartographic animation of historical data. It has been selected for this publication to exemplify issues, which should be taken into consideration when developing and producing similar products.

9.2 Background of Product Development

The need for a more holistic approach for the interpretation of spatio-temporal data requires new forms of cartographic representations. The implementation of virtual realism in displaying time-dependent data is a step in the creation of maps-in-motion. The creation of virtual reality images for the display of time-dependent geographical information enables us to perform dynamic presentations applicable to mapping (Armenakis 1996). One of the advantages of electronic mapping and dynamic cartography over conventional cartographic presentations is the capability to display motion and changes over time by use of animation (Siekierska 1983). Animation also supports dynamic data exploration and visualization. The evolution of Canadian territory is represented in the 'hard-copy' 4th edition of the National Atlas of Canada, published in 1974, as series of maps each showing a distinct period of history. In the 5th edition of the National Atlas the territorial evolution is shown on one map. However, it is a rather complex representation due to the amount of information which had been incorporated, thus map readability and perception of changes of the boundaries is difficult.[1] Therefore, this map became a prime candidate for experimentation with the animation of historical data when the Canadian electronic atlas was being developed (Siekierska and Palko 1987). Animated maps significantly extend the mapping capabilities by including the visual display of time, a variable of an inherently dynamic nature. These maps allow the continuous display of time-dependent data in chronological order, thus adding realism to the display process.

During the course of development, a number of data sets were used to test the functionality of the Electronic Atlas software. Territorial Evolution was originally developed to demonstrate the potential of representing time-dependent data using the cartographic animation capabilities of the Electronic Atlas System. Dates related to the entry of provinces into Confederation and to changes of boundaries throughout the political evolution of Canada were stored as attributes. The data sets used for the Territorial Evolution electronic map were derived from the Fourth and Fifth Editions

[1] http://atlas.gc.ca/site/english/maps/historical/territorialevolution/1867-1999

of the National Atlas of Canada. The map on the Electronic Atlas contained additional information, such as a chronology of places.

The animation was based on a time-composite map, linked to time-stamped display parameters. The time-composite map is one map, which contains all the time-maps in a single cartographic layer. Each map can be extracted from the composite-map for display purposes. The elements in each map are linked to time-stamped attributes, which include a series of cartographic display file attributes. The animation is driven by the attributes. As the animation progresses, time-stamped attributes become valid or invalid, and they activate or de-activate, the corresponding graphic display files. The display of the maps in succession gives the idea of movement through time.

The animation of Territorial Evolution is a very effective display of the changes to the boundaries of the Canadian Confederation. The animation of these changes gives a picture of the evolution of the boundaries within Canada, which cannot be easily visualized from a static map. The animated electronic map is potentially a very good teaching tool, and it was thus decided to transfer this data to the widely used desktop computers. The integration of maps-in-motion with other multimedia data was implemented according to hypermedia concepts (Armenakis 1993).

9.3 Example of an Interactive Multimedia Presentation

The combination of the concepts of animated cartography and hypermedia offers an effective tool to design and develop interactive type multimedia cartographic representations (Siekierska 1990, 1993). These electronic maps enhance the cartographic information by providing direct access to multiple sources of information from within the cartographic presentation and by supporting flexible navigation schemas, allowing exploration of possibilities for dynamic presentations. In the Territorial Evolution multimedia presentation (Armenakis 1992, 1993 and 1996; Armenakis et al. 1992), the hypermedia network was built based on predefined links. The nodal information was organized in three levels linked to each other based on pre-established relationships (Fig. 1).

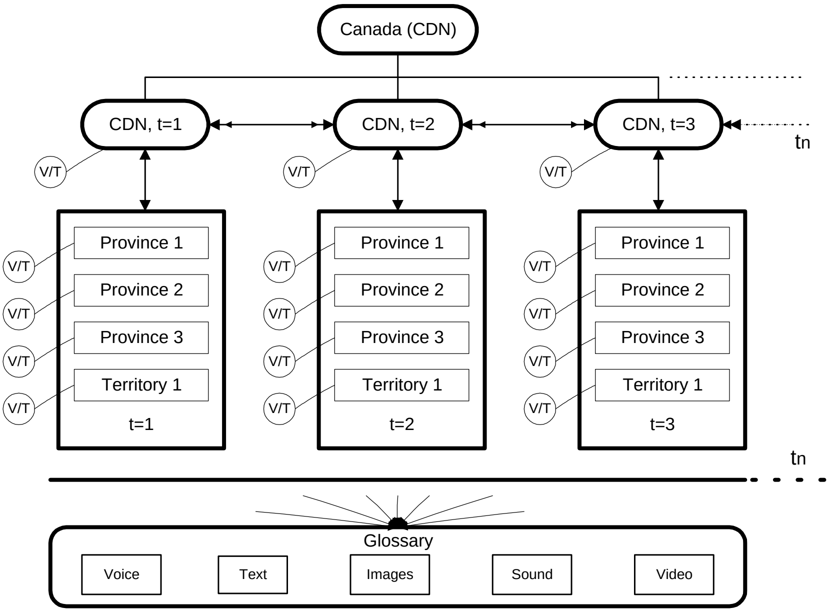

Fig. 1. The hypermedia network of the Territorial Evolution (V:voice; T:text).

9.3.1 Thematic Content

The *Territorial Evolution of Canada* depicts the evolution of Canadian territories since the time of Confederation in 1867, until 1949, when the last province (Newfoundland) joined the Confederation. In 1999 the internal boundaries of Canada will change again as the new territory of Nunavut has been established. The Territorial Evolution product consists of a series of electronic maps, which show the changes in the national and provincial boundaries of Canada. The maps are accompanied by textual information, still and animated images, sounds, music and voice commentaries, which explain and illustrate the historical events that lead to particular changes in the boundaries.

The product is divided into three levels.

1. The first level consists of maps and descriptions of boundary changes at the national level, and includes a series of maps, additional textual information and narration. It contains 20 time-series maps.
2. The second level consists of 28 frames depicting the evolution of the various provinces and territories. They are chronologically attached to the appropriate map of Canada at the national level; the maps and are

also linked to voice and textual information. The access to the evolution of individual provinces is via a map of Canada, and it is possible to explore the provincial evolution from any national level map.

3. The third level, called the ‘glossary’, contains additional illustrations and accompanying text and sound and consists of 13 related topics depicting historical events or people, which are central to understanding boundary changes and are referred to in the previous two levels.

The animation of the evolution of boundaries in Canada is shown at the first and the second levels. It is thus possible to view the evolution of the country through maps showing Canada as a whole, or to follow the evolution of individual provinces and territories. Sound was added as a spoken commentary on the evolution of the country as a whole.[2] The spoken text is shorter than the written textual information. Reference to the text accompanying each map provides the user with additional information.

The Electronic Atlas maps were created from *Arc/Info* files derived from information found in the 4th and 5th Editions of the National Atlas of Canada. This data consisted of a number of *Arc/Info* graphics covers, one for each year in which the boundaries of Canada change. These covers were imported into the Electronic Atlas and attributes were associated with the graphics. Using the time-series display capability of the Electronic Atlas, electronic maps for each year were displayed and screen captured. These Sun raster screen images were saved, converted to .GIF format and transferred to the *Macintosh* computer.

The provincial maps were derived at various scales from the Canadian maps, and the text was written, both in French and in English, to accompany the electronic maps. The bilingual text used in the multimedia version was specifically written for this product to conform with the school curriculum. This text gives information dealing with the boundary changes, namely the reasons why they occurred, and how these changes actually affected the territory. Additional historical information was also given when it was found necessary to explain the context of the changes.

9.3.2 Cartographic Design Issues

The cartographic representation of information follows very closely the conventional cartographic map representation. The approach taken was to replicate the style of the cartographic design of the conventional paper map of the 5th Edition of the National Atlas of Canada. This is particularly noticeable in the selection of colour schema. The variations of hue differentiate the British possessions from the provinces that signed the Canadian

[2] The CD-ROM version has spoken commentary in all three levels.

confederation. The variations of colour value differentiate the stages of development of individual provinces. The same approach is used in all versions of the map, that is the paper copy, the CD-ROM version and the Internet version.

Due to time constraints to produce an electronic version within a short period prior to the anniversary exhibition no efforts were made to prepare digital files appropriate for visualization on smaller size screens. As a consequence, the existing CD-ROM version and Internet product were derived from the graphic files prepared for the production of the 5th Edition of the National Atlases digitized from the 1:7.5 million scale paper map. No generalisation operation was applied to prepare these files for display at the computer monitors, which depending on the size of the screens can correspond to scales varying from 1:15 to 1:60 million The lack of generalization is particularly noticeable at the coast lines.

9.3.3 Authoring Tools

The stand-alone multimedia prototype was built around the first level -the time-series maps of the evolution of Canada and their associated text (Armenakis 1992, 1993). It was developed on a *Macintosh IIci* with the *HyperCard/ HyperTalk* application program using a customized version of the NCSA *HyperCard* Animation Package. A proof-of-concept prototype was developed using the *SuperCard/SuperTalk* software and incorporated the second and third level information (Armenakis 1996). This second prototype also allowed for the juxtaposition of two neighboring temporal maps for visual comparison.

The MacroMind *Director* 3.0 authoring software, created by MacroMind Inc. (now Macromedia), was used to build the multimedia cartographic presentation having all the specified functional requirements of the product, including color, sound, graphics and animation. This software was selected because it is user friendly, it includes examples and tutorials, it has tools for authoring and for creating animation, and creates stand-alone.

There are two integrating modules within MacroMind *Director* – Overview and Studio. The Overview module is used to design presentations and to join documents with the animation created by the software. The second module, Studio, is used to produce the series of still frames for the movies (animation). The objects, such as graphics, sound, text, colour, of each movie are stored in a database called Cast, and all the activity in each frame of the animation is created using a storyboard-like window called Score. Score keeps track of the position of each cast member in each frame and controls the timing of special effects like transitions, tempos, sounds and palettes. The *Lingo* scripting language permits sophisticated interactive control. The presentation is designed through the use of scripts, which can be attached to objects or frames within the animation.

9.3.4 Graphical User Interface

In the first level, where the maps of the country are displayed, the interface metaphors include a text button to display a text window, a sound button that activates an audio playback of the short version of the text, an video-camera button which animates the maps, and a time selection bar which gives the user the opportunity of selecting a specific year in the evolution (Fig. 2).

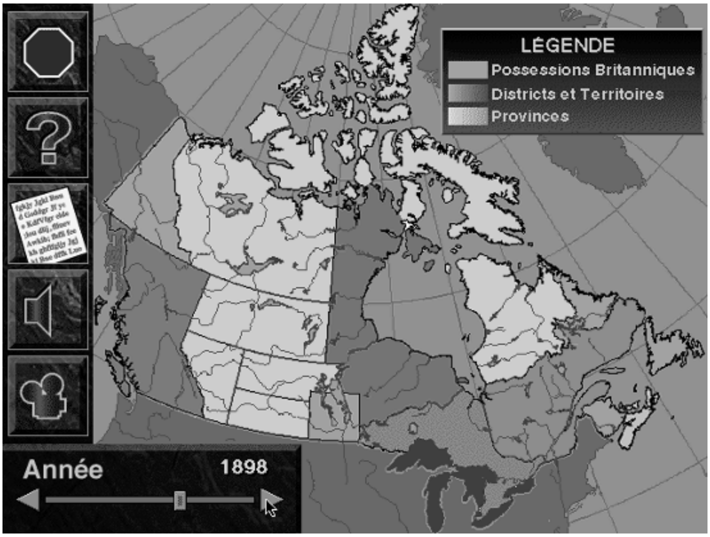

Fig. 2. The user interface, first level.

The second level is reached by selecting the different provinces and territories. When a province or territory is retrieved, the area is highlighted on the screen, then an enlarged view of the area is displayed. In this second level, there are text buttons, a time slide bar to permit an animation of the province or territory, and a return button that brings the user back to the main Canada map. Some of the text windows include hot-spots, which permit access to the third level. These hot-spot buttons are highlighted words in the text, and were chosen to provide additional information on these subjects or people as needed. When the user selects the third level, a graphic background and text are displayed.[3]

9.3.5 Operation

The user can access all three levels and navigate from one level to another. The user can view in motion (reconstruct) the *Territorial Evolution of Canada* using play-back computer animation maps of the whole country. Frame by frame motion and retrieval of the time-series maps at a specific time is also possible with a temporal slide bar. The play-back animation is done through the dissolving of colors which results to a relatively smooth transition between frames. The animation can also be interrupted at any time and restarted at the position where it stopped. At any point, the user can access textual and sound information, or a provincial or territorial map, which is also accompanied by text. In addition, each province or territory is linked to its temporal conjugate, therefore enabling a complete reconstruction of the evolution of each province or territory. The third level is accessed through highlighted hot-spots in the text of the national and provincial and territorial levels. Sound narration is available in all three levels of the final CD-ROM version.

9.3.6 Design Considerations

The Territorial Evolution multimedia presentation operates in an active cartographic environment (Armenakis 1996), where the users view and understand the evolution of temporal patterns, control the motion, study the evolving images at their own pace, interrupt the rolling of images, visually compare multi-temporal images, and consult and integrate various sources of information. The following basic characteristics were considered:

- interactive operations;
- complete control over the animated displayed frames (direction of motion, speed, frame by frame direct access and display, selective retrieval);
- hypermedia links to other information sources, including book-marking of certain nodes/anchors for direct access and return;
- user-friendly interface, with icons and metaphors for intuitive operations, with on-line help and navigation schema for guidance; and

[3] In the final CD-ROM, which was produced for distribution, the hot-spots in the text were replaced by additional buttons for accessing information of the third level.

- good overall performance (e.g., quality, speed, consistency).

Dynamic map production requires well-defined programmable operations. Scripts describing the stages of the dynamic depictions (screen background, features, position, duration, colour, speed, etc.), as well as the links to other multimedia sources, are developed and tested during the design stages. Working in a hypermedia environment it is important to have a good understanding of the subject and the user's level in order to select the appropriate information nodes and their types, and identify the associate relationships to form the hypermedia network.

Other aspects considered were the display speeds, the amount of display information and the continuous changes of map contents. These elements affect the interpretation and understanding process. It is important to know how much time the user will spend viewing the map, and whether the viewer is a novice or an expert.

The animation used in this multimedia cartographic presentation is a play-back animation where maps were created in advance. The computer displays the maps (frames) in chronological order, based on a predetermined sequence. In the case of territorial evolution, this was found to be an acceptable solution, since the contents of maps represent absolute temporal states, as defined by the historical events.

9.4 The Internet Implementation

The multimedia version of the Territorial Evolution of Canada was implemented on the Internet World Wide Web as part of the Geomatics Canada contribution to the SchoolNet project.[4] The relatively early implementation of the Territorial Evolution map within the Internet environment resulted in the relatively static portrayal of this map package (Medaglia 1994). Thus, the dynamic user interface used in the CD-ROM version has been replaced by a table with dates where significant changes to Canadian boundaries occurred. The table provides access to maps corresponding to each date. The commentary explaining the changes is provided only in textual form, as the spoken commentary is time-wise still rather expensive mode to convey this information on the Internet, due to the speed of transmission of voice and music at the time of the implementation (Siekierska and Williams 1996).

4 http://www.pch.gc.ca/special/gouv-gov/section4/sites_e.cfm

9.5 Conclusions

The *Territorial Evolution of Canada* is one of the early examples of multimedia cartographic applications (Siekierska 1996). The animation of the changes of the boundaries gives a complete, easy to comprehend picture of the territorial evolution within Canada, one which could not be easily visualized from a static map in a conventional cartographic presentation. A hypermedia organization of information permits the user to access it in an intuitive way, guided by interests and previous knowledge of the subject. Multimedia, multi-channel communication facilitates the easy assimilation of large amounts of information, making learning with multimedia products an interesting experience.

The cartographic elements of the product such as colours, text placement, frame transition and generalization suitability for smaller size monitors could be further improved, if time allowed. On the other hand, the product is one of the early examples of complete multimedia cartography (with still and animated images, text, sound, video, narration), operates in both stand-alone and interactive mode, provides very intuitive and unrestricted navigation, it has zero learning time, and it is integrated with the school curriculum.

The final version of the product was produced in cooperation with the private sector. The CD-ROM product is currently distributed by the Mapping Services Branch, Geomatics Canada, Ministry of Natural Resources.

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10 Wula Na Lnuwe'kati: A Digital Multimedia Atlas

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10.1 Introduction

The Mi'kmaq Nation is one of North America's aboriginal peoples. The group is part of the north east culture area and speaks an Algonkian language. Our traditional territory covers most of Canada's Maritime Provinces as well as parts of Newfoundland and the Gaspé Penninsula. It is from our eastern geography that we are known as 'Keepers of the Eastern Door'.

Wula Na Lnuwe'kati[1] is a multimedia atlas of the Mi'kmaq Nation. It was developed from 1994 to 1996 as a Master of Arts thesis in geography at Carleton University. The work was intended both as an academic work and an artistic endeavour. The atlas grew out of a personal interest to learn more about the culture and history of the Mi'kmaq people as part of a journey of personal discovery/recovery. Development of the atlas continues to take the project to a publishable form.

10.2 Target Audience

Wula Na Lnuwe'kati will be donated to Mi'kmaq Native Friendship Centres as it is intended to give the work back to the community from where it comes. The atlas will also be commercially available to the general public.

[1] 'Wula Na Lnuwe'kati' can be translated as 'This is Indian Land'. This is best understood as our relationship to the land as a trust given to us by Niskam (the Great Spirit/Creator). As the Mi'kmaq, our identity is distinctly linked to the land we call Mother Earth through our culture, traditions and language. Our culture grows from the land and within the concept of respect for the land, nature, humankind and all living things on earth.

The intended audience is all who are interested in Mi'kmaq geography and history with a focus on senior high school students and university undergraduates. The audience may be Mi'kmaq or of non-native heritage.

10.3 Selection of Chapters

- The 'Place Names' chapter represents a reappropriation of the land. The re-insertion of Mi'kmaq place names into the landscape asserts the fact that this is a territory of Mi'kmaq occupation … past, present and future.
- Stories of how the land was formed is the theme of the 'Legends' chapter. This section was selected for reasons similar to 'Place Names'; it offers the reader the chance to know the Mi'kmaq people as part of the land from time immemorial.
- The 'Geopolitics' chapter was chosen for its potential to instruct the reader on issues concerning the structures of political organization. The chapter examines Mi'kmaq political life in the context of a sovereign nation and in an international context.
- The 'Trade' chapter was selected for reasons similar to 'Geopolitics'. This chapter describes trade with other nations for goods not produced domestically.
- Mi'kmaq population distributions, discussions of forces which shape these distributions, as well as explanations of pressures contributing to population decline are offered in the 'Population' chapter.
- The 'Canoe Routes' chapter was selected to provide an opportunity to use previously learned animation techniques.
- The 'Information' section was included to create a place to give the map reader instructions on the atlas's functions, give an artist's statement and biography, references, acknowledge the contributions of others and to let the reader close the atlas.

A number of possible themes for the chapters of the atlas were considered. Those that were considered, but not selected, were: the geography of resistance, loss of territory due to European expansion, and sacred sites. Noel Knockwood, Elder and Spiritual Leader of the Grand Council of the Mi'kmaq Nation provided significant advice in these decisions. While these themes were not portrayed in the first iteration of Wula Na Lnuwe'kati, they will be represented in future editions of the atlas. The themes that were selected are described above.

10.4 Software

A number of software packages were used in the production of Wula Na Lnuwe'kati. Maps were drawn using Aldus *Freehand* 3.11. Textured map fills, hill shading and special presentation effects were produced using Adobe *Photoshop* 2.5. Digital video clips were compiled with Adobe *Premiere* 3.0. Sounds used in the atlas were sampled and engineered using *SoundEdit Pro*. Type for maps was designed using Adobe *Illustrator* 5.5. Macromedia *Director* 4.0.3 was used to assemble the elements together and to create the interactivity.

10.5 Production of Base Maps

10.5.1 Scanning

The International Map of the World (1:1 000 000) published by Natural Resources Canada served as base maps for this work. These large sheets were scanned in sections on a flat bed scanner. Image integrity and clarity was maintained by balancing brightness and contrast. The distortions introduced through scanning were removed at the same time the sections were joined together with *Photoshop*.

10.5.2 Tracing

In drawing the map, an important consideration was: How well will the linear complexities of the design hold up when converted from a vector drawing to a raster drawing? A 1/2 point line worked well to preserve the integrity of the drawing. The *Photoshop* file was imported into *Freehand* to serve as the template for generalizing and tracing shorelines, watercourses and contours.

10.5.3 Textures

There was a definite need to create maps that are warm, inviting and with rich surface interest. With this accomplished, the information on the maps is more available to the reader because the reader is likely to linger and enjoy the image and therefore pay more attention to it. The maps are presented as both information and image.

Textured fills for the maps are based on the work of a number of Canadian First Nations artists selected by the author. The images, taken from exhibit catalogues, were digitized and imported into *Photoshop*. Sections of an image were isolated and used to build a conglomerate. These were built to serve as both water fill and land fill. Variations of colour were produced for some textures, which together constitute a palette that were applied to the maps as hypsometric tints.

10.5.4 Compilation

A number of steps were needed to take the base map image to its final form. The software used was *Photoshop*. The grey tints were blurred and embossed to reveal hillshading. This was blended with the land texture resulting in the final land fill. The water texture was faded around the coast lines and added to the land fill resulting in the final map image. Experimentation established a formula that would perform consistently to produce images that are similar in style, colour and feel.

10.6 Media Choices

10.6.1 Maps

The variety of maps grew out of the author's need to find different ways of presenting the information in the atlas. The base map, with its hillshading and subtle textures, delivers a sense of permanence, as if the land form was eked out a block of granite, unpolished and rough, inviting the hand to register its topography. Hydrography can be clearly seen but remains damped by the anti-aliasing inherent in the treatment of the land fill.

Water areas in the base map have a rhythmic quality. Colour variations in the water fill call on an abbreviated blue palette while reflecting some of the earth tones of the land. The water fill has been faded along the shorelines as a way to elevate the land mass and establish a figure/ground relationship.

The map in the 'Place Names' chapter serves as the interface for sourcing other information. In the 'Geopolitics' chapter it is the base on which textual and graphic information is layered. This chapter opens with the names of political districts displayed on the map. When the reader moves the cursor over the map, the result is areas of the political districts are shown. These boundaries are generous in their extent, easily flowing into neighbouring districts; the lines fade toward the inside edge of the extent.

This is intended to convey the understanding that the limits of these districts are not sharply demarcated: they are more understood than measured.

The Wabenaki Confederacy map is interesting in the way it is presented. The map is built through a short but effective animation sequence which first shows the cartographic base, then the international boundaries and finally, the names of each member nation. This logical sequence reinforces the message of the map.

The map uses the same texture for its land fill but has been drawn without hillshading. The territory outside the membership of the confederacy is given a less colourful textured fill. While the water has a flat colour, it has been vignetted along the shorelines to contribute to the figure/ground relationship.

The success of this map is due to how it, at once, compliments and contrasts with the base map. The simplicity of its surface moves against the richness of the base: this deflects attention to the new information that is offered within. The similarity in palette and texture reinforces that the two map are part of the same chapter.

'Legends' and 'Canoe Routes' have maps which describe yet another cartographic approach. These maps are energetic with lively colours and smooth textures. The impression is one of fertility, abundant resources and a landscape flooded with sunshine and promise. The hypsometric tints were critical in the discussions of landform creation but also served as an interesting point of departure in the 'Canoe Routes' chapter as well.

The 'Trade' chapter uses as its base a small, unassuming map done in soft shades of yellow and green. The textures are flatter than seen elsewhere. In combination with the restrained palette, the size of the map, and how it is cropped, seems to make the map whisper. This soft quality acts as a foil for the livelier line work with more saturated colours. When examined in terms of tone and feel, the map in the 'Trade' chapter is most closely related to the Wabenaki Confederacy map.

All the maps described above, have been designed specifically for the computer screen. This means working with the screen as a new medium and accepting its limitations. It is impossible to achieve the crisp, sharply delineated line work in a map that is to be displayed on a computer screen that we can in a map on paper. Instead, work with the limitations of the medium by camouflaging stepped line work and jagged looking shorelines with textures and colourisations that suggest the feature's characteristics rather than declaring them. This approach serves to extend the vocabulary of cartographic production.

10.6.2 Typography

When designing type for the maps, the approach was similar to that which would be taken if working on a paper map. Rules of proximity, extent and balance were important in the process. This insured that the composition was readable and attractive. The shape of paths for curved type was carefully drawn and colours used were given special attention.

Palatino 14 point with 10.5 point leading is the most readable typographic configuration for text blocks in Wula Na Lnuwe'kati. Palatino was the best choice to create text that is both attractive and readable. The serifs create fluidity and the clarity of letter forms ensures readability in a raster environment. Inset caps are Lithos Black 36 point and are decorated with strikes of colour that represent the four sacred directions. Chapter titles are Lithos Black in various sizes. Political district names are Lithos Bold, water feature and land feature names are Gill Sans Bold. Some type was designed in colours other than black and blue. Here, attention was paid to compatibility and contrast of type with the map image.

10.6.3 Imagery

Throughout the atlas various images are offered to the user. These images are rooted in Mi'kmaq traditional decorative practices or borrowed from contemporary Mi'kmaq art. The background for type blocks is birch bark selected by the author's father from his wood pile. Birch bark also has been used for many start and end screens for digital video clips in Wula Na Lnuwe'kati. Birch bark is an important material in Mi'kmaq culture. Using the image of birch bark in Wula Na Lnuwe'kati is a link to the more traditional artistic practice of the Mi'kmaq people. Chapter icons are details from a painting by Luke Simon a Mi'kmaq artist. While some icons are borrowed directly, others are created in the same style as Simon's work.

Navigation devices have been carefully designed to be integrated decorative elements in Wula Na Lnuwe'kati and to contribute to the experience of a reader's visit. Paging is done with arrowheads and other navigation buttons are drawn to resemble chips of flint. A smoky field embraces the media elements, suggesting continuity from one form to another.

10.6.4 Audio

Sound in Wula Na Lnuwe'kati is a very important media element. It is used as an interface feedback device, to establish cultural context, to deliver information and to serve as a sound track for video clips.

Every choice made by the reader is met with an auditory response. These audio clues are distinct for each type of interface navigation device helping to distinguish one from another. The response to clicking on section buttons is a guitar lick from a recording by Don Ross, a musician of Mi'kmaq decent. Other audio selections are from The Eagle Call Singers, traditional Mi'kmaq singers. Their version of "Mi'kmaq Honour Song" is part of the animation sequence which opens the atlas, establishing the cultural context of the piece. The beating of a drum has been merged with sounds of the ocean, and songs of whales. This union of sounds assumes physical characteristics of the territory which offers deeper understanding of the nature of the land to a wider audience. It also helps to reinforce the atmosphere established in the opening sequences of the atlas.

The 'Place Names' chapter features pronunciations of Mi'kmaq place names spoken by the author's sister. Here, audio is used to its most powerful effect. The inclusion of these pronunciations has a transformative effect on this map. The cartography moves away from the graphic and embraces an alternate media in a way that extends the traditional cartographic vocabulary. The author's mother also contributes her voice to the atlas with a welcome message at the opening, and at the closing sequence with a final statement.

10.6.5 Video

Digital video easily lends itself to cartographic communication. Motion video can be used cartographically by selecting clips that offer a look at the topography of the land, as in the case of the video of Eskasoni. Video can also continue the discussion of an event at a specific location as in the case of the Grand Entrance of the Feast of St. Ann. The videos have been edited to focus attention on important locations shown on the map or to offer an alternative perspective on the information. In this regard, video has been applied in Wula Na Lnuwe'kati in much the same way that still photography is used in a printed atlas.

Adobe *Premiere* was used to compile and edit the raw digital video footage. All video clips included in Wula Na Lnuwe'kati are set to run at 30 frames per second and are sized to 160 pixels x 120 pixels. They have been saved in Apple *QuickTime* format as this can be played in *Macintosh*, *Windows* and Unix environments.

10.6.6 Atlas Interactivity

The interface for Wula Na Lnuwe'kati is based on an appliance metaphor. Basing the operation of the interface on something familiar has a very important benefit: it helps the user recall actions and reactions that are familiar and comfortable rather than having to re-learn the basics of operation.

Each type of button in the atlas has an ‘on’ condition signaled by distinct graphic and audio cues. This is important to help the reader learn how each of the different buttons and navigation devices may be used to explore Wula Na Lnuwe’kati.

The chapters are not explicitly named in the interface. The reader is not encumbered by type in the basic interface structure. Instead, chapter titles are available through rollovers of the chapter icons. This is a way to encourage non-linear exploration. Direct naming of the chapters or listing titles would encourage a reader to fall back to a linear approach.

The six chapter buttons operate even while video is playing or several items of information are on the screen; there is no need to close everything down before choosing another section. A reader may move to a different section at any time. Such freedom of movement allows the reader to satisfy curiosities by collecting information of particular interests.

The atlas has been constructed to offer the responsibility of choice to the reader. Explorations in creating Wula Na Lnuwe’kati, are oriented toward action in expanding the roles and responsibilities of reader and map. Wula Na Lnuwe’kati breaks down any formerly established narrative and invites the reader to construct a new, self-directed narrative.

Wula Na Lnuwe’kati has a structural foundation whose role is to serve as the interface’s skeletal form. It is to this skeletal structure that information sources are secured. The basis of this structural foundation is several carefully constructed subroutines of code that describe the action/reaction of user interactivity.

10.7 Conclusions

Wula Na Lnuwe’kati is a cartographic product which reintroduces a different type of art into the practice of cartography: maps are more than information sources, they are offered to as images that invite one to linger and enjoy.

In a digital multimedia environment, the atlas redistributes the responsibilities of map maker and map user. Through interactivity, the map user is a participant in the writing of the cartographic narrative. This user engagement is facilitated by an interface that offers many avenues for self-directed exploration through a complex of possibilities.

Media elements compliment each other and are presented as partners in information delivery. Interface devices assume the dual roles of both functional and decorative components. Sound and image are vehicles for information delivery as well as acting to ground the work within its cultural foundation.

What has been achieved in Wula Na Lnuwe'kati is, in part, a result of embracing the possibilities of new technologies while allowing traditional techniques to influence the evolution of the cartographic practice.

While this chapter has let the author dissect his work (not an easy undertaking, but a very valuable exercise), the best way to experience Wula Na Lnuwe'kati is to explore it. If a reader interprets the piece in a way that was not foreseen, the work has not been created as an encapsulated moment: it has achieved a life of its own.

11 The Atlas of Canada – User Centred Development

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11.1 An Evolution in Mapping

The Atlas of Canada (http://atlas.gc.ca) was first published in 1906 and will celebrate 100 years of cartographic excellence in 2006. Through five printed, and now a complete Internet-based version, the Atlas has always shown a diverse geographical picture of Canada over its formative 20th and 21st century years of growth. The Atlas' role today is to present topical and issue-based information in a geographical context, through maps. It provides a home for national thematic and framework datasets. The Atlas team works with partners, in government and academia, to visualize data related to the Canadian society, economy, environment and history. The goal of the Atlas is to reach all Canadians as well as others interested in Canada, around the World.

Since the 1st Edition, the characteristics of Canada, as reflected in the Atlas, have evolved. The thematic focus, while diverse, began with an emphasis on transportation and immigration (1st and 2nd Editions), changing to industrial and urban development mid-century (3rd and 4th Editions) and then to the environmental and socio-economic themes and issues (5th and 6th Editions). The need for geographic information and knowledge has increased over the last 100 years and each published edition has reflected the information needs of the time (http://atlas.gc.ca/site/english/about_us/).

The advent of the Internet in the early 1990s offered a new direction for the Atlas of Canada and its first Web-based Atlas product was put on-line in 1994. The National Atlas on the Internet heralded the new influence of technology on mapping and cartography. This was a totally new mapping environment for both the Atlas and the user with new paradigms being developed with no pre-existing models and experience to follow. The Atlas experienced an incredible surge in the number of Canadians using its maps in a way that would never have been possible with the previous printed editions. All these new users brought with them a new level of interest, expectation and demand on the Atlas. The efficiency of freely available maps available to anyone with Internet access changed forever the Atlas of Canada.

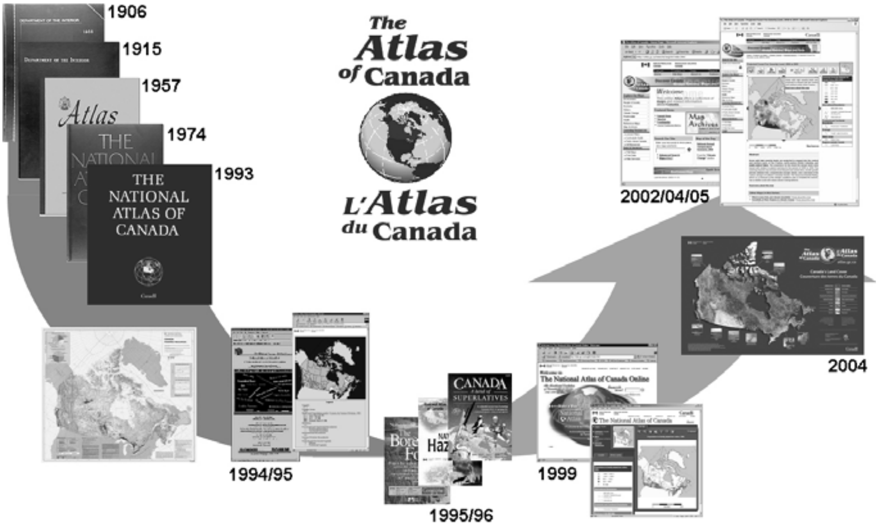

Fig. 1. The evolution of the Atlas of Canada, 1906 to 2005, Copyright, Her Majesty The Queen in Right of Canada.

The printed editions were published with little consultation and feedback from users. It was an era when government map makers were the "official purveyors" of cartographic products and while using established techniques and conventions, users were not included in the mapping and development process. The first Internet-based Atlas product moved quickly into the educational realm in a partnership with a new government initiative called SchoolNet (http://www.schoolnet.ca). The program encouraged the creation of quality educational resources in the new and emerging Internet. This introduced some consultation with the educational community through a Teacher Advisory Group. While technology and a "we know best" attitude still lead the way at this point, the teachers' influence was felt and the product development incorporated some of their suggestions. As a result the first positive effects from user input found its way into the Atlas.

The considerable success with the National Atlas on SchoolNet lead the way to a new Internet-based National Atlas program and includes the Government of Canada's commitment to on-line product and service transformation. This resulted in the official 6th Edition of the Atlas of Canada launched in Ottawa in August 1999. The latest mapping technologies were developed with a renewed focus on mapping content and other geographical information. The Teacher Advisory Group gave recommendations on content and organization of themes into issues. While this shift in direction was positive, the development of product was still left to an internal development team with very little input from the user. There was no formal process of including user groups in the development and design process. In addition, a very broad brush stroke was given to defining user groups, making them very large and inclusive. The Atlas wanted to be many things to many people, from basic to the more sophisticated users.

Despite these issues, the user base was growing and the success of the product was evident in e-mail feedback being offered through the Web site. Many of the early changes to the 6th Edition were based on these comments, but it was clear that not all issues were adequately dealt with in this way. The question of how representative the feedback was, along with not knowing how to continue to improve, led the Atlas team to realize it was time to better understand users' needs. This prompted many questions such as, who exactly are the users; what do they really use the Atlas for; how do they use it and how satisfied are they. The era of a user centred development and design process began (Williams, O'Brien, and Kramers 2003). In 2000-2001, comprehensive public opinion and usability research was conducted on the Atlas Web site, encompassing both design and functionality. The high-level objectives were to:

1. Identify and profile the Atlas of Canada's user groups;
2. Measure overall satisfaction with the site, focusing on the interactive and static mapping;
3. Assess the content, functionality, structure and usability of the site;
4. Understand users' behaviour when interacting with the site;
5. Determine the users' unmet needs with the existing site.

11.2 User Centred Development and Design

The User Centred Design process (UCD) adopted by the Atlas consists of three main stages prior to deploying additions or revisions to the Web site. The first stage is an examination of business requirements, followed by detailed user requirements research in the second stage. Next, in the third, is the product and systems design. This approach saves effort and cost due to the quality of the end result and the reduction of design errors (Nielson 1994). This process can be applied to any product or service. The Atlas has used UCD for Web-based, data and printed products, and development activities such as requirements gathering, prototyping and product validation.

The process of defining business requirements begins with user and client definition (Scanlon and Percival 2002). It is impossible to be everything to everyone. Lack of focus or an inaccurate understanding of actual user groups results in a product that may end up not serving anyone's needs.

The business requirements stage is a high level look at the business case from the perspective of the organization, the user and stakeholders. The business needs and goals have to be assessed in conjunction with user acceptance of the product, addition or change. Is there sufficient requirement from both to proceed? Stakeholders, for example other government departments and academia, have a significant role to play in the Atlas with their sources of data and domain expertise. Do any goals for each group conflict? There are a number of research methods that allow the Atlas to answer these questions including focus groups, online surveys and structured interviews. The result of this research provides the general information and opinions that will support a business case and a decision to proceed with more detailed research. The feedback at this level is opinion based. It provides apparent clarity but it is not necessarily definite, factual or explicit. There is still a high level of assumption and proceeding into a design phase at this point would be risky due to the lack of specific user understanding.

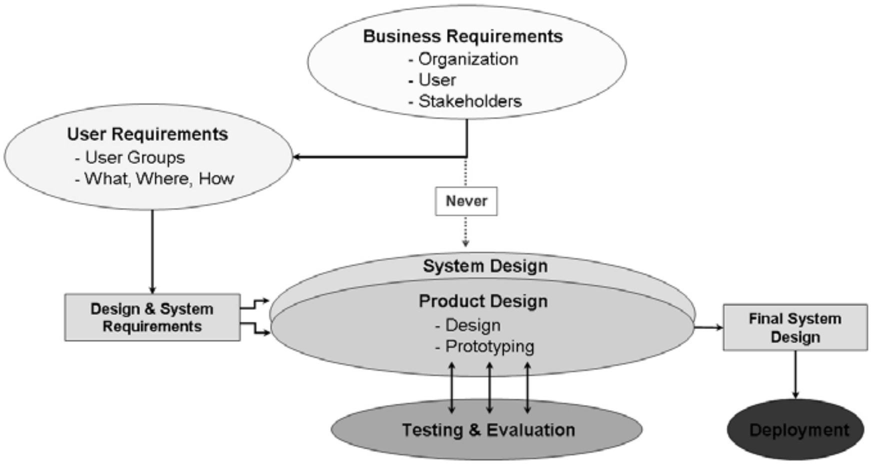

Fig. 2. The user centred design methodology.

The second stage is user requirements. At this point a more in-depth look at the composition, characteristics and needs of user groups is undertaken. This type of research allows an understanding of the difference between what users think they want and what they really need. Typical tasks carried out by individual user groups are identified. The goal is to find the actual need and then add functions to support that need. The contextual use is also important, and is different from the actual interaction with the on-line Atlas. It identifies where the Atlas is used and the factors surrounding that location of use.

The Atlas has collected user requirements information using on-line surveys, in-depth interviews and focus groups. Three on-line surveys were completed in 2000, 2003 and 2004/5. After defining the user groups and developing an initial user profile and satisfaction measurements, with the first survey, repeat surveys have provided insight into how they have changed over time. These are mainly quantitative in nature and provide valuable, statistically representative data. After conducting the surveys more qualitative research is done in the form of in-depth interviews. These interviews follow a consistent series of questions and can provide a much greater understanding of specific user needs, uses and satisfaction with the Atlas. They can also probe into issues discovered in the survey providing the clarity necessary to fully understand them.

A simple example from the most recent on-line survey completed in January 2005 illustrates the information and insight to be gained. Educational users were identified in the business requirements stage as a primary user group with strong current use and excellent potential for growth. A more specific breakdown of this group, in the user requirements research, revealed this group's composition.

The table below shows the percentage distribution of the various subgroups.

Table 1 "Educational Subgroup" data is from the Atlas of Canada On-line Survey Report, March 2005, Copyright, Her Majesty The Queen in Right of Canada.

Educational Subgroups	Percentage
Total Student (elementary, secondary, university)	21
Elementary Students	2
Secondary Students	6
College/University Students	13
Total Teacher (elementary, secondary, university)	9
Elementary/Secondary Teacher	5
Professor	4
Other Education related	1

Another interesting characteristic is the actual use of the Atlas. The following table shows the various reasons visitors use the Atlas resources.

Table 2 "Use of Atlas" data is from the Atlas of Canada On-line Survey Report, March 2005, Copyright, Her Majesty The Queen in Right of Canada.

Use of Atlas Information	Percentage
Personal project or research	39
Own school assignment/project	14
Work assignment or report	17
Child's school assignment or project	5
Develop or support curriculum	10
Travel/trip planning	2
Immigration/ visit to Canada	2
General browsing	4
Share info with friends/clients/children	2
Other	2
Not Used	2

By correlating the user groups with the type of use, a clearer profile is created of individual user groups, as shown in the table below. This is only one attribute and can be done with more of the data collected.

Table 3 "Use of Atlas Information by User Group" data from the Atlas of Canada User Profile Summary Report, March 2005, Copyright, Her Majesty The Queen in Right of Canada.

Use of Atlas Information by User Group	Students	Teachers	Personal Users	Work Related Users	Users Browsing
Personal project or research	19%	15%	78%	12%	46%
Own school assigment	56%	11%	/	1%	4%
Work assignment or report	5%	7%	2%	64%	7%
Child's school assignment	1%	5%	3%	1%	6%
Develop or support curriculum	11%	54%	1%	13%	7%

An example of the value of the in-depth interviews is shown in the understanding of the context of use for a high school teacher. The results provide a profile as follows: a high school teacher typically uses the Atlas to find a drainage basins map, at home, in the evening, over 15 to 30 minutes with or without interruptions to find resources, printed on a colour printer, to support the following day's environmental studies lesson plan.

The outputs of this research are detailed user profiles and typical usage scenarios. A user profile would include detailed information in areas such as demographic characteristics, behaviours in site use and satisfaction and loyalty measures. A usage scenario begins with a description of why a typical user needs a product or service, their context of use, followed by all the tasks that would be carried out to fulfill that need. These are the source inputs for the product and systems design and bridge the user requirements and design stages. At this point use cases are developed, based on the usage scenarios, to support system design. A use case is a description of a sequence of events or interactions between a user and a system for a specific task. Design principals including standards, organizational guidelines, and technical requirements are all taken into account.

The third stage has two major components, the product design and the systems design, the "front end" and the "back end". Product design begins with simple concepts, paper mock-ups, and story boards. These are the first components that can be put before typical users in a usability test. The results of the testing allow design decisions to be made for improvements and the development of more sophisticated and detailed prototypes. These can then be assessed. This process is repeated and the number of iterations or cycles depends on many factors including the complexity of the product, time and funds available. Ideally, iterations are repeated until an acceptable level of completeness is achieved. Usability testing does require some financial and human resource investment but the results speak for themselves and make it completely worthwhile (Souza 2001). Systems development occurs at the same time with points of interaction based on the usability testing schedule and the inputs required from it.

Usability tests assess a participant's response to and performance on predetermined testing scenarios that are based on the usage scenarios. The testing scenarios are a series of tasks linked together to form a complete sequence of steps that a typical user would conduct. They are based on the user profiles and usage scenarios determined in the user requirements stage. Success is measured by observation and the ability of the participant to complete the tasks. Participants go through the scenarios individually with a moderator who observes and records the results. The interviews can be observed by the project team, in another room, either through one-way glass or by video link. There are no other people involved in the session and no interruptions. Participants typically talk out loud to express what they are thinking as they carry out the tasks. The combination of this and the actual observation are invaluable in understanding whether something works, how well and what issues there may be in preventing a successful result. Different testing scenarios of the same function or interface design can help to refine them. If a task is unsuccessful, analysis of the participant's performance can lead to better design decisions. The results of a usability test are objective. Design is not achieved with a usability test; design decisions are made based on them. This environment is also not suitable for subjective, opinion based feedback. Questions and comments can, however, clarify a usability issue. It is commonly accepted that six to eight participants are sufficient in assessing usability (Nielson, 1994 and Szeredi and McLeod, 2000), but not to be representative for opinion based feedback.

The release of a product is not the end of the story. Continued feedback from a broad range of users is necessary in assessing overall success. Methods of collecting this include surveys (on-line, mail, phone), focus groups, interviews and even usability tests. The UCD process aids in removing risk that permits much greater levels of success. Table 4 shows a number of satisfaction measurements from the three surveys.

The UCD process, used in part and entirety, has been implemented by the Atlas for every change, revision and new component. In many cases research for one component of the Atlas, can be used for another. For example, the results of usability testing on the thematic mapping user interface can be used in developing the Archive Mapping user interface. The result is that a single usability testing iteration was necessary to complete this new archive component. In another case when developing a new promotional poster-map series, user requirements research from the on-line Atlas and printed wall maps reduced the amount necessary for this project.

Table 4 "Satisfaction attribute" data is from the Atlas of Canada On-line Survey Reports, March 2001, March 2003 and March 2005.

Satisfaction Attribute	2004 Survey	2003 Survey	2000 Survey
Overall site satisfaction (satisfied or very satisfied)	81%	79%	63%
Overall satisfaction with interactive thematic maps (satisfied or very satisfied)	82%	71%	57%
The scope of information provided meeting needs	68%	64%	49%
Willingness to return	88%	75%	72%
Recommend the site to others	88%	79%	78%
Number of 1st time users	67%	78%	79%

11.3 The Value of the User Centred Design Process

The following lessons have been learned in implementing the user centred design process:

- Define the audience and mission;
- Organizational buy-in – spend the time selling the process internally to operational teams and management;
- Never assume anything about your users;
- Understand the UCD process – you cannot just talk to friends and colleagues and call it usability testing;
- Balance UCD needs with budget and time, strive for a functional/achievable solution; do as many iterations as time and money allow;
- Integrate it into the production process; it should not be optional;
- UCD saves money in the end;
- Remove everything that is not needed;
- Function is more important than aesthetics;
- Fast direct access to primary content is paramount;

- Have a clear hierarchy of content;
- Spend time, but not too much, on labels: you cannot please everyone. Don't assume users know what you mean – avoid jargon, select words users would understand; and
- Make the site usably dynamic.

The user-centred approach to Atlas' design and development has been invaluable. It has reduced the effect of inaccurate assumptions. Using the results of the various research methods has led to a greater level of informed decision making. The Atlas has broken away from the internal "we know what's best" cycle. In the past, assumptions were based on anecdotal comments from many sources that were inaccurate and not representative of Atlas users. UCD has provided a structured method of balancing business and user requirements. This process separates developers and development teams from evaluating their own designs and solutions therefore reducing internal bias. The net value and result is increased user satisfaction and product effectiveness by producing the right product, for the right reasons, for the right users.

11.4 Case Studies

Three case studies will be presented that illustrate the user-centred design process and the results that came from employing it. The first describes a number of general user interface design issues and the solutions that were applied to the Atlas. The second outlines the usability problems encountered with the early mapping user interface tools and how these were modified. The third describes how the user-centred design methodology was applied to the integration of topographic maps in the Atlas. This example describes why and how specific research methods were used and the type of information that was collected from each.

11.4.1 Case Study 1 – Mapping User Interface Design

The first Case Study illustrates how the Atlas' thematic mapping user interface was evaluated and redesigned using the User Centred Design (UCD) process (Miller and Pupedis 2002). The first mapping user interface design for the Sixth Edition (1999) came about as a result of the best efforts of the design team. It reflected their understanding of what would make a suitable and usable on-line mapping user interface. The arrangement of the mapping user interface components and the functions and tools all worked from their perspective. The UCD process brought to light the difference between what the Atlas' development team thought to be the right solution and what users needed and found usable. Without the UCD process, this would not have been known. The two screen captures below show the Sixth Edition's original thematic mapping user interface (1999) on the left and the version that resulted from the UCD process (2002) on the right.

Fig. 3. The original (1999) and revised (2002) thematic mapping user interfaces.

The two images in figure 3 are shown correctly scaled relative to one another. The first significant difference is the overall size. Research, undertaken in 2000, revealed that 95% of Atlas users used a screen resolution of 1024 by 768 pixels or less or their monitors, with half of those using an 800 by 600 pixel screen resolution. In addition, Government of Canada Standard Web site "Common Look and Feel" specifications (http://www.tbs-sct.gc.ca/clf-nsi/) required that all pages use a format compatible with the 800 by 600 pixel format. What is visible, using that dimension, is shown with the red outline on the user interface images in figure 3. That meant that the components of the first user interface were not completely visible and required users to scroll continuously to view and use them.

A number of issues presented themselves as a result of the layout of the user interface components. In the upper left corner of the original UI there were a series of four links to other textual, graphic and multi-media resources related to a map's theme. They were placed in this prime location to attract attention. There were two significant issues with them. First, their titles did not mean anything to users and, second, when the map was viewed they were no longer visible in the browser window. This was remedied by replacing these links with a new tool in the tool bar.

To the right of these links is the locator map. This was given a prime location to provide easy and quick reference to the user when zoomed into the map. The research revealed that users did not use the locator map and it was only partially in view when the map was in full view. In the new user interface it was made slightly smaller and given a new location in the upper right corner that reflected is importance relative to other user interface components.

The legend on the left side, while detailed and clear, presented a number of problems. Firstly, it began at a position almost halfway down the map. Secondly, it used more screen real estate than was necessary. Thirdly, it was too detailed and spread out, therefore requiring the user to scroll vertically. Finally, when the map was viewed, almost none of it could be seen due to horizontal scrolling required to see the entire map. The user requirements research also found that users really only wanted information relevant to the maps theme in the legend, not all the base map features. The new legend design corrected all of these issues as can be seen in the image to the right.

On the original interface, just above the left side of the tool bar, is a small button that allowed users to go to the table of contents and select another map. While the button was the most clear and usable on the user interface, it did require users to go to another page and follow a rather long and cumbersome process of selecting a new map. This problem was corrected with placing menus on the left side of the window. This successful solution continues to permit access to every map in the Atlas, numbering over 1400 in late 2005.

The tool bar above the map had a number of significant issues that are described in detail in the next case study. The one point to mention here is that once users scrolled down to see the entire map, the tool bar was not visible. Once out of view it tended to be forgotten and not used. The result was that many users viewed the maps only at a very small scale without the benefit of all the tools that permitted their full detail to be explored. The new user interface design changed all of this making the tools visible whenever the map is viewed.

Adopting the UCD approach allowed the Atlas design team to understand the hierarchy and varying importance of the components of its mapping user interface. The map is always the most important followed by the tool bar, legend, locator map menus and other text and links. The new design corrected the previous issues with a new focus on the hierarchy and placement. That, in turn, resulted in greater user satisfaction and growth in the number of maps being fully accessed.

11.4.2 Case Study 2 – Mapping User Interface Tools

The second Case Study reviews the development of new tools for the thematic mapping user interface. The development for the Sixth Edition user interface (1999), as previously mentioned, was done internally and without user consultation. The tools were an assortment that the development team thought would sufficiently allow users to explore the interactive maps. They functioned like most "GIS-like" tools and the team expected that users would understand this behaviour. What was discovered was that users came to the mapping user interface with a different understanding of the tools. In many cases they had little previous on-line mapping experience to guide them. The result was that many users could not use the tools to effectively explore the maps. The two biggest oversights were first, not understanding what tools were needed by users and secondly, how the tools needed to function for them to be effective and useable.

The user requirements research uncovered what features or functions users needed and expected to be available with maps on the Atlas site. In order of priority the following functions were needed:

1. Zoom in and out;
2. Print a map;
3. View a legend;
4. Move about the map; and
5. Select a specific feature and obtain information about it.

While icons are a common and intuitive feature for identifying tools and their use, they did not prove to be the sole solution to designing effective and usable tools. The research revealed that all participants, regardless of user group, felt that a label should accompany an icon. Users also indicated that some form of explanation would be useful (for example, a mouse-over, tool tip or alt tag). Consequently, the mapping tool icons have a label as well as an instruction, where needed, for their use. Usability testing revealed that users responded best to a label beginning with a verb.

The image below shows the tool bar of the original mapping user interface from July 1999.

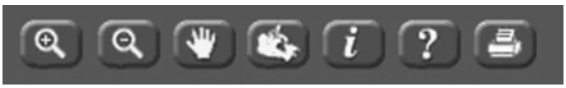

Fig. 4. The tool bar from the 1999 thematic mapping user interface.

The following image presents the new tool bar that resulted after the initial user requirements and usability research was completed in April 2002.

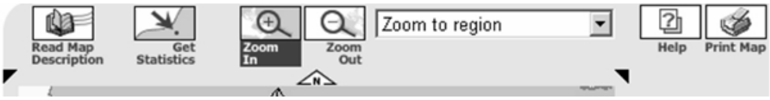

Fig. 5. The tool bar from the 2002 thematic mapping user interface.

Participants in the research intuitively clicked on the map to zoom in without making reference to the zoom tool and did not notice that it was highlighted indicating that it was the “active” tool. This was modified so that zoom in was active by default when a map appeared. The original “Zoom Out” tool worked in a standard two-step operation, one step to select the tool and a second to click on the map causing the zoom out action. Participants, however, expected it to work in a one step operation, invoking the zoom out action immediately upon clicking on the tool icon. The “Zoom Out” tool was changed to a one step operation so that when selected, the map would automatically zoom out one level, keeping the same map centre.

A zoom level indicator, that used five different sized circles, was not used by any of the participants in the testing sessions. Several printed mock-ups, using other shapes such as thin rectangles, were shown to those tested. Most indicated that the shape made no difference in their decision not to use it. This was surprising as this type of feature is commonly used by some well-known commercial Web mapping sites.

The “Pan” tool was not well understood. Participants did not know what the “hand” icon meant and as a result did not think of using it. Different icons were tested without success. The solution was to remove the tool, replacing it with eight panning arrows surrounding the map. This is a widely used solution and participants in the usability testing intuitively clicked the “arrows” to effectively “pan” the map.

When participants were required to move from one zoomed in location to another, they did not find or think of using the “Reset Map” tool. The icon used in the original interface was an image/icon of Canada. The confusion over a two step tool, as with zoom out, existed here as well and the participants required instruction on how it worked. When the “Reset Map” tool was described, participants felt it would be good to keep, even though they did not use it. Although they said this, their behaviour showed something else. They tended to want to zoom out and then zoom in, to move about the map. The “Reset Map” tool was removed from the tool bar and a “Zoom to Region” feature was added. It has a drop-down menu that includes Canada, the provinces and territories, and major cities. This was not tested, at the time, due to the available time and resources. It was successfully used on other mapping UIs developed for the Atlas and in later usability tests it proved to be a valuable tool.

The "Query" or "Identify" tool, represented by an "**i**" symbol, was interpreted as a help symbol such as in a visitor information centre on a paper road map. As a result, participants did not think of using it to get information from the map. The two step process of selecting the tool and then selecting a feature on the maps also caused confusion. The "Query"/"Identify" tool, however, could not be converted to a single step tool. A clearer icon and label were needed, as well as, visible instructions to help users. The solution that brought some initial success was to create a new icon containing an arrow and renaming the tool "Get Statistics". There was limited success with this solution, but resources did not allow further research at the time. The tool was further improved, using a different icon, label and tool tip, with much greater levels of success in the most recent tool bar.

An important component of all interactive maps is their supporting textual, graphic and multi-media resources. These describe and illustrate the map's theme and interpret the patterns appearing on it. In the initial user interface (1999), there were links to these resources in the upper left corner of the UI. Most users did not easily find these as they were presented. In further research, it was found that users responded better to a tool with a book icon and a label, "Read Map Description" (2002). User requirements research found that these resources were valued. Due to their importance, more research was carried out developing a new information model, site structure and navigational tools. The "Read Map Description" tool was eventually removed and replaced with a small, removable, floating text box on the face of the map that contained a fact from the map and a link to the complete resources (2003).

Fortunately, the "Help" and "Print Map" tools were very intuitive and did not require any modifications except a graphic enhancement to fit with the other new tools. The "Print Map" tool was slightly modified after the usability testing of the Map Archives mapping user interface (2003). It revealed that the label "Print Preview" was more accurate as the tool invoked the page to refresh with a "printer friendly" formatted page that could then be printed.

Many more improvements, using the UCD approach, have been made to the tool bar since these changes. The following image shows the newest tool bar with improvement implemented in June 2005.

Fig. 6 The tool bar from the 2005 thematic mapping user interface.

The underlying lesson behind all the interface tools' issues and solutions is that a design team is not a user and cannot replace them. When designing the tools, as well as any product or service, those for whom the end product or service is intended must be part of the design process, from beginning to end. The perspective and experience of a development team is very different from that of a user and cannot replace them. That difference must be understood, respected and applied.

11.4.3 Case Study 3 – Integration of Topographic Maps in the Atlas of Canada

The third case study profiles how the User Centred Design (UCD) process was applied to bringing an entirely new component into the Atlas of Canada. This section focuses on the application of the process, rather than the actual results. The integration of topographic maps in the Atlas came about as a result of an internal review of the various Web mapping applications offered by the Earth Sciences Sector of the Department of Natural Resources. Management felt that the public would be better served if individual Web mapping applications, serving common user groups, were integrated or merged. The UCD expertise utilized in developing the Atlas site was beneficial to the further development of the existing on-line topographic mapping product, Toporama. The primary goal was to replace and update Toporama by successfully integrating topographic mapping data into the Atlas Web site while meeting the needs of both Toporama and Atlas users. The first step taken was to complete the examination of the business requirements.

An examination of the value of topographic maps to the Atlas and the opportunity this offered was done. The Atlas' maps were mostly compiled at a small scale of 1:7,500,000 with some at 1:1,000,000. Topographic maps are at the scales of 1:250,000 and 1:50,000. Feedback collected through user requirements and usability research, over many years, indicated that Atlas users did want maps at larger scales. While topographic maps are not normally associated with a thematic Atlas, many Atlas users do in fact use them. More detailed information was required to fully understand who the topographic map users were, their needs and what the impact would be if both thematic and topographic maps were offered in the Atlas of Canada.

The first research step was to conduct an on-line survey of the existing users of the Toporama Web site to identify the user groups and their uses of topographic maps. This on-line survey would provide the remaining required information for the business requirements and the beginning of what was needed for the user requirements. The main objectives of the survey were to:

- Profile site users in terms of demographics and technology use;
- Understand users' motivations for using and returning to the site;
- Understand the manner in which the site was used;
- Understand most common usages of the topographic maps from the site;
- Measure overall satisfaction with the site and interest in current and future features; and
- Recruit participants for the in-depth interviews of the user requirements stage.

The results satisfied the business case and began the user requirements research. The on-line survey provided some initial high level insights but more specific and detailed information was needed. To achieve this, in-depth interviews were conducted with participants from each user group. The interviews were conducted in person and over the phone for out-of-town participants. The main areas of investigation for the user groups were:

- Characteristics typical of each user group;
- Characteristics of use – online interaction;
- Characteristics of use – offline interaction with topographic maps;
- Context of use – online requirements/Location Discovery;
- Context of use – output requirements; and
- An analysis of typical tasks performed by each user group.

The outputs of the user requirements research were detailed user profiles and usage scenarios. The profiles began with a description of a typical user. They established a persona around which typical characteristics could be identified. These included type of map use, experience using maps, skill level, context of using topographic maps and goals in using maps and activities. The usage scenarios began with a description of how a typical user would use the map. It then listed the specific tasks that this user followed to carry out the complete scenario. For example, it began with finding the Atlas Web site, then locating a topographic map for an area of interest, outlining what user interface tools were used, how the map was interpreted and finally how the map was output or saved for off-line use. This was followed by a description of their context of use, both on and off-line.

Once the user profiles and usage scenarios were completed, they were used as primary input for the usability testing scenarios and the systems design use cases. There was a bit of initial skepticism among the project team as to the effectiveness of this approach. The personas seemed too personal and unrepresentative of the entire user group. The reason this approach worked was that the design decisions were made based on a real user carrying out a typical task, for an actual real-life use, not a fictitious user doing an imaginary task in a made-up situation. These usage scenarios, while focusing on a specific example, were based on the research that was representative of the broader users. Informed design decisions can be made very effectively this way. This approach worked extremely well with the design of the topographic mapping user interface.

The systems design proceeded with the completion the use cases describing the step-by-step operation of each function and mapping tool in the new user interface. The interface design was based on the Atlas' thematic mapping user interface. The new functions and tools required for topographic maps that were identified in the user requirements research were identified. For example, these included:

- new tools for determining coordinates;
- measuring distances and elevation;
- a new legend style;
- manipulating the map layers; and
- search tools for searching by coordinate, map sheet and place names.

In some cases, two or three variations, of the above, were designed for the usability testing. This allowed the Atlas team to determine what designs, labels and behaviour were the most usable.

The usability testing was done in three iterations using eight participants in each. The testing scenarios, based on the usage scenarios, were kept consistent through all three testing iterations. The first usability test began with the initial design and functionality assessment using static graphic models. In this step the variations for each tool and function design were assessed using different scenarios. Design and functionality decisions were made based on the results. This was followed, in the second testing iteration, by a more refined design of the user interface components and functionality. It was evaluated using graphic models with limited functionality. The final design decisions were made and a final prototype was produced. The use cases were updated and given to the systems design team. A final pre-deployment validation usability test is planned prior to deployment in the February 2006.

The image to the left below shows the final prototype of the topographic mapping user interface at the initial view, with the search tab to the right of the map. The image on the right shows a topographic map at a viewing scale of 1:50,000 and with the scrollable legend tab to the right of the map.

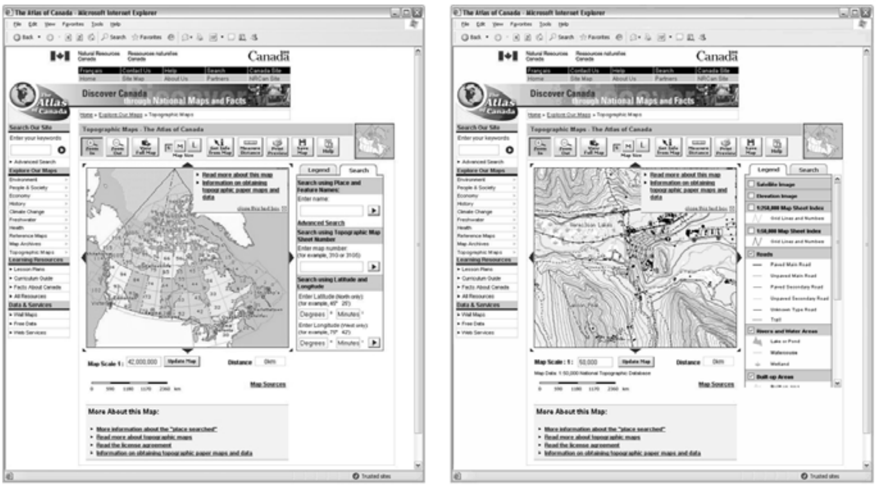

Fig. 7. The Atlas of Canada's topographic mapping user interface, 2006.

The integration of topographic mapping required the use of the entire UCD methodology. It allowed the Atlas of Canada team to understand and evaluate the user group(s), their needs for on-line topographic maps and then make informed decisions on the product built for them. The design phase allowed for usability testing that determined what tools, behaviour and features worked best for the users. There are always many options that can lead to vastly different designs. Users bring their own knowledge, understanding and know-how and it is these that must be respected and understood for a truly useful product to be developed. The UCD methodology ensures that the resultant product incorporates the most correct and usable options. That, in turn, saves time and money and leads to success and user satisfaction.

11.5 Conclusion

The user-centred design process has fundamentally changed development in the Atlas of Canada. It, in fact, brought a change in mind-set from an internalized "we know best" approach to an outward looking and more open development process that includes the end user. Questions such as: Who are the users? What do they need? and How do they use it? are now central to the Atlas of Canada's design and development process. Possibilities not previously conceived of have been developed and utilized. It has resulted in the Atlas being the right product, for the right users, for the right reasons, at the right cost.

The UCD process does add a new set of tasks to the development time line and additional costs. While these cannot be ignored in accounting for resources, the end results cannot be ignored for their value. The first two case studies show the before and after of its implementation. The cost after the fact is much higher than if UCD would have been incorporated from the beginning. Products can be evaluated, improved and refined before they are deployed. From the point of view of the user, they want the best product from the very beginning, not after the mistakes have been made and corrected. UCD removes risk by ensuring that the decisions are made using the best information.

While using the entire UCD process ensures that the most usable and successful product or service is developed, it is not always necessary to be done in entirety. Time, personnel and financial resources do not always allow this. Which parts of the methodology are needed depends on what is being researched, changed or newly developed. The Atlas' business and user requirements research has been applied to many changed or new components. Research from the development of the thematic mapping user interface has been used for others, such as the archive topographic mapping interfaces. What is important is that the relevant sections of the methodology be used as resources allow. When UCD becomes a part of the design and development process in this way, it always makes a positive difference to the end result.

The effect of informed decision making, based on research using valid and established methods, has allowed the Atlas to develop and grow with greater levels of success. This can be seen in increased and measurable user satisfaction as well as significant growth in overall use. The result has made the Atlas of Canada a more valuable resource for its users, an excellent outreach vehicle for the Government of Canada and a leader in effective geographic and cartographic communication.

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12 *Atlas of Switzerland 2* - A highly interactive thematic national atlas

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12.1 Introduction

The *Atlas of Switzerland* (*AoS*) is now a well-established cartographic product and a national brand with a wide variety of usages and applications. The second edition of the interactive *Atlas of Switzerland 2* (*AoS*) plays a prominent role in national diffusion of spatial knowledge. The atlas is based on concepts propagating adaptive maps and interactive tools in a multimedia environment. The framework also considers a graphical user interface concept and the integration of 2D and 3D maps.

An overview of the thematic *Atlas of Switzerland 2* gives insight into project management and editorial work. Furthermore, it demonstrates the realisation of the conceptual ideas and the basics of technical implementation. The features of *Atlas of Switzerland 2* are discussed in detail, placing emphasis in the 2D part on adaptive maps, the interactive tool kit and the topics. In the 3D part, visualization, analysis and navigation features are of concern.

Looking at future atlas development, the potential of interactive atlases is, even ten years after beginning, still very high.

The range of application includes schools and universities, where the *AoS* is frequently utilised for educational purposes, for teaching cartography and even architecture. Private individuals use the *AoS* as an information centre (visualization and analysis of census data, terrain features, mountains, etc.), as a planning tool for hiking tours, and for illustration purposes. More technical applications of the *AoS* in industry can be found in mobile communication, transportation industry and water management. With its 2D maps and 3D panoramic views, the *AoS* serves as well for technical, informative illustrations in various magazines and newspapers. 3D terrain visualizations were even used for a game (‘Tour of Switzerland’ by Carlit) and for political and product advertisement (voting for a new sports stadium, ads for public transport). Since the first prototypes of Edition 1 in the late nineties, the *AoS* has often been a substantial part of public exhibitions: 'Eiszeit – Zeit für Eis' 2004, 'Maps of Paradise' at the Swiss Embassy in London 2004, 'Mapping Switzerland' 2005, '150 Years ETH Zurich' 2005, to mention just the most recent instances.

The *AoS* initiated and supported several derivative products, e.g., a point of interest station at the *Bergführermuseum St. Niklaus 2000*, the CD-ROM series *Statistical Atlas of Switzerland* (Swiss Federal Statistical Office SFSO 2003ff), and a CD-ROM *Political Atlas of Switzerland* (SFSO 2004). Based on edition 2 of the *AoS*, a CD-ROM *Audio-Visual Linguistic Atlas of Switzerland* (University of Berne 2005) and the *Statistical Atlas of Switzerland* on CD-ROM (SFSO 2006) are actually planned.

For its GUI and cartographic design as well as for the categories of interactive functionality and didactic capabilities, the *Atlas of Switzerland* has won several national and international prizes.

12.2 Brief history of the *Atlas of Switzerland*

The *Atlas of Switzerland* is really a success story. Since its start in 2000, more than 20,000 copies have been distributed. While the first edition was sold 14,000 copies, the second edition reached 6000 copies within the first year of publication.

The first digital edition, the *Atlas of Switzerland – interactive* (2000) was conceived with the following characteristics and principles:

- CD-ROM in four languages (German, French, Italian, English) for Mac and PC;
- Run-time edition with plug & play;
- Graphically and cartographically well designed product;
- 250 highly interactive statistical topics and a 3D part with panoramic views and block diagram representations;
- Basic tools for map and terrain visualization and explorative analysis; and
- Time-line for temporal map analysis.

The second interactive edition, the *Atlas of Switzerland 2* (2004), has undergone in an evolutionary sense a fundamental graphical and technical redesign (fig. 1). In addition to the first edition, it contains the following main features:

- CD-ROM and DVD edition;

- More than 1000 map topics. Update of the 250 statistical topics, adding another 100 statistical topics, and 650 topics from the field of ‘Nature and Environment’;
- 2D section. New map types (raster and symbol maps, etc.), advanced analytical tools (comparison), amplified base map and geographic information;
- 3D section. Smart navigation tools (‘climber’, etc.), multiple layer overlay, advanced visualization modules (analytic, cartographic, photorealistic);
- Multimedia elements. 600 text panels, hundreds of pictures, sound and video;
- Visualization attribute export to store the map setting; and
- Image export and printing.

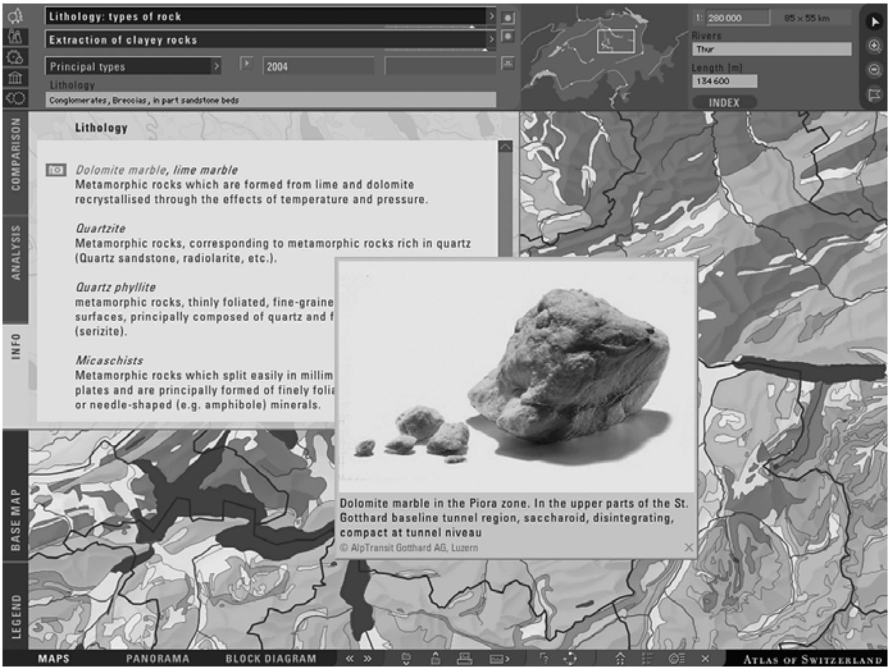

Fig. 1. Graphical User Interface ‘Atlas of Switzerland 2’ 2D part with information panel.

How was this achieved and managed? First of all, a ‘user-centered’ vision was followed, keeping the ‘useful’ visualizations and interactions at the centre of thinking, designing and programming. In contrast, many other interactive atlases and maps on the Web often use a technical driven approach, resulting in Geographic Information Systems (GIS) - like tools people do not understand.

The second item of success is ‘quality’. Quality has to be understood not only in a cartographic sense, but also as overall graphic quality, thematic consistency and depth, and even as quality in technical design and implementation.

To fulfill these demands, it needed, as well as funding and a winning team, much time and patience!

12.3 Basic concepts and other thoughts

The basic idea of the *Atlas of Switzerland* is communicated best with the metaphor of the atlas as a ‘story book’. It should present a framework that users get familiar within a few moments. The atlas ought to make them feel comfortable – whether they are laymen or experts eager to be immersed into the stories, to take a journey without getting lost in space (serendipity effect). On these journeys the map is always the starting point for investigation and provides the main metaphor; it acts as an anchor. But the map also represents the completed product and the result of the investigation is always shown cartographically. Then, with sophisticated maps and easy-to-use tools to explore the thematic and topographic Swiss world in 2D and 3D, the atlas can fulfill not only user curiosity, but also meet their demands.

To realise these main objectives, various concepts and approaches have been elaborated upon during the last ten years of atlas work. In the following sections we provide a short overview of atlas considerations.

12.3.1 GIS in Multimedia

Dealing with interactive atlas applications, there are basically two methodological approaches: ‘Multimedia in GIS’ and ‘GIS in Multimedia’ (Craglia and Raper 1995). While ‘Multimedia in GIS’ means that atlases run in a GIS environment adding multimedia functionality, the ‘GIS in Multimedia’ approach is based upon an authoring system; navigational and analytical functionality have to be added.

The ‘story book’ idea of the *Atlas of Switzerland* strictly calls for the ‘GIS in Multimedia’ approach. Choosing this concept implies time-consuming programming of all interactive map functionality by the atlas authors. A big advantage is that navigational, visual and analytical functions are assembled and assimilated according to the atlas users’ needs.

Now, powerful digital atlases should not only be able to analyse, process, and model multi-dimensional and spatio-temporal data, they should also focus on excellent graphics and high cartographic quality (Bär and Sieber 1999). Therefore, any geometry data, in vector and raster format, for the *AoS* undergo a cartographic refinement process. As a result, the visualization of the map elements can run in an intelligent way and accord to sound cartographic principles.

12.3.2 Adaptive Map

Interactive maps and 3D representations in a ‘GIS in Multimedia Cartography’ environment require an intelligent organisation and visualization of map graphics and a flexible connection with the attribute data. The ‘Intelligent Map’ concept (Hurni, Bär and Sieber 1999) follows these principles. In the meantime, it has been constantly refined, and its focus shifted to adaptive techniques. Focussing on interactive atlas maps, we therefore propose a new concept - ‘Adaptive Map’. The Adaptive Map concept is realised by means of self-acting, pre-defined settings and interactive processes. The ingredients are numerous, ranging from layer management and self-acting adaptive zooming to cartographic quality aspects.

Adaptive zooming can be described as continuous and smooth zooming, always maintaining the same map element density and providing more detailed information when zooming in. For the *Atlas of Switzerland* this means that all base map layers need to be available in two map scales, and within one map scale up to three density levels. Furthermore, zoom-in makes thematic point symbols enlarge more slowly than the overall map zoom factor, leading to less symbol concentration in otherwise crowded map areas.

Layer management also deals with the concept of ‘active/passive’ layers, letting the users steer the activity mode of the layers, and also with ‘hidden’ layers. In the latter case, thematic layers do not appear in the main menu, but can be visualised as an associated second map layer. Thematic or topographical information may be accessed by means of underlying assistant ‘invisible’ layers, thus providing a comprehensive query system. Regarding queries, the concept provides the foundations for multiple simultaneous queries.

Cartographic quality in an adaptive map is a combination of self-acting, pre-defined settings and interactive processes. Layer consistency, screen-adapted symbolisation methods and anti-aliasing are prerequisites, while other parameters of visualization (e.g., transparency and colour gradients) could be altered in an ancillary way by the users.

All-in-all, the ‘Adaptive Map’ concept fits for any map type (vector and raster maps, 2D and 3D maps) and thus for heterogeneous layer, but it works with an almost overall homogeneous functionality. The ‘Adaptive Map’ concept provides one of the prerequisites for a fully interactive atlas. To deal with such adaptive maps, a tool kit with interactive functions for visualizatio , navigation and analysis has to be provided, as well as a consistent but flexible GUI.

12.3.3 Graphical User Interface

The Graphical User Interface (GUI) plays an important role in information acquisition and in transforming this information into useful knowledge. In an atlas, *information access* can be achieved in many different ways, but is most efficiently done via maps, topics, multimedia, didactics, or even language.

Since an atlas is understood as a formal compilation of maps, the map should always dominate the GUI. This requires an appropriate *segmentation* of the screen surface, a strict *modularisation* of the GUI elements, neat *interaction* possibilities between GUI elements, and high *consistency* of content, graphics, actions and feedback.

Segmentation is merely accomplished in a functional sense. According to the basic conceptual framework, five main functionality groups can be distinguished: Thematic navigation, spatial navigation, visualization, analysis and general atlas functions (print, export, etc.). These groups are implemented in the *AoS2* as corresponding atlas segments. For example, the spatial navigation segment includes a reference map, displays coordinates, height, directions etc., and provides indexes of map elements, pins and other orientation tools (fig. 2).

Modularisation means that the GUI is organised in a shell/content manner (Huber, Jeller and Ruegsegger 2005). The shell of the atlas consists of a variety of independent but linked modules, while its content is treated separately.

GUI interaction can be subdivided into internal and external facets. The atlas should allow for dynamic adaptation of the GUI to different screen sizes, considering any standard formats. The *AoS2* is designed for screens with 1024 x 768 pixels or higher. Another internal interaction category is about decisions whether, when and in what way to close windows or panels when overlapping. External interactions can be subsumed under the keyword ‘feedback’. Every action of the user has to be followed by an immediate reaction of the system (wait cursor, different status of buttons - active/inactive, etc.). In an atlas, this feedback should be given whenever possible in a cartographic way, for example by using the map to visualise search results, or the map preview for navigation and orientation.

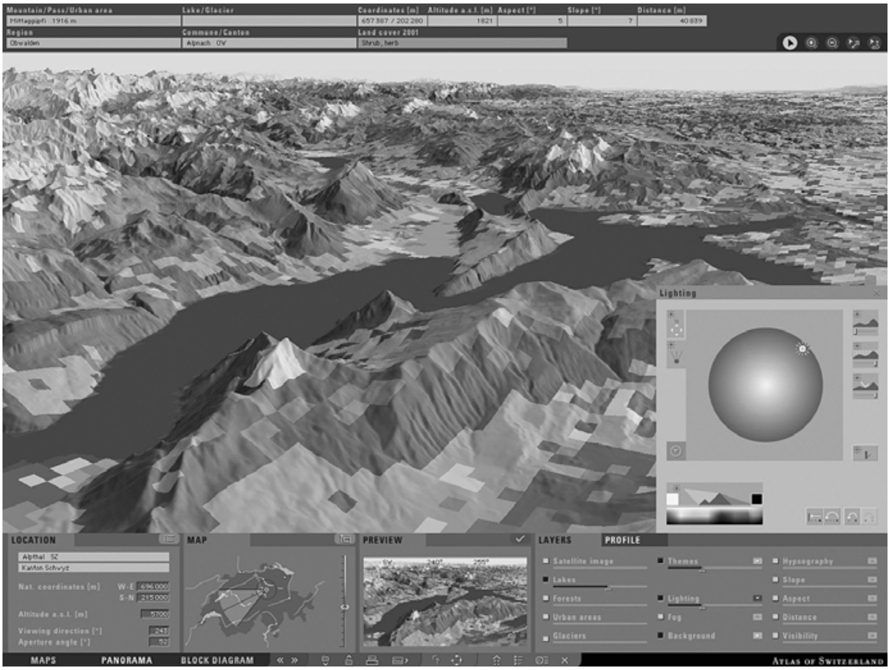

Fig. 2. Graphical User Interface 'Atlas of Switzerland 2' 3D part, panoramic view.

GUI graphics are the essential link to the user. The 'look and feel' should be both pleasing and unique. We propagate an unobtrusive overall design, clearly distinguishable from other applications and from the map itself. GUI fonts and icons should be easily readable, and colours have to be discreet. In the *AoS*2, the dark blue colour communicates a sophisticated product with reliable, interesting information.

Consistency affects nearly every facet of the atlas GUI, whether it is thematic content, tools, graphics, actions or feedback. A crucial point is the consistency between functionality and usability (what does the user expect?). In an atlas with 2D and 3D maps, the consistency between the map modes is also a concern.

12.3.4 3DThinking

The *Atlas of Switzerland* integrates 2D maps and 3D maps (Huber and Sieber 2001). In the long run, the gap between 2D and 3D should be closed as 2D maps are only a special case of 3D maps. Most of the navigation and analysis tools could be approached in the same way. Even the user interface might look and act in the same way. Navigation – defined as “the overall process of motion and wayfinding” – becomes a central feature of interaction. 3D navigation can be given or interactive, or, alternatively, discrete or continuous. The concept of ‘3D Thinking’ in interactive atlas navigation results in user-friendly solutions, which allow for a smooth transition between 2D and 3D maps and for easy 3D navigation, with no orientation loss.

As 3D maps have become widespread the concept of visualization methods for 3D (2.5D) surfaces has been developed (Huber, Sieber and Wipf 2003). The visualization module approach is based on independent modules (like aspect, lighting, etc.) that can be combined. First the rendering engine calculates for each pixel the 3D coordinate and the surface normal; secondly for each pixel a colour value with alpha channel – allowing semitransparent colours – has to be determined. A single visualization module like hypsography provides a colour value. The weighted average of the colours of all activated visualization modules is the colour value requested. Visualization methods can be classified on the basis of four criteria: spatial dependency (local vs. global), calculation base (coordinate value, surface normal, etc.), dimension of colour values (constant, dual, 1D, 2D), and optional additional parameters (e.g., point, vector). A visualization method specified by the criteria is a base type. Specified for thematic uses a single base type or a combination of base types builds a visualization module. The visualization module may own specific analysis and visualization tools. The combination of visualization modules is a powerful analysis tool. For example, avalanche risk regions can be modelled using hypsography, aspect, and elevation.

12.4 Organisation and implementation

The *Atlas of Switzerland* is a joint venture by different academic and administrative groups, currently within a ten-year period from 2000 to 2009. This decade of the project is basing on a business plan formulated in the mid-nineties. In the following sections, the *Atlas of Switzerland 2* (*AoS*2) with respect to project organisation, management and workflow is described.

12.4.1 Project organisation

A Steering committee with members from ETH Board, ETH Zurich, swisstopo, and SFSO manages the global project with respect to supervision and financing. The Atlas team ETH Zurich is responsible for project management, software development, GUI implementation, data acquisition, editorial work, cartography, prototyping, mastering, related teaching and research.

An affiliated Atlas group of swisstopo Wabern deals with cartography, multimedia, marketing, product manufacturing and distribution. SFSO Neuchâtel serves as a main statistical data provider, and does the translation of statistical topics.

A small company, Duplex Design, Basel, is responsible for graphic design of the GUI. Over 50 data owners mainly from public administration provide statistical data, geometry and multimedia elements. And finally, more than 20 professional translators are involved in the project.

All these activities between the different contributors are coordinated by the Atlas team ETH Zurich.

12.4.2 Project setup and management

Each project phase of the *Atlas of Switzerland* begins with a two-day *start-up meeting* in a location away from daily business activities. The aim is to discuss long-term objectives and the main focus of the planned atlas edition, new technologies and – last but not least – to build team spirit. The main result of this meeting is a brainstorming list, with future thematic and functional features outlined. The list contains possible new or extended functionality of the atlas edition in a rather unstructured way.

In the next step the project framework is established. It defines the overall structure and the content of the atlas. The functionality is more precisely defined and the wish list is structured in a hierarchical way. The project framework and its content are updated constantly during the prototyping phase.

On a more concrete level, a storyboard with typical applications and scenarios is created, containing sketches of GUI elements and atlas layout. In parallel, technical investigations and definitions concerning multimedia platform, etc. are undertaken. Then, a roadmap with milestones sets the timetable for the project. These steps are of great importance for the whole project because they define the route of the planned atlas. The decisions made at this point should not be altered at a later stage.

After this, editorial work and prototyping takes place. At the same time as the editorial work, technical prototyping is of main concern. As both editorial and technical prototyping take up a big part of the project's time – for example, more than two years for *AoS*2 –, they are described in detail in the following sections. As a matter of course, prototyping is an iterative process, refining all quality categories mentioned in the concept section.

As per team working in parallel, the collaboration of the team members is highly simplified using a version control system both for software development and data handling.

Prototyping is accompanied by testing and after each prototype milestone is met, functional tests or usability tests are conducted. The results of these tests lead to technical and graphical corrections and adjustments. In fact, prototyping and testing complement each other.

In the last six months, the atlas was tested at 'Beta-Version', 'Release Candidate', 'Ready for Publication' and, finally 'Official Publication' with an associated press conference.

12.4.3 Editorial workflow and prototyping

Editorial work is handled in three main phases: familiarisation (with themes, owners, topics and data), refinement (data structuring, cartographic) and implementation (geometrical and numerical data, map descriptions, multimedia elements). First of all, the editorial group has to carry out investigations on themes and topics. Questions about main themes, possible data sources, data quality, data availability, spatial and temporal resolution are addressed. Information is gathered mainly from experts, publications and newspapers. After familiarisation with the potential topics, data owners are contacted. Presenting ideas, maps and sketches is very important to communicate the project's mission, and to get a contract for test data and multimedia features.

Data acquisition includes the definition of the data wanted and the delivery of geometrical and numerical data. Once the data is delivered they have to be controlled and structured. The structuring process includes data harmonisation, data completion (adding missing values and additional information), and data recoding. Geometry data often needs thorough cartographic refinement and always needs preparation for an adaptive map application. At the same time, the potential of the data has to be understood. The authors have to evolve a strategy how the data can be turned into a map that fits into the atlas framework.

Data implementation is done by using XML-based map description files, which fully qualify topics. The ongoing software development does not affect data implementation. Multimedia elements are collected, edited and integrated in the atlas prototype. Whilst textual information has to be at a popular-scientific level, pictures and tables need additional remarks and copyright information added. Most of the text is delivered in only one or two languages. Professional translators acquainted with the topic provide translations. Finally, to get feedback and to develop a well-founded proof of concept model, the editorial team discusses the results with data owners and other experts at different stages of design and production.

12.4.4 Technical implementation

The technical implementation of the *Atlas of Switzerland 2* needs to take into account several prerequisites and guidelines, namely:

- Provide an overall graphical user interface design, which hides the system user interface;
- Use a common operating system (Mac *OS 9* and *X*, *Windows 98* and newer; with five years backward compatibility);
- Work within a multilingual environment;
- Give fully separate 2D and 3D 2D and 3D part of the atlas, as the CD-ROM version contains two disks;
- Offer full screen display with adaptive layout;
- Ensure that editorial staff and software developers work side by side;
- Consider that the development is a highly iterative process; and
- Be prepared for derivative products.

These demand a highly modular software design to achieve extensibility, and reusability. Operating system related differences need to be isolated and minimised. The *AoS*2 is conceptually split into three sections (GUI, core and data); the interfaces between these sections are kept as lean as possible with strictly defined, consistent interdependencies (fig. 3). As derivative products need to be supported, the interface shell is largely separated from the interface content (Huber, Jeller and Ruegsegger 2005). As mentioned earlier, XLM-based files fully qualify topics.

Both 2D and 3D parts of the *AoS*2 work independently but they are linked. The introduction, multimedia information elements and most of the GUI of the main sections have been implemented using the Macromedia *Director* authoring system. *Director* has an open architecture, allows free graphics design, and supports cross-platform development. The *Director* section was written in ‘Lingo’, *Director’s* object oriented scripting language. Shared sections of the 2D and 3D part are placed into independent, so-named, ‘Casts’.

Everything else (the larger part), maps on demand (2D and 3D), more complex widgets (for example, the map legend), all data handling and printing, as well as handling the multilingualism were written in C++ using the software-development tool suite *Metrowerks CodeWarrior* (*Macintosh* and *Windows*). The 2D and 3D sections share much source code organised in a cross-platform framework. For each section, a dynamic C++ library was built. The C++ libraries were added by lean 'Xtras', Macromedia's plug-in interface.

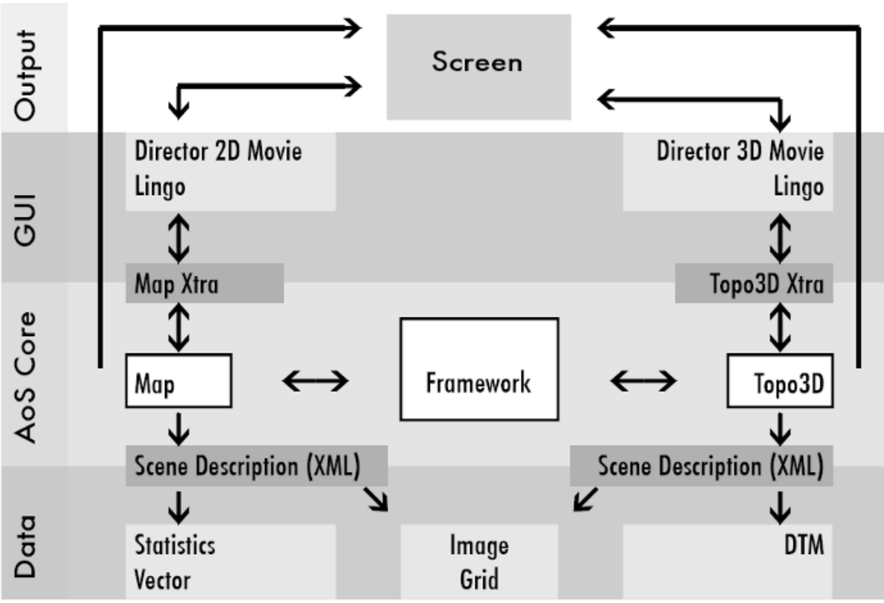

Fig. 3 Modular implementation of 'Atlas of Switzerland 2'.

12.5 The 2D world: maps are beautiful

The 2D map section of the *Atlas of Switzerland 2* (fig. 1) contains maps covering over 1000 topics. In total there are more than 7000 maps. Topics are accompanied by multimedia elements and tools for visualization, navigation and analysis is offered.

12.5.1 The adaptive map

The adaptive map assembles many cartographically prepared, anti-aliased map layers of different types. Two content groups are distinguished - base map layers and thematic layers. Eighteen base map layer groups can be combined in any number of ways, allowing the base map to be adapted to the topic such as cities and villages, lakes and rivers, glaciers, railways, roads, forests, boundaries, mountains and passes, contour lines, relief or satellite image. Up to two potentially active thematic layers (one is active at a time) can be added as well as so-called 'mute' layer, which contains non-interactive graphics. In order to support adaptive zooming, a base map layer group consists of two scales. Within one map scale there can be up to three density levels, for example, the layer 'river' consists of five complementing layers. This is done beginning with the first sub-layer of major rivers at a scale of 1:1,000,000 and accomplishing the full river network with the fifth sub-layer of tiny creeks at 1:500,000.

From a technical point-of-view raster and vector based layers will be defined. Raster based layers are either non-interactive images like satellite imagery and relief, or thematic raster maps (Ruegsegger, Schmid and Sieber 2004). The thematic raster maps can be interactively queried, classified (depending on the level of measurement of the data) and coloured. Vector based base map layers can be queried only. The most important vector based thematic layer types are the choropleth layer and several types of point symbol layers. These can be interactively queried, classified, and coloured as well.

12.5.2 The atlas 'tool kit'

The tool kit includes all tools used to interact with the adaptive map. Different tools handle different visualization, navigation, analysis and query-related tasks, whereas tools may partially combine tasks from different functionality groups. The following summary explains the capabilities of most of the tools in the 2D section, while 'thematic navigation' will be discussed in the section following this.

'Spatial navigation'. The reference map with a resolution of two kilometres per pixel shows the mapped area and this can be altered. The map itself serves as a more accurate navigation tool. There are three modes - pan, zoom-in, and zoom-out. The rectangle selection tool is designed to select the map area to zoom-in. The scale can also be changed numerically.

'Gazetteer'. An index contains a list of names of places or areas relating to the map topic, as well as terms used on the base map. The object moves into the centre of the map by clicking on the name. All these navigation features of the 2D section are only a subset of the 3D navigation features. Visual ‘pins’ store ‘favourite’ positions for later recall.

‘Queries’. Virtually all objects of thematic and base map layers can be queried. The 2D section provides for a thematic map of up to four map-defined fields.

‘Legend’. The legend adapts itself to the map types and shows all thematic map layers. A few maps, like geology, are highly structured, with many levels of information presented, and their legends have to be organised hierarchically. Legends provide the potential for interactivity. The objects of the map that have been already queried are highlighted in the legend and a mouse click in a legend field temporarily converts all the other objects on the map to greyscales, highlighting the objects selected. The base map tool allows a choice of base map layers.

‘Analysis tool’. Individual cartographic representations can be created for analysis and visualization by assigning other colours or a colour gradient to classes. In addition classes are added or removed and class boundaries can be moved. If possible, the classes are represented by a histogram. Basic statistical analysis is also provided. The level of measurement or limited availability of the map data may restrain the functionality. For example, nominal data only supports colour assignment.

‘Comparison’. Individual map objects can be easily compared. A mouse-click on the map causes the value to be represented as a coloured bar (fig. 4). The bars are ‘sortable’ by name and value. The ten objects containing the largest or the smallest value can be represented as well. Again, the level of measurement of the map data may restrain the functionality. If the theme on the map, or the time span or period is changed the selected items are retained for further comparisons, if possible. The comparison tool also offers a navigation feature. A mouse-click on a bar temporarily highlights the map object and moves the object, if necessary, to the centre of the map.

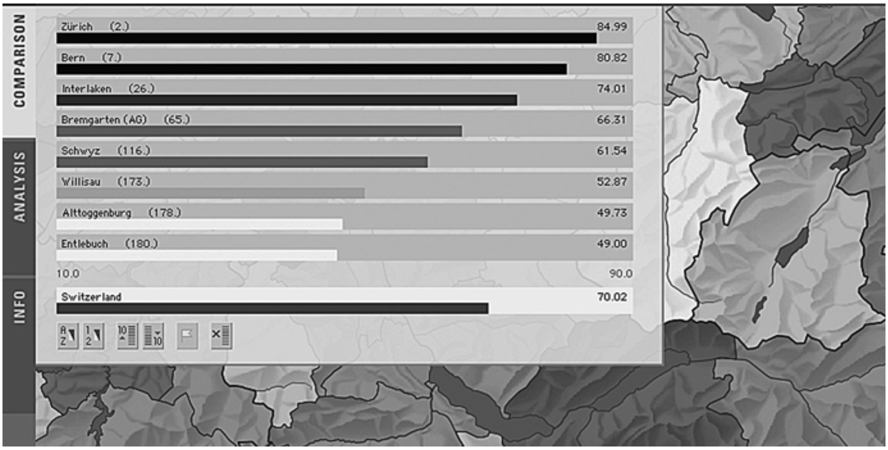

Fig. 4. Comparison tool as an example of 'Atlas of Switzerland 2' tool kit.

'Second map'. There are several ways to combine and compare two maps – 'side-by-side' display, 'alternating map' display, map overlay, etc. The *Atlas of Switzerland 2* offers map overlay whereby only one of the maps is active at any time. The transparency of the two maps can be individually adjusted in order to control the visual weight of each map.

12.5.3 Topics

The essence of a national atlas is the topics. As stated previously, the *Atlas of Switzerland 2* covers more than 1000 topics totalling more than 7000 maps. The largest domain is 'Nature and Environment' (over 650 topics) covering weather and climate, geology, soil, water, ice and snow, landscapes, flora, and fauna. Additionally, more than 350 statistical topics cover society, economy, state and politics. Several of these topics are also treated in a European context. The topics have been derived from dozens of sources.

Topics may provide several spatial resolutions (e.g., communes, districts, and cantons) and time spans or periods (e.g., monthly temperatures). Changes can be displayed in the form of an animation. Each map offers a few edited so-called second maps for combination. Second maps are thematically related and cartographically qualified – colour ranges and layer types (e.g., point symbol map onto choropleth map) differ. While statistical maps are virtually always point symbol maps or choropleth maps, more than half of the maps of the domain 'Nature and Environment' are raster maps.

Topics can be selected hierarchically (four levels) using thematically-arranged menu (*thematic navigation*). On each of the four levels, there are on average seven topics. As well as the topic selected, spatial resolutions and time periods can be changed on the theme panel. As a shortcut closely related topics can be selected on the theme panel without opening the menu. Once the topic has been changed, the *AoS*2 tries to find the best matching of spatial resolution and time period.

Some topics may not be intelligible to all, or the user simply may want to learn more about the topic background. If this is the case, additional information is most valuable. In this regard multimedia atlases are very flexible; they can provide different media. The *AoS*2 contains an information panel that is linked to the active thematic layer. It provides brief informational text about the topic depending on how the topic links to other multimedia elements. A total of over 600 pages of text, hundreds of photos, tables, sounds and videos will be offered.

12.6 Switzerland in 3D

As mentioned earlier, '3D Thinking' needs to be implemented to close the gap between 2D and 3D. The guidelines for the 3D section of the *Atlas of Switzerland 2* are that it must contain easy-to-use spatial navigation, have high rendering quality and use powerful visualization methods. Two types of perspective views are provided - block diagrams (figure 2) and panoramas.

12.6.1 Visualization and analysis

High rendering quality was achieved by high-resolution terrain and overlay data (up to 25 m) and powerful rendering methods. The *Atlas of Switzerland 2* rendering engine uses a ray-tracing method. Multi-resolution representation of terrain and overlay data accelerates the rendering process and improves the representation. As ray-tracing with high-resolution data is rather slow, a small preview image is integral part of the interface.

Thematically determined visualization methods are encapsulated into the product as visualization modules. The *AoS*2 contains a wide range of analytical, cartographic, and photorealistic visualization modules. Different modules can be combined. As the corrected weighted average of the colours of all activated visualization modules determines the final colour, the visual weight of each module can be specified. The majority of the modules offer additional settings and analysis tools. As regards to content, two groups of modules can be distinguished. These are analytical modules, exclusively based on the terrain model data itself (a few modules use additional parameters) and overlay modules that assign various 2D data onto the 3D map as textures.

Overlay of 2D data includes topographic data like lakes, forests, urban areas, and glaciers. Besides a satellite map module makes photorealistic 3D maps possible. A further forty topics qualified for 3D visualization from the subject areas atmosphere, lithosphere, hydrosphere and biosphere, and were implemented as 3D thematic cartography elements. In the 2D section individual cartographic representations can be created for analysis and visualization by assigning other colours or a colour gradient to classes. In addition classes can be added or removed and class boundaries can be moved.

Analytical modules with local spatial dependency are hypsography, slope, aspect, background (haze), fog and lighting. Visibility and lighting with cast shadows have global spatial dependencies that demand intricate calculations. The calculation bases are 2D coordinates for distance and background (haze), altitude for hypsography and fog, surface normal for slope and lighting, 2D surface normal for aspect and 3D coordinates for visibility. Lighting requires a light vector as an optional parameter. Distance and visibility need a point that can be selected on the 3D map. The colours of all analytical modules can be interactively altered, so five analytical modules offer the same features as the thematic overlays.

Among the further settings two are of special interest. Lighting offers a time and date selection tool to calculate the direction of the sun. A camera-related lighting method (keeping the angle between line of sight and light vector constant) for panoramic views generates artificial lighting.

Extracting vertical profile cross sections of the terrain is a well-known visualization method (fig. 5). The intersection points can be interactively selected and edited on the 3D map. The resulting intersection path is linked with a profile map that may contain not only the altitude but also thematic data. During queries the intersection path or the profile map, altitude, base map entries like mountains as well as thematic data are displayed on the profile map. The current position is marked on the 3D map.

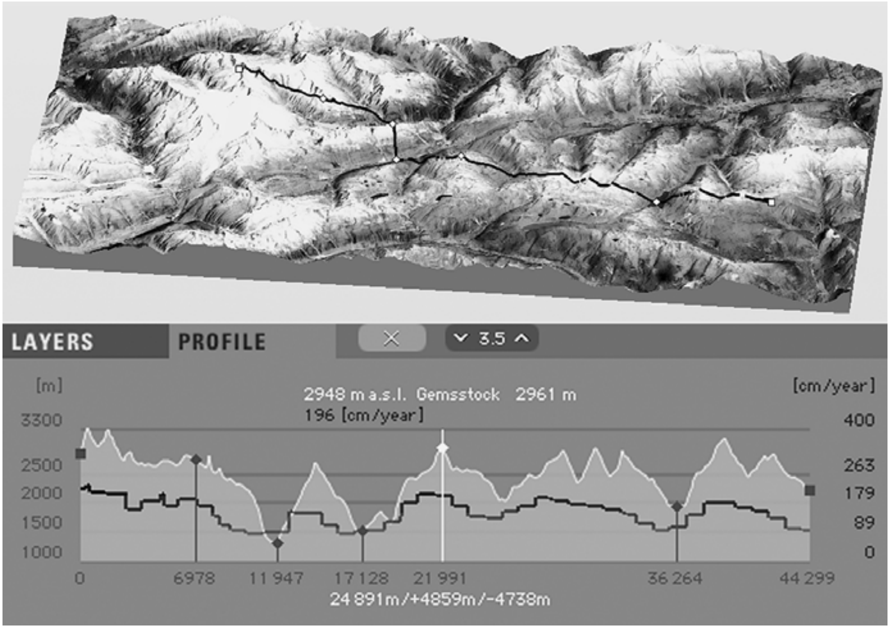

Fig. 5. Terrain profile from a panoramic view.

12.6.2 Navigation

Easy wayfinding demands constrained and intelligible navigation modes (e.g., stabilized horizon in panoramic views), The *Atlas of Switzerland 2* offers several discrete or continuous navigation modes in 2D or 3D space and huge lists of viewpoints. In 3D space a small preview image supports, amongst other things, interactive-continuous navigation. Related to navigation, two frames of references can be distinguished: exocentric (external view – appropriate for block diagrams), and egocentric (self-view – appropriate for panoramic views).

The preview image serves as a continuous navigation tool. The block diagrams can be rotated around two axes by mouse-drag. The rotation about the x-axis (in world coordinates) is constrained so that block diagrams will never be inverted. The selected area can be shifted using keys. Finally, a combination of mouse-drag and modifier key offers continuous zoom. The panoramic view can be horizontally rotated (yawing) and vertically shifted. Further degrees of freedom are handled either by mouse-drag combined with a modifier key, or by combinations of keys (vertical transformation of the camera (altitude), forward translation with a ground-level option - the camera follows the terrain, and zoom-in and zoom-out).

The 3D map itself serves as an accurate navigation tool. There are five modes: shift; zoom-in; zoom-out; position and line-of-sight; and ‘climber’. ‘Shift’ only provides for continuous movement (dragging) of the 2D image as long as the newly rendered image fits the moved image. For block diagrams only horizontal and vertical shifting is provided (2D map related). For panoramic views yawing (horizontal rotation, camera related) and vertical shifting accomplishes this criteria. The preview shows the resultant 3D view of the other navigation modes. Both block diagram and panoramic view support zooming. The rectangle selection tool is designed to select the 3D map area to accurately zoom-in. In panoramic view mode, a new observation *position* can be inserted directly into the terrain, while a suitable line-of-sight can be continuously selected with the arrow (fig. 6). The ‘climber’ (alpinist) mode accesses the mountain database. In panoramic view mode, the position can be placed on the top of a mountain. In the block diagram the selected mountain is centered. The position mode has its own climber variant, where a ‘modifier’ key moves the position to the top of the selected mountain.

A 2D map in two resolutions (2 km, maximum 500 m per pixel) serves as a navigation and orientation tool. It shows either the block diagram area, or the camera (position, line of sight, field of view) of the panoramic view. All parameters can be altered interactively.

In addition to the navigation modes in 2D and 3D space further navigation features are available. Whilst navigation in 2D or 3D space requires spatial sense, selecting predefined viewpoints from lists is a simple but limited way to navigate. The *AoS*2 offers several lists of viewpoints including mountains, passes, communes, etc., totalling nearly 7000 viewpoints. The resolution of the 2D reference maps is limited; with the large map has a maximum resolution of 500 m per pixel. Thus accurate values for all camera parameters can be put in text fields.

Extensive simultaneous queries facilitate navigation and orientation in 3D space. All objects of the hidden base map layers can be queried. Geographic regions, administrative entities (communes and cantons), urban areas, mountains, glaciers, passes and lakes are available. Terrain related queries include for each pixel on the surface altitude, national coordinates, aspect, slope, distance from the camera (panoramic view), and, if available, thematic information.

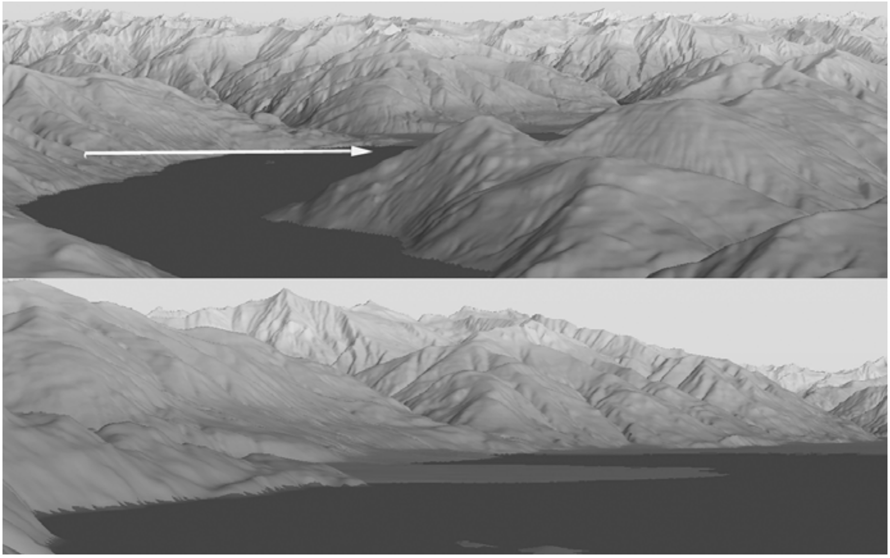

Fig. 6. ‘Navigation’ mode ‘position’ and ‘line-of-sight’.

12.7 Conclusions and outlook

The *Atlas of Switzerland 2* provides many requested features for interactive multimedia atlases in a now mature edition. The conceptual framework and modular design allow for sophisticated map authoring and future functionality extensions.

During its 10-year plan the *Atlas of Switzerland* will consecutively cover the main subject areas of interest. Each edition of the *Atlas of Switzerland* has a main theme for identification purposes. The *Atlas of Switzerland 2* provides maps from ‘Nature and Environment’. Edition 3 will treat ‘Traffic, Energy and Transportation’, and a further edition will focus on ‘Culture and History’.

Functionality development within the *Atlas of Switzerland 3* will include visualizations of multivariate point symbols and diagrams and network maps. Extended 3D visualization methods (sky, clouds, the moon and stars, waves and reflections) and 3D vector element handling and statistical 3D surfaces will also be part of the work. The atlas will offer new tools like user-defined labelling and advanced colour mixing, as well as the integration of external statistical data and GPS tracks. GIS techniques like selection and aggregation will be added. With a smart legend approach, the merging and augmenting of a legend and the provision of analysis tools (Sieber, Schmid and Wiesmann 2005).

Concerning future delivery platforms and product lines, interactive atlases will migrate to atlases on the Internet, to atlases for schools, or to extractions for regional atlases and tourist areas. Together with the *Atlas of Sweden* (Cramér and Arnberg 2005) the *Atlas of Canada* (Kremers 2005 and elsewhere in this book), the *Atlas of Germany* (Hanewinkel and Tzschaschel 2005) and many more, the *Atlas of Switzerland* has already established itself as a contemporary atlas product.

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13 AIS-Austria – An Atlas Information System of Austria

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13.1 General Overview

"AIS-Austria – Atlas Information System Austria" is a cooperative scientific project with the goal of developing an online system that enables the user to explore national (Austrian) as well as international (European) statistical information. Users can compare and analyse data and visualise the selected information in a high-quality cartographic environment. AIS-Austria is a synthesis of Cartography, Geographic Information Technology, Multimedia and Statistical Analysis. The integration of these domains is being developed in an environment where interface design, map design and multimedia programming operate independently and coherently. To ensure that this can happen, access to up-to-date and homogenised, spatially distributed statistical data is essential. AIS-Austria offers a powerful and efficient way to view various spatial aspects of Austria and the European Union.

The pressure on specialists, dealing with geo-data nowadays is steadily increasing, due to the ever increasing amount of information being processed. This can result in an overload of information with little use for specific queries. In order to alleviate the mounting frustrations created when trying to locate certain details using conventional methods, information systems can offer suitable solutions by applying systematic extraction. In order to evaluate the output in an appropriate, spatial way, it has to be displayed in a suitable and adequate cartographic manner. One of the crucial aspects of cartographic visualisation is to emphasise and stress optical representation. The aim therefore is to provide insight in variable spatial data and point out their connectivity.

New technologies have an increasing impact on the way we perceive things and obtain information. The Internet based “Atlas Information System Austria” is an innovative example of this development.

On behalf of the Austrian Conference on Regional Planning (ÖROK), the AIS-Austria consortium members (University of Vienna - Department of Geography and Regional Research, Technical University Vienna – Research Group Geoinformation and the Austrian Institute for Regional Studies and Spatial Planning) have assembled a prototype that provides a unique multimedia-based application. This tool is being used for developing a feasible approach for further improvements including a framework to present national statistical information at various regional levels. The primary source for this data is based on federal statistical and environmental data. AIS-Austria is a product that, as well as providing a number of possibilities for statistical data processing also considers spatial aspects and ensures high-quality cartographic visualisation of the subsequent results.

Cartographic design issues as well as the visualisation of geodata play an important role in an atlas information system. They are essential for spatial communication and for effective perception of information. Therefore, high quality cartographic visualisation is fundamental to ensure an optimum usability of available geodata. For these reasons cartographic design issues have to be addressed in order to control spatial depiction. Cartographic design and composition of specified signatures as well as the means of presentation should fit all representations and must always guarantee construable and legible visualisation. On the basis of these specific cartographic considerations the general conception of an atlas information system as well as the AIS-Austria portal will be discussed.

Geographic Information Systems (GIS) and cartographic visualisation incorporate an elaborate way of capturing, analysing and visualising georelevant phenomena. The symbiosis of cartography and GIS is the perfect approach for dealing with complex thematic data, enriched with spatial information. The intention of using GIS functionalities is to provide analysis tools which allow the user to integrate a spatial component into his/her examinations and thereby raise the information content of the existing data.

However, major focus in the development of an atlas information system should be focused on cartographic aspects, concentrating on a cartographic visualisation environment for thematic data, rather than merely producing a geographic/statistical toolkit with map output. This approach towards high quality cartography is accomplished with contemporary technical solutions to develop an online atlas as such, rather than another arbitrary selection of GIS tools and functionalities as in conventional Web-GIS applications.

High quality cartographic output, based on a dual-media concept (digital/analogue), helps the user to derive a holistic view of the entire data, combining thematic and spatial characteristics of global and regional context. These spatial manipulation tools allow a variety of possibilities for analysing as well as visualising highly complex geodata in an effective and sophisticated way.

Recent existing atlas information systems (for example, the Tirol Atlas and the Atlas of Canada (see the chapter on the Atlas of Canada by Kramers elsewhere in this book) clearly show this development towards a cartographic information system, functioning as a gateway to a variety of information, where the distinction between layman and expert can not be defined on the basis of a clear separation line. In fact, such systems take care of individual user abilities and skills by adapting themselves to user needs.

13.2 AIS-Austria Concept

Cartography and geo-information can offer a promotive function in the amalgamation of heterogeneous information sources. Therefore, an important task of AIS-Austria is to provide comprehensive documentation of spatial statistical information in a concise, as well as intuitive method of information storage and analysis. Interactive cartographic forms of information presentation function as an interface to the user. This is realised in an easily visible and accessible structure to perform a sustainable way of information networking.

AIS-Austria allows to reference all objects in space (3-dimensional) and time (4-dimensional) and to assign other thematic or behavioural attributes (multidimensional). Furthermore, the dimensionality is being extended by the level of detail or granularity of information, allowing the description and access of features on different levels of scale and aggregation.

Data characteristics besides the mere position in space, such as time and other meta-information demand unique modelling, structuring and maintenance. Usually, when describing or modelling these features in an atlas information system content is registered and presented as a single, point-like information (0-dimensional). It can however have additional, rather restricted set of describing attributes, such as time information (age, date of occurrence, owner, etc.). Such multi-dimensional processing and representation of spatial information is being examined and implemented in AIS-Austria.

The major aim is to stimulate and support this development by providing a multidimensional framework, allowing to compile, homogenise, manage, analyse, query, compare and visualise spatial statistical data in a comprehensive and user- friendly way.

From the conception to the completion of building a successful cartographic online product, designing the presentation of information to facilitate understanding is an essential task. Cartographic information architecture, the purposeful structuring of spatial-related information in the sense of 'architecture of information' is a key issue in developing an interactive system.

Major focus of development in such systems can therefore be seen in a concise user-centred design, where the modelling of problem solving methods must have higher priority than technical restrictions. One dominant aspect is to define, what the system should be able of, and often more important than that, what not. Methods of information architecture have been widely adopted for the creation of web pages. Insight in this field, such as the extensive use of metaphors and conventions can be adopted by developers of cartographic focused, atlas information systems, to enhance the usability of their applications.

Cartographic design issues as well as visualisation of geodata play an important role. They are essential for spatial communication and for effective perception of information. Therefore, high quality cartographic visualisation is fundamental to ensure an optimum usability of the available data.

Graphical design and management of data sources with spatial reference can be efficiently realised by using sophisticated cartographic and Geographical Information System (GIS) methods. Cartography has a long tradition in visualising geo-relevant phenomena and uses many different types of approaches for representing spatial information. These can range from classical printed maps with a single dimensional appearance, all the way to multidimensional, interactive online representations, such as Web mapping or interactive GIS-applications.

13.3 AIS-Austria Requirements

The requirements on AIS-Austria are complex, both in terms of thematic content management as well as technical implementation. Based on – and existing alongside – a printed version of the ÖROK Atlas, the Internet product had to match the thematic and cartographic quality of the analogue version. To fulfil all prerequisites, AIS-Austria was built upon special system architecture considerations, based on the following key issues:

Modularity: The modular aspect of the system architecture offers the possibility to work in a decentralised environment and enable high efficiency for the implementation of specific system functionalities;

Flexibility: Not the technical environment is of importance, but the definition of standardised interfaces between various system components.)This approach results in a system, which can be considered as a “thin”-implementation, compared to monolithic ‘fat’-systems.);

Extensibility: Due to the chosen system architecture, it is possible to extend the framework with additional expert module at any time;

Distributed resources: The creation of a multi-national Internet atlas needed the cooperation of several domain experts. (The thematic linkage of heterogeneous expert modules into a homogeneous application was one of the main challenges of the project.); and

Heterogeneous working environments: Following the basic principles of modularity and efficiency, resulted in a diverse landscape of operating systems (Linux, Windows, MacOS) and programming languages (C/C++, Java, PHP, Perl). All modules had to be exchangeable throughout operating systems and programming language boundaries.

Besides these requirements, limitations and constraints had to be identified and taken into account. These constraints had a strong influence on the system integration and implementation.

It is clear that from these basic ideas, several forms of implementation were imaginable. In the case of AIS-Austria, major focus was put on the cartographic issue. The backbone of the system is a database-driven map server, enriched with a high performance system interface module.

In its basic function a map server is an interface between a geodatabase on the server side and an Internet browser on the client side. A map server offers basic spatial and thematic navigational functions with certain possibilities for query. The advantages of map servers lie in the graphical processing and presentation of spatial data, which allow a fast and visually attractive transfer of information in the Internet. (Dickmann, 1999).

Evaluation of practical software solutions for cartographic projects not only focuses on price. Besides the cost of a tool, various other decision criteria have to be considered. Two of the most important are functionality and availability. In other words, finding suitable answers to the following questions: “Can the software fulfil my functional requirements?” and “Can I afford it?”

The evaluation of several possible map server solutions led to the decision to build AIS-Austria on a free software technical basis. The variety of free software for the use in online cartography and Web mapping is expanding daily and product quality can definitely bear a comparison with commercial products. Free software - often used as a synonym for Open Source software - is software without encumbrances, but not necessarily free of cost. Unlike commercial oriented software, Open Source software is developed by a multiplicity of independent contributors worldwide. The intention is to create applications that are free to use for everybody. The basic idea behind Open Source is very simple: When programmers can read, redistribute, and modify the source code for a piece of software, the software evolves. People improve it, people adapt it and people fix bugs. And this can happen at a speed that, if one is used to the slow pace of conventional software development, seems astonishing. Application developers in general, cartographers in particular can benefit from the use of Open Source software.

Being a rather small group with limited impact on the global software market, cartographers often use tools that were not specifically developed for cartography, but for graphic design or DeskTop Publishing. Adapting the software to meet the demands of cartography is a hard task, if not an impossible one. Update cycles for implementation of desired functionalities are long-winded and above all software vendor business does not view cartography is as a driving force. In this context, Open Source shows its full potential for cartographic use.

The whole AIS-Austria system thus consists of several free Open Source software modules which can be exchanged individually without having to change the overall concept of the prototype. This configuration is very economical and it easily allows for further extension of the project.

13.4 AIS-Austria Functionality

Within AIS-Austria, two main approaches to begin the application were implemented. The first approach uses the search metaphor. Analogue to Google, the user can enter any search string. The system returns all information concerning this string from maps to diagrams, tables or texts. Furthermore, the user can enter the application by choosing from a list of predefined maps. This list consists of pre-processed maps, defined by cartographers. All maps consist of one or more layers representing point, line or polygon data. Based on this fact, multilayered maps using different cartographic representations can be displayed in the system. All selected maps are stored in a map-pool, giving the user the possibility to switch between utilised maps.

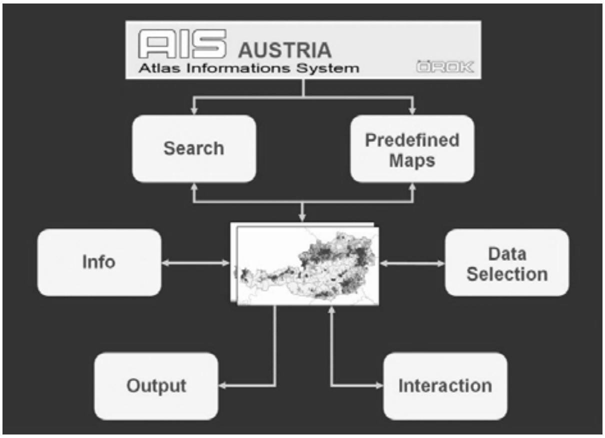

Fig. 1. AIS-Austria System Approach

AIS-Austria addresses three types of geoinformation layers that are embedded within the system. These layers are described in the following sections.

In an atlas information system topographic information must be structured as components of map elements. Therefore topographic information is determined according to the accuracy of their geometry as well as in the semantics of their objects determined by map scale. AIS-Austria utilises three map scales for topographic information. The first represents Austria in total, the second corresponds to a regional view of the federal states of Austria and, finally, the local level covers individual districts.

Geoinformation that can be related to socio-economic phenomena is called thematic information and encompasses data that is referred to positions, line segments or polygons. The visualisation of this data results in thematic maps or cartograms.

All information that does not use cartographic methods for visualisation can be summarised under the term ‘additional components’. This is primarily information such as text, diagrams etc. which is attached to specially marked symbols, lines or areas in different scales of topographic maps.

The system uses a unique approach for storing thematic data. Data is not stored in flat files but in a multi-dimensional cube-like structure, which allows the user to access all the different dimensions of a dataset. All calculated values (e.g.” inhabitants per area”) are calculated on-the-fly and visualised in the map. The user can access all detailed datasets by choosing dimensions, enter their own calculation methods and show results in the map or as a table.

From the beginning, AIS-Austria was designed as a dual output system. This means that besides the digital interactive Web mapping option, a high quality vector map output was incorporated as well.

The presentation of cartographic information on computer displays more often suffers from certain graphical restrictions. The screen resolution is still very poor for cartographic needs. Some cartographers have suggested developing new graphic designs for maps to compensate for these visualisation restrictions. If screen resolution would be identical to that of printed maps, nobody would be interested in producing an unattractive and simple design for maps. A further handicap for cartographic visualisation is the dimension of the screen.

It is a fundamental issue that the legibility of cartographic information must be ensured for cartographic information transfer. Therefore, cartographic information transfer must be divided in different levels of information which enable the user to choose between base and local information in order to support the user in getting the desired information. A contrary position in cartographic information transfer would be the presentation of cartographic information without taking legibility into account. In such a case only one cartographic information level would be available.

The editorial staff of AIS-Austria decided that legibility of cartographic information is of such importance that cartographic design of screen maps always had to take this fact into account. In connection with this consideration, a further decision had to be seen, namely, to use the same graphic design for the interactive screen maps as for the printed maps. The reason for this decision was to provide a familiar map 'look' for the user. This decision, to come up with ensured screen legibility for maps can be seen as a restriction in terms of an information system. It is proposed to enable the map user to perceive the presented information in a flexible way without any additional action.

A further predicament is map scale dependent visualisation of thematic data. In AIS-Austria, a database query is usually linked to the representation of nearly 2,500 geometric units (communities), which have to be computed and depicted. Without doubt, graduated symbols for example cannot be an optimal solution for characterising different value steps, due to the fact that such a representation would not be legible. Therefore in the first step of the visualisation process, only an overview of Austria is given, without using an equivalent symbolisation. In other words, the database query can only be visualised by using an ordinal or nominal scale level. In the next step the user defines the region of interest whereby the map scale will be changed and the adequate cartographic symbolisation can be displayed. The problem of this two-step method is that users possibly may lose the spatial interdependencies of the represented data because they can only see a small section of the whole map. Of course, the user can apply scroll functions to change the displayed map sections but this possibility cannot really compensate for the overview available when using a printed map.

13.5 AIS-Austria System Structure

AIS-Austria is based on modular system architecture. A combination of GIS, geodatabase and a map server visualisation environment, consisting of GRASS GIS, PostGIS object oriented, spatially enabled relational database and UMN MapServer prove to be a complete online cartographic information framework on a free software basis. The use of this framework enables the user to work on a state-of-the-art Web mapping environment without the need for licensed software. Functionality, scalability and efficiency of these free software packages are combined with the power of holding the code source in one's hands.

13.5.1 Visualisation environment

The open source map server of the University of Minnesota (UMN *MapServer*) is used as a visualisation tool, fulfilling all required criteria for the AIS-Austria prototype. The heart of the UMN *MapServer* is a CGI-based application for delivering dynamic GIS and image processing content via the Web. The package also contains a number of stand alone applications for building maps, scale-bars and legends offline. The *MapServer* system supports *MapScript*, which allows popular scripting languages such as Perl, PHP, Python, Tk/Tcl, Guile and even Java to access the *MapServer* C API. *MapScript* provides a rich environment for developing applications that integrate disparate data. In the case of AIS-Austria, the system interpreter had to be enriched with the programming language PHP to gain full access to the scripting interface of the visualisation environment. UMN *MapServer* is not a fully-featured GIS, nor does it aspire to be so. It does, however, provide enough core functionality to support a wide variety of Web applications. Beyond browsing GIS data, UMN *MapServer* allows the creation of ‘geographic image maps’ - maps that can direct users to content.

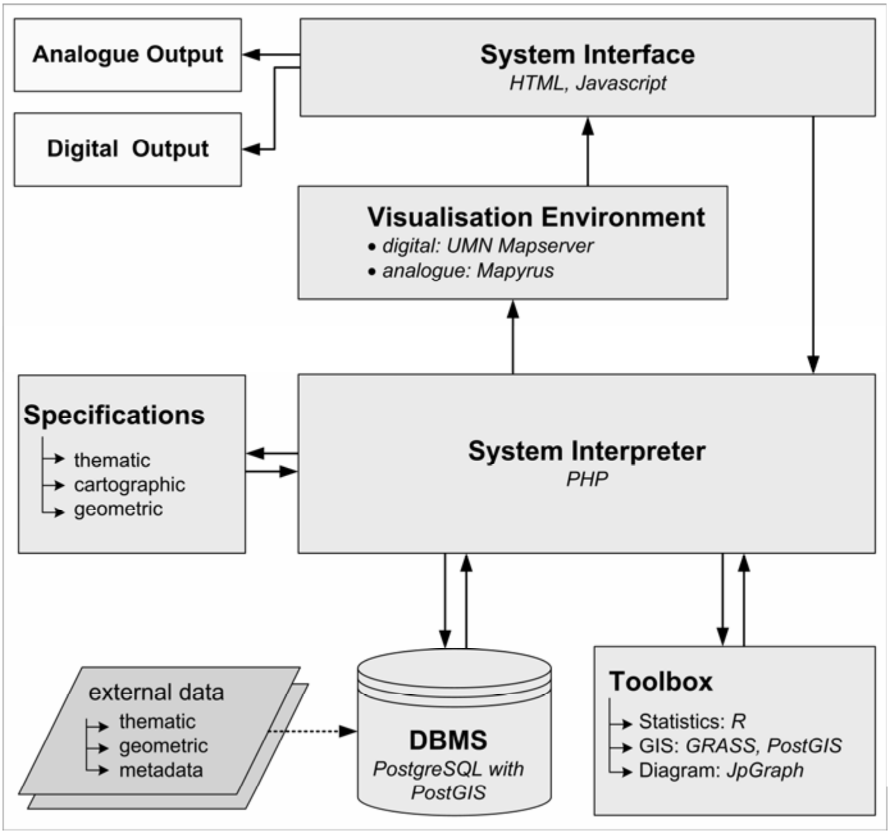

Fig. 2. AIS-Austria System Architecture

UMN *MapServer* is used for digital visualisation; the 'analogue' PDF output is created using *Mapyrus*. *Mapyrus* can create plots of points, lines, polygons and labels to PostScript (high resolution, up to A0 paper size), Portable Document Format (PDF) and Web image output formats.

13.5.2 Geodatabase

For the database backend, *PostgreSQL* was chosen which provides all advantages of a spatially enabled relational database. It has a strong linkage with the UMN *MapServer* and – as Open Source solution – is available without further costs or license fees. *PostGIS* adds support for geographic objects to the *PostgreSQL* object-relational database. In effect, *PostGIS* "spatially enables" the *PostgreSQL* server, allowing it to be used as a backend spatial database for geographic information systems, much like ESRI's *SDE* or Oracle's *Spatial Extension*. *PostGIS* follows the OpenGIS "Simple Features Specification for SQL".

13.5.3 Spatial analysis

GRASS (Geographic Resources Analysis Support System) is used to perform spatial operations, primarily in batch mode. *GRASS* is a raster/vector GIS, image processing system, and graphics production system. *GRASS* contains over 350 programs and tools to render maps and images on monitor and paper, manipulate raster, vector, and site data, process multi spectral image data and create, manage, and store spatial data. *GRASS* uses an intuitive windows interface and a command line syntax for ease of operations. *GRASS* can interface with commercial printers, plotters, digitisers, and databases to develop new data as well as manage existing data.

13.5.4 System interpreter

In order to ensure technical modularity and flexibility, standardised interfaces were developed to connect all system modules and ensure proper input/output communication between each other. This fact brings up the necessity of a centralised system component, that handles all input and output operations within the system. To ensure correct content data processing and presentation to the user, the system interpreter must be able to supervise all information concerning its thematic, cartographic and geometric correctness. To serve this purpose, the correctness of the data has to be tested on the basis of content information specifications, stored alongside the system interpreter. If any plausibility check fails in any stage of a user query system workflow, the application will terminate this query and send a failure message to the user via the graphic user interface.

13.6 Conclusion and Outlook

Cartography and GIS incorporate elaborate ways of capturing, analysing and visualising geo-relevant phenomena. Combined with powerful datbase management systems (DBMS), cartography and GIS in concert is an ideal approach for dealing with multidimensional, spatial statistical information.

Interactive information systems facilitate a sustainable way of multidisciplinary research and communication for a co-ordinate interdisciplinary approach. This procedure allows a dynamic interface for a close collaboration between the system and user. This should strengthen the synergy within the scientific community as well as raise the public awareness of the overall project and of atlas information systems in general.

Based on the experiences with AIS-Austria, several other system implementations have been also realised by the University of Vienna, Department of Geography and Regional Research using free software, underlining the quality of such software packages in operational use. The integration and incorporation of several additional modules, such as *R* for statistical analysis, *JpGraph* for on-the-fly diagram creation and *Mapyrus* for high quality postscript vector output highlight the critical framework abilities and demonstrate flexibility, extensibility and sustainability.

The decision of using free software as a basis of a Web mapping environment turned out to be very successful. Free access to the source code gives the developer the possibility to implement required functions and thus have full control over the software, enabling the user to adapt the product to his/her own personal needs. The fact that almost all Open Source software is also free of charge - to guarantee the software's free availability - is another strong advantage over licensed software packages. The existence of this open environment gives everybody, especially financially limited organisations full control over a state-of-the-art cartographic information system.

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14 Toward a New Generation of Community Atlases - *The Cybercartographic Atlas of Antarctica*

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14.1 Introduction

The movement towards the reader as author is increasingly prevalent in the information society as a whole. Increasing development of wireless connectivity and relatively inexpensive tools with which to access the Internet has resulted in the ability to be in an ‘always on’ state. The geographic information domain is highly implicated in this movement. In the first half of 2005 Google released *Google Maps* and soon after, *Google Earth*. This followed the release of NASA's World Wind (v. 1.2) in 2004. These releases followed by others such as Microsoft's *Digital Earth* took the already existing Internet map scene dominated by sites like MapQuest to the next level. These next-generation applications provide better performance and integration with general search functions and the ability to upload and display your own data and use Application Programming Interfaces (APIs) to create ‘hacks’ or ‘mash-ups’ that adapt for use in their own on-line applications (Erle, Gibson, & Walsh, 2005). This opens new horizons in the way we map the world. These technological changes have resulted in the development of knowledge construction communities. Wikipedia (http://www.wikipedia.org) is probably the best known example of knowledge construction through collaborative effort enabled by emerging technologies. Examples such as *Placeopedia*, *Openstreet*, or *Geowiki* are emerging from similar communities. Anybody with Internet access can now access and provide geospatial information.

At the same time, location in the real world can be captured and mapped easily with all kinds of devices and tools such as GPS or RFID. These tools are being combined with the increasingly popular activities associated with Locative Media such as location-based pervasive games (Chang

& Goodman, 2004). These popular applications are changing the way cartography and geographic information is being collected, represented and shared. For example, 'Geotagging' is the process of adding geographical coordinates and other metadata to various real world features and associated media such as websites, RSS feeds or images; 'geocaching' (http://www.geocaching.com/) is the reverse process: finding artefact in the real world based on geospatial coordinates usually made available over the Internet. Geotagging, coupled with the ability to plot to geographic information infrastructures like *Google Map* is resulting in an increasing base of personal geographic information.

This combination of located information and flexible user interaction provides challenges related to an increase in user participation in atlas development. These developments have implications for atlases which are an attempt to provide a thematic collection of maps. Where, for centuries the atlas was the result of often months or years of effort by an individual or group of specialists and then published in a by nature of the medium, static, bound (often heavy!) paper form. In more recent years, this gave way to digital atlases in the form of CD ROMs and the Internet. CD ROMs added an interactive and dynamic component plus portability. The Internet made way for the atlas that could be widely disseminated and constantly updated. However, until recently, these atlases were authored by an individual or relatively small group. There were good reasons for this, as technologies, collaborative data transfer and security issues presented a high cost of involvement. The aforementioned technological developments and widespread adoption of related behaviours is revolutionising the possibilities and reducing these costs. This chapter discusses the implications for these developments in the context of the production of the *Cybercartographic Atlas of Antarctica* (The Atlas).

In the next section we describe the context of The Atlas. In section 3 we discuss some of the specificities of The Atlas in terms of modularity and interoperability. These points are developed more specifically in section 4 from a technological point of view through the description of the atlas development framework. Finally, in section 5 we present some of the cybercartographic outcomes of this process which leads us to conclude on discussing from different perspectives the notion of a community atlas.

14.2 The *Cybercartographic Atlas of Antarctica* Project

The *Cybercartographic Atlas of Antarctica* is being developed within a larger research project entitled Cybercartogaphy and the New Economy. In January 2003 a multidisciplinary research team from cartography, film studies, geography, international trade, comparative studies in literature, language and culture, music, psychology and computer science emerged at Carleton University in Ottawa, Canada to carry out basic and applied research within the framework of cybercartography (Taylor, 2003). It was argued that, in addition to theoretical discourse, the exploration of a cybercartographic approach to cartography would constitute an important contribution to the new economy by making the increasing volume of information available from databases more accessible, understandable and useful to the general public, decision makers and researchers in a wide variety of disciplines. To illustrate this it was proposed that two innovative atlases be produced – the *Cybercartographic Atlas of Canada's Trade with the World* and the *Cybercartographic Atlas of Antarctica* on which we focus more specifically in the chapter.

Antarctica is the coldest continent on Earth, is primarily covered by ice and has no permanent inhabitants. The closest continent to Antarctica, South America is more than 1000 km away. There are a number of reasons for an increasing interest in Antarctica and the Polar regions in general geographic discourse. Antarctica is increasingly being seen as a unique laboratory for studying global processes like climate change. The ecological sensitivity of the poles makes them useful as early warning indicators to detect global environmental change trends and effects. The most obvious relationships are related to the hydrosphere (global ocean currents) and atmosphere (climate change). Less obvious are the lessons we can learn using the Antarctic as a case study of human exploration, resource exploitation, territoriality, resource management, the role of science in society and developing concepts of a global commons (Berkman, 2002; Joyner, 1998).

No one country ‘owns’ Antarctica. While Antarctica is not a sovereign state, organisations have formed to create links within and between Antarctic stakeholders. The Antarctic continent and surrounding region is governed by a consensus based system known as the Antarctic Treaty System (ATS). Other groups, such as the Scientific Committee on Antarctic Research (SCAR) (http://www.scar.org) play a formal advisory role to the ATS. Due to the governing structure of Antarctica, unlike most countries, there is no central organisation tasked with managing geographic information or knowledge for the area. There are however at least two SCAR groups tasked with facilitating the organisation, management and development of information produced by the science community. The groups are: the Experts Group on Geospatial Information – Geographic Information and the Joint Committee on Antarctica Data Management. These groups act as an important link to various Antarctic communities of practice.

It is not the intention of The Atlas project to collect substantive new data, but rather to bring together selected existing datasets in a new multimedia form. Thus, from the outset, the project was designed around the concept of a community-built atlas. The aforementioned groups and others operate as interconnected communities of practice. Here we define a 'community of practice' as a group of people who share an interest in a topic (or an 'issue domain'), who continually interact, and who accumulate and disseminate knowledge. Thus, participating in these communities of practice appeared to be the most effective way to facilitate the development of a reasonably comprehensive Atlas.

14.3 Atlas design: modularity and interoperability

The conceptualisation of the community approach to development, and the belief that an atlas could be constructed by distributed content developers, was in part inspired by one of the author's involvement in open source software development. Open source software development is often characterised by self-organising; typically distributed groups using networked tools to collaborate and develop software (cf. http://sourceforge.net). Some of these software products are complex (e.g. http://www.openoffice.org) and/or ubiquitous (e.g. http://www.apache.org).

Through interaction with the SCAR community, a number of active participants were engaged in the process from early in the project (Taylor & Pulsifer, 2002). Source data are being accessed through partnerships with members of the community with a variety of data sources being used. Framework data layers include remote sensing data, such as those collected as part of the Radarsat Antarctic Mapping Project (Jezek, 1999). Primary Topographic data is provided by the Antarctic Digital Database project. This vector database, compiled under the direction of researchers at the British Antarctic Survey, is constructed from source maps with scales primarily between 1:100,000 and 1:1,000,000. A number of other databases are being made available from sources such as: The United

States Geological Survey's Atlas of Antarctic Research, the King George Island GIS (KGIS), Australian Antarctic Division, Wuhan University (PRC), and many others. In addition to data contributions, others are providing content including maps, multi-media and narrative in the form of content modules. As the Atlas develops it is expected that more community members will play this role of content (rather than data) provider by developing their own module.

Central to the distributed, community based approach used for development of The Atlas, are the concepts of modularity and interoperability. Developing content in a modular way, provides each community member (individual or organisation) the ability to contribute to the process within the context of their individual disciplines, technical capacity, institutional frameworks etc. Modularity has been actualised in the form of the Content Module model (Pulsifer, Parush, Lindgaard, & Taylor, 2005). In the context of the iteration of The Atlas currently being developed, Content Modules are Web-based representations of Atlas topics or concepts. A Content Module is:

- A component of the atlas containing cartographic, narrative, and multimedia elements for the purpose of examining a particular question, topic, area, or phenomena related to the Antarctic region such as Antarctic Exploration, Climate Change or Geomorphology of the McMurdo Dry Valleys;
- Typically associated with one or more Chapters and Volumes (broader concepts);
- Evaluated for quality;
- Under the responsibility of individuals or groups of individuals;
- Developed for a particular audience; and
- Described by a well-defined set of properties.

Thus, individual Content Modules contribute to the development of a greater whole – an atlas for the continent.

Interoperability is a term used to describe a situation where data and operations can easily be shared and individuals do not require product specific expertise to use a given software system (Goodchild, Egenhofer, Kemp, Mark, & Sheppard, 1999). At the outset of the project, in keeping with available technologies and partner capacity, the initial approach to interoperability involved contributors providing data and content on disc in an agreed upon standard format. This content would then be incorporated into a central server system. As time went on and standards and supporting technologies developed, there was a move to adopting a distributed information approach. In this model, data providers produce Web-based services that are used by the atlas across the Internet.

Several elements of interoperability are typically identified in the literature (Goodchild, Egenhofer, Fegeas, & Kottman, 1999). These are: Syntactic (e.g. operating system and format), Schematic (e.g. data structure) and Semantic (e.g. symbols and signs used to signify concepts and terms). These terms would be appended with 'interoperability' as in syntactic interoperability. At present, in developing The Atlas a standards based development approach is addressing the syntactic element of the interoperability. The schematic aspects are currently under development and are expected to take the form of a schema adopted by the Antarctic geographic information community (see http://www.antsdi.org). Whether the development of a widely adopted, standard schema is a realistic goal for a diverse set of communities remains to be seen. Semantic interoperability is probably the most challenging aspect. Work is being done on a ‘feature catalogue’ (cf. http://www.aad.gov.au/default.asp?casid=6259) and on modelling the ontological aspects of the feature semantics.

While the modular, interoperable design is expected to support the distributed community well, a resulting consequence is that the community must consider how to best abstract, integrate and represent (mediate) (Pulsifer and Taylor, 2005) potentially heterogeneous content. In terms of data, while each data resource is shared, it has been developed by an individual or organisation for use in a particular context such as topographic base, ecological research, glacier modelling or environmental modelling. This presents a challenge for mediation that must be met by the cartographers developing The Atlas. Addressing this challenge is ongoing. The solutions under development range from establishment of formal data models and formal specifications for feature semantics (e.g. the aforementioned Feature Catalogue) to more emergent elements of mediation such as an open cartographic symbol repository whereby any interested member of the community can contribute symbolisation which is open for use by others. As this process continues to develop, it is expected that some de-facto standards will emerge.

The concept of dynamic, multilayer mediation is particularly important for The Atlas because, as stated, the objective is to use The Atlas to serve a variety of different user groups (Figure 1). The form used to serve these audiences may be quite different and range from, for example, a Web based Atlas for the general public, to a Web based atlas information service for Scientists (Parush, Pulsifer, Philp, & Dunn, 2006).

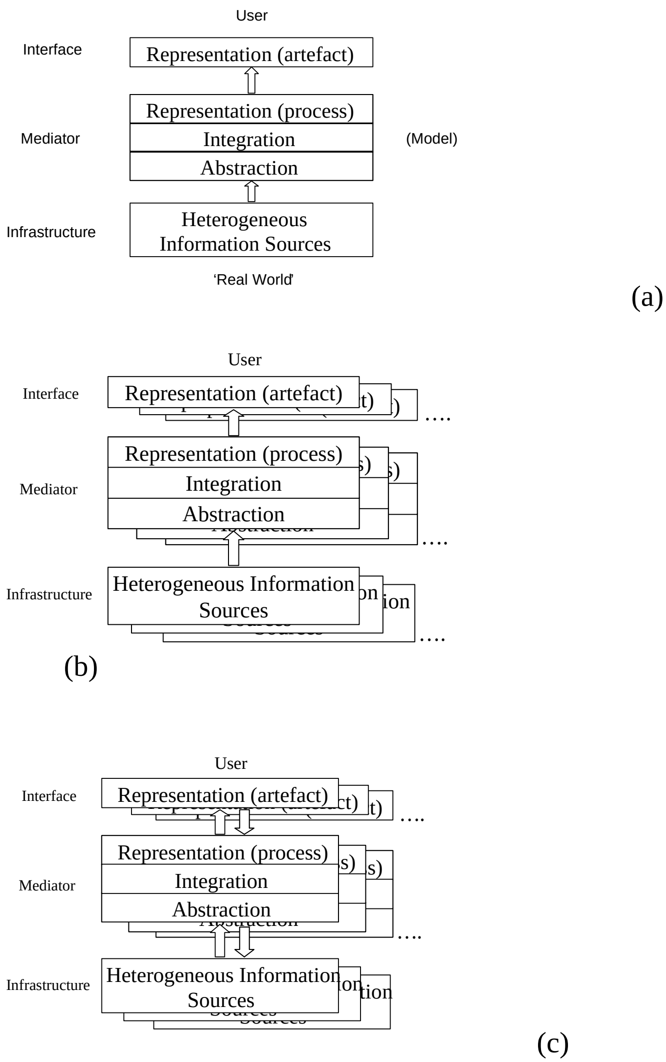

Fig. 1. (a) A depiction of a single layer, unidirectional information flow where the system is designed to meet the needs of a particular target group. (b) A multilayer, unidirectional model (current status of The Atlas) (c) multi-layer, bidirectional information flow where the system is designed to meet the needs of multiple target groups and supports the modification or contribution of content by end users (potential future iteration of The Atlas). (Image courtesy of the Geomatics and Cartographic Research Centre, Carleton University.)

In real terms, The Atlas is being built on a newly developed framework which revolves around semi-structured data and Web services. The framework developed in response to design guidelines uses eXtensible

Markup Language (XML) to structure The Atlas and facilitate interoperability between several open source system components (Caquard, Pulsifer, Fiset and Taylor, 2005).

This modular, interoperable approach was first conceptualised in the form of the Open Cartographic Framework (Pulsifer and Taylor, 2005) and is now evolving and changing to adapt to the requirements of cartographers, users and developers through the incorporation of new technologies. This framework should also allow the integration of multimedia and multimodal elements which are central in the context of the atlas development.

14.4 The atlas development framework

The framework has been developed in response to design guidelines. A number of requirements were established through a User Centred Design process developed by a team of psychologists involved in the project (Pulsifer et al., 2005).

In considering the various end user requirements, technical options, perceived profile of authors abilities and stakeholder needs it was decided to take an approach where the atlas modules would be written independently of the atlas' implementation details. Using this approach, the authors of atlas modules have a certain area of responsibility, while the atlas provider and atlas host have other clearly defined roles. This model was developed over time and inspired by a variety of sources including interoperability and cartography research (Bishr, Pundt, Kuhn, & Radwan, 1999; Kottman, 1999; Zaslavsky, 2003) and related public sector initiatives such as the Open Geospatial Consortium, the World Wide Web Consortium and the open source benchmark project *DocBook* (http://docbook.org) (Figure 2). In this approach, content documents are written independent of formatting implementation details. Part of the benefit of this design is the ability to transform information into a variety of formats including Web sites, PDF document and Mobile device content (Lehto, 2003).

In addition to the aforementioned issues related to interoperability and mediation, the development and use of the described framework has presented the team with a number of challenges. These challenges relate to system usability by non-experts, limited ability to use multiple formats, use of infrastructure in multiple contexts and the limits of formally modelling cartographic representation.

At the outset, some cartographers and content authors found the need to create XML as part of the production process to be a barrier to efficient Content Module construction. This problem is being addressed through the development of an easy-to-use author interface which abstracts the process in a way that those without expertise in XML can more easily develop modules. Related to ease of use, the potential requirement for development skills on the cartographer's part has also been an important issue. The development framework is very powerful in that it supports repurposing of content, strong links, dynamic representations and other functions. However, currently, if a cartographer needs to go beyond the capabilities of the data infrastructure or the software framework to support a particular cartographic function or effect, advanced development skills are required. This has introduced a production model whereby the cartographer potentially needs support from content (data infrastructure) and software developers to create a 'map'. It is expected that the aforementioned author interface will ameliorate this requirement to some extent, but the team approach to cartographic development may well be a characteristic of emerging forms of cybercartographic production.

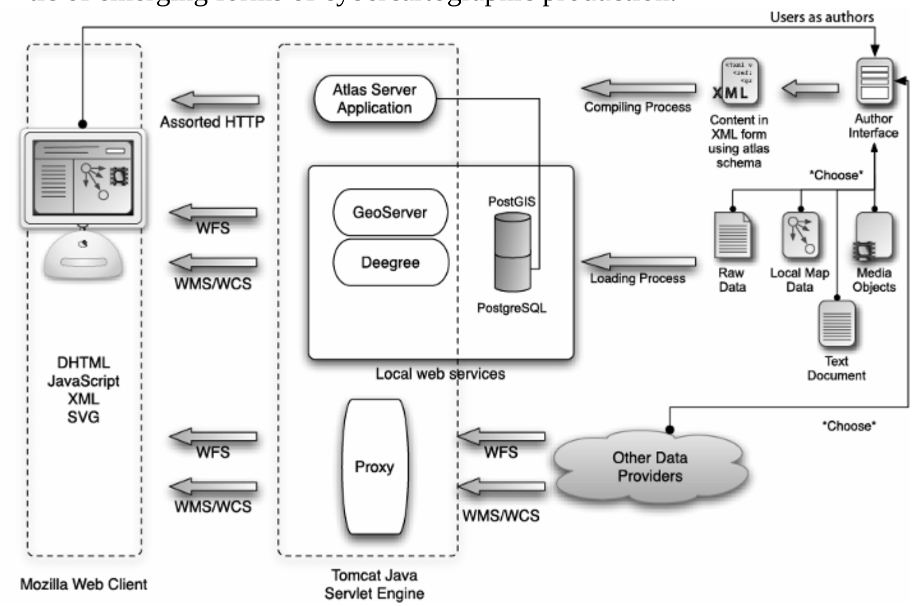

Fig. 2. The Atlas framework (Jean-Pierre Fiset, Amos Hayes and Peter Pulsifer). (Image courtesy of the Geomatics and Cartographic Research Centre, Carleton University.)

At the time of writing, the development framework cannot render a large number of multimedia formats (e.g. *Flash*). The native rendering format of the framework is Scalable Vector Graphics (SVG). This limits possibilities in terms of accessing cartographic artefacts developed outside of the framework. Ideally, these objects could be incorporated with information being exchanged between the objects and its associated module and, in turn, the overall atlas framework. Technical and design solutions to this constraint are currently being developed.

Much of the data infrastructure used by The Atlas is being developed in concert with the Scientific Community whereby the primary interest is in delivering data to be used for further analysis in an analytical system (GIS, modelling or visualization software etc.) (eg. DiBiase, 1990; MacEachren and Kraak, 2001) rather than 'content' that addresses an education and outreach need and is presented in a common Internet enabled interface (Web browser, mobile device etc.). In the Scientific use case, connectivity to the most up-to-date (possibly near-real-time) data and information is often critical. However, in the case of an audience from the general public, students or policymakers, connectivity to database may not be a requirement.

During the development of the preliminary Content Modules, it was found that in some cases, connectivity to the infrastructure was beneficial where in other cases the connectivity simply limited the cartographic possibilities, degraded performance, had no added benefit (e.g. the content was static) or, in the worst case scenario, destroyed the integrity of the content module. By integrity, we mean the logical and semantic connection between elements of the content module. Should the map change without a suitable change in the narrative, the intended meaning of the module could be modified or destroyed. This situation was foreseen in the original model conceptualisation and thus the ability to maintain local 'closed' data resources was maintained.

There is, of course, an important assumption in the approach taken to date. This assumption is that we can 'model' the cartographic design and creative process. As with any model, ours is a representation of the cartographic development reality that we see. We accept that this model is not comprehensive and thus it must grow as the needs of users and cartographers are communicated.

At the time of writing, the new developments described provide us with the ability to move beyond the unidirectional model with single content and software developers to one that is bidirectional, supports multiple developers and authors and, thus potentially supports multiple perspectives (Figure 1c). The challenge now is to establish the extent to which enabling this type of approach will serve the needs of the end-user, cartographer and other project stakeholders.

14.5 The Atlas from the end user's perspective

The dynamic relationship between the creation of a cyber-atlas (i.e. The Atlas) and the investigation of the conceptual frontiers of cybercartography lies at the centre of the Cybercartography and the New Economy project. Thus, rather than simply producing a new artefact, the cyber-map, this project has the overall goal of exploring and expanding the contemporary terrain of cybercartography. This section will draw directly on this dynamic relationship by presenting an overview of recent research that examines the use of cybercartographic elements as a means for conveying information to the end user. In particular, the use of "live" elements in the atlas narrative, the combination of sound and graphics, and the exploration of three-dimensional visual data, are specifically examined as a means for generating an engaging educational experience.

Before presenting this research, it is important to point out that two fundamental principles have shaped the production context of The Atlas. The first is the belief that the user is central (Taylor, 2003). Accordingly, the end user's perspective has been integrated into the atlas design through a Users Needs Analysis (UNA). High school students were chosen as the primary target audience (Rasouli et al., 2004). This UNA is part of an overall process called the User Centered Design (UCD) approach. This approach is based on an iterative process. In the context of The Atlas, this iterative process involved individuals with backgrounds from psychology, geography, computer science and graphic design. Thus, this multidisciplinary approach is the second fundamental element in The Atlas design. It assures that The Atlas is not just meaningful, engaging and understandable, but functional and capable of evolving, as well. Since disciplinary knowledge can embody a range of perspectives and priorities, this can generate tensions in terms of cybercartographic production. However, such a multidisciplinary environment can be highly stimulating as demonstrated by the various multidisciplinary research clusters created in the CANE project (Lauriault & Taylor, 2005). In our experience, the work done in these clusters has profoundly shaped the design of The Atlas. In what follows, we will draw on research accomplished by distinct clusters and the way in which this research has been integrated into The Atlas.

Research accomplished by the cluster on live 'hypernarrative' directly inspired the introductory page of The Atlas. Live hypernarrative combines "ideas from the dynamic nature of the World Wide Web with those from 'hyperfiction', and so concerns hypertext stories where dynamic data from the outside world affects the content and structure of the stories" (Greenspan, Dormann, Caquard, Eaket, & Biddle, 2006). In live hyperfiction the content and structure is determined by 'live' information that changes depending on where and when it is accessed, and on what is occurring in the world as represented on the Web. To support such narrative a technical architecture and working prototype software have been designed and incorporated into the introductory module of The Atlas. In this module live elements such as the date, time, and weather conditions at the user's geographic location, as well as in Antarctica, are integrated into the narrative structure of the text. Therefore, the content of the introduction varies based on where users are and when they access the atlas. For example, users accessing this Web page from Denmark in January will discover that their country is about 400 times smaller than Antarctica and that the current temperature might be slightly warmer at McMurdo station than in Denmark. This gives the user an immediate sense of the multiple 'distances' – geographic as well as climatologic – that separate her/his environment from Antarctica. This narrative strategy vividly draws the end user into learning about Antarctica. As Greenspan et al. (2006:36) argue, this "manner of integrating live information and non-trivial navigation within narrative structures points toward new ways of involving users in exploring digital environments, a key principle of cybercartography".

To add further texture to the live elements described above, graphic representations in the introductory module are continuously shifting as well. For instance, the orientation of the location map of Antarctica is always rotating. As a result of this rotation, the content of the atlas is visually different each time the user accesses the page. This representational strategy is designed to emphasise the 'live' dimension of the content of the atlas. The rotating map of Antarctica has another important representational function; by demonstrating that the orientation of maps can easily shift, it directly challenges the strongly traditional and naturalised design of maps that always portray "North at the top" (Pickles, 2004, p. 57). Exposing users to maps of Antarctica, where the North is in every direction, further emphasizes the particular southern location of Antarctica (see Figure 3).

Another multidisciplinary group of researchers in the CANE project explores the problems and opportunities of using sound in cybercartography. According to Théberge (2005), "sound (among other sensory modes of communication) needs to be considered as an integral part of the mapping process. In so doing, spatiality and temporality, data and narrative structure, image and music, and many other relationships will present themselves as both problem and opportunity." While sound can have a range of functions in mapping, this group draws on insight from film theory to focus on its immersive, emotional and narrative dimensions of sound. The sound identity of The Atlas is still under development. Several sound tracks have been designed in order to evoke the Antarctica environment by combining techniques such as stereo panning and volume modulation (Jasen, 2005). ‘Authentic’ sounds such as wind buffeting or radio signals collected from the Antarctica atmosphere are combined with particular sound effects to generate a unique sense of place.

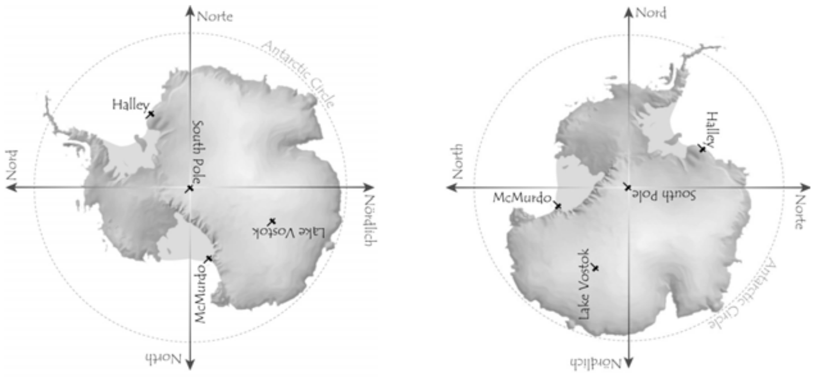

Fig. 3. In Antarctica the North is everywhere. Rotating map used in the introduction page of The Atlas. (Images courtesy of the Geomatics and Cartographic Research Centre, Carleton University.)

Music has been integrated in other modules of The Atlas such as the module dedicated to Antarctica exploration. This historical module is structured around what might be called an ‘animactive’ timeline. In other words, the timeline associated with the map of the exploration of Antarctica may be played either as an animated sequence or studied interactively. This ‘animactive’ map conveys information about the navigators, their routes, their journeys, their discoveries, and their perceptions of Antarctica. One of the goals of this map is to convey the idea that Antarctica moved from being an imagined to a mapped place. As McGonigal and Woodworth (2001:384) write, the “early exploration of Antarctica was a process of whittling down the fabled Great South Land.” To demonstrate this transformation, Sir Thomas Moore’s 1518 image of the ‘Island of Utopia’ overlaps the map of Antarctica (Figure 4)[1]. Over time, this image, which represents “the fabled Great South Land” is “whittled down” to reveal the modern map of Antarctica. On the map, mimetic sounds are used in an animated sequence to depict the different modes of transportation associated with distinct periods of Antarctic exploration, including maritime, terrestrial and aerial periods. In this sequence, pieces of music are incor-

[1] It is important to clarify that Thomas Moore did not design the “Island of Utopia” with Antarctica in mind.

porated to convey a range of perspectives on Antarctic exploration. For instance, when the user clicks on the Cook expedition (1772-75), s/he can listen to the String Quartet Nº3 by Mozart, composed during the same time period. In this context, the music invokes a broader geographical context and suggests that these explorations were related to other events taking place at the same time in different parts of the world. Music also emphasises the different time periods separating distinct eras of exploration. Thus, the sound of Mozart that accompanies Cook's exploration contrasts with the music of Miles Davis' that accompanies the Fuchs and Hillary parties (1958). In these particular instances, music offers a very specific aesthetic environment providing the user with a pleasant experience.

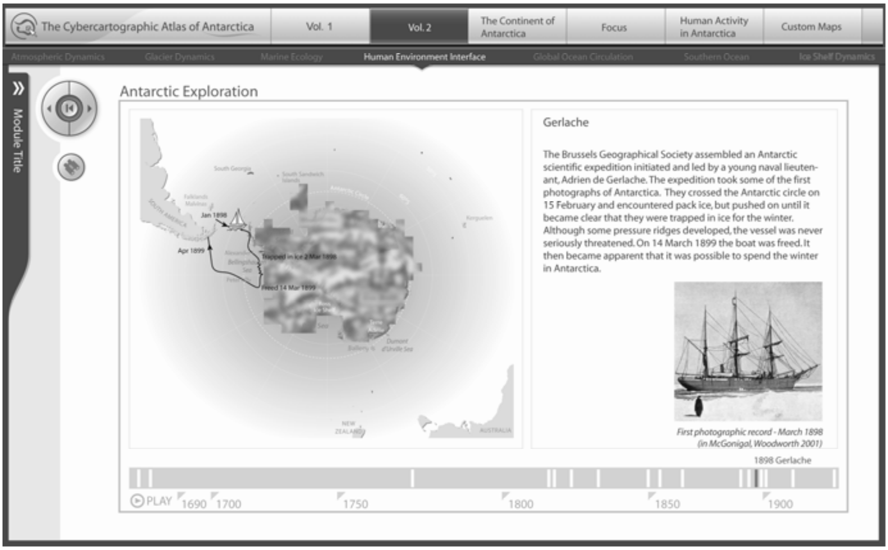

Fig. 4. The exploration module. The fabled Great South Land is "whittled down" to reveal the modern map of Antarctica. (Image courtesy of the Geomatics and Cartographic Research Centre, Carleton University.)

Voices have been integrated in another module of The Atlas, that of the territorial claim, to quite a different effect. In this module, the function of sound serves to highlight the tension between the United Kingdom, Chilé and Argentina with regards to territorial claims in Antarctica. In order to do so, newspapers articles from the three countries that directly address this issue have been recorded. In turn, these audio sounds have been linked to an interactive map of the territorial claims (Figure 5). When the mouse is over a part of Antarctica that is not contested the user listens to the news report from the country claiming this part of Antarctica. When the mouse is over a contested territory, the user hears multiple voices simultaneously. This layering of voices and languages increases the sense of confusion and tension between the different countries. It generates a destabilising auditory environment that contrasts sharply with the clarity of the graphic delimitation of territorial claims. As a result, the message that territorial claims are much more complex than simple lines drawn on a map is clearly conveyed to the end user. This approach builds on the work done by Brauen in his sound map of the results of the federal election in Ottawa in 2004. Brauen (2006) developed the idea of overlapping sound in maps and developed the technology that allows these sounds to be accessed 'on the fly' from remote databases.

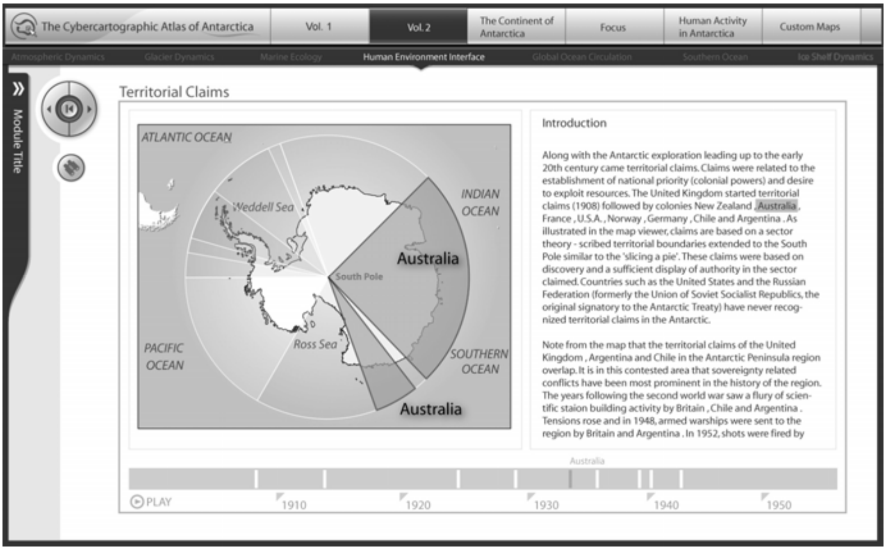

Fig. 5. The territorial claim module. The layering of voices and languages emphasizes the overlapping territorial claims over the Antarctic Peninsula. (Image courtesy of the Geomatics and Cartographic Research Centre, Carleton University.)

Designing these modules helped us to better understand the intimate relationship between sound and image in cartography (Caquard et al., 2005). Yet, sound design cannot, or rather should not, be viewed as a simple additive element to visual design (Théberge, 2005). Rather, this combination forces us to rethink the very concept of the map as a primarily visual image of space. In a broad sense, designing cybercartographic maps that use a combination of different media is a complex process of arrangement and interaction. Each medium can interfere with the others thereby affecting the message that is being conveyed. Adding sound, therefore, necessarily requires a transformation in graphics. The addition of sound, furthermore, can shift the perspective that is portrayed in the visual information. Neither sound nor graphics are neutral. Both can be culturally specific and integrating the two requires an iterative approach.

Using a range of technologies, The Atlas also provides opportunities for the user to explore Antarctica's physical environment in an immersive fashion. Terrain visualization can help both students and geo-scientists to better understand structural phenomenon within an environmental context. In designing the module dedicated to the Geomorphology of McMurdo Dry Valleys, Woods (2005) has explored the potential of different technologies to construct three-dimensional interactive representations (figure 6). The terrain rendered in this manner integrates visual landmarks as well as hidden ones to encourage serendipitous exploration (Woods, 2005). For example, an invisible sound bubble has been incorporated into the terrain. Each time the cursor hits the boundary of this bubble the sound of running water can be heard. As the cursor gets closer to Don Juan Pond, the volume increases. The user discovers that even at a very cold temperature, the pond is not frozen, a fact that reflects the high salinity of the water (Woods, 2005). In addition to this kind of educational purpose, the interactive terrain described here also could be used as a repository for scientific knowledge. In this particular part of Antarctica, much research has been conducted in different scientific fields such as glaciology, geomorphology, geology and climatology. Giving the opportunity for these different scientific communities to share, access and visualize other data in an understandable form through visualization could facilitate the development of a collaborative virtual environment (MacEachren, 2001).

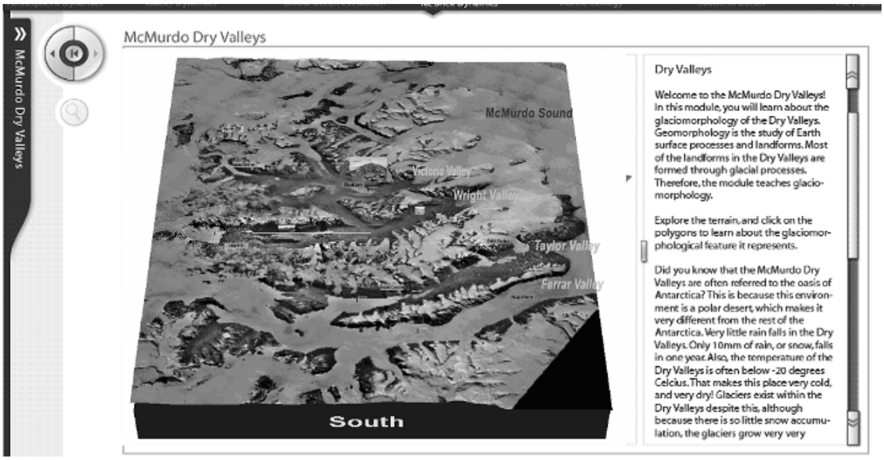

Fig. 6. The Geomorphology of McMurdo Dry Valleys module created by Birgit Woods. (Image courtesy of the Geomatics and Cartographic Research Centre, Carleton University.)

Some of the modules developed use interoperable databases. This provides support for the addition of, for example, new environmental base data which may not have been included or available when the Content Module was originally authored (e.g. the average remotely sensed sea surface temperature for the current month). Similarly, the ability to connect to data services maintained by multiple providers supports the inclusion of up-to-date field observations from scientists, tourists or logistics managers (e.g. wildlife sightings). Figure 7 illustrates a content modules designed around these capabilities.

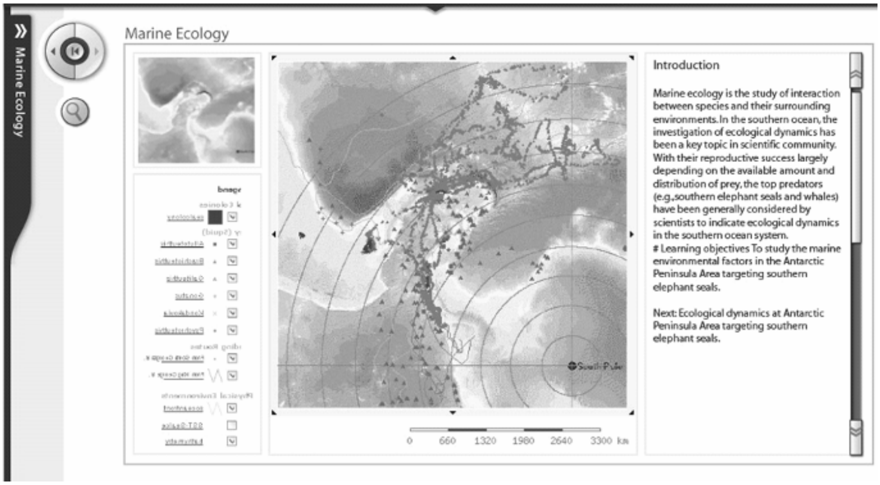

Fig. 7. The Marine Ecology module created by Xiuxia Liu. The module supports connection to distributed databases including updated observations on the state of marine mammal populations as they become available. (Image courtesy of the Geomatics and Cartographic Research Centre, Carleton University.)

With respect to multisensory technology, the current version of the atlas is still limited to sound and vision. Nevertheless, research is ongoing in other sensory fields, including haptics (Vasconcellos & Tsuji, 2005) and smell (Lauriault and Lindgaard, 2006). A group of fourth year students in Industrial Design at Carleton University is pursuing applied work in this regard, through the development of multisensory, multi-modal devices for education and communication. The impetus for creating such devices begins with the recognition that, as we navigate in space, we simultaneously hear, touch, smell and see its character. These multisensory experiences enrich our understanding of a place's context and character. Thus, a device that captures, records, or constructs a multisensory environment could be used to convey a particular individual experience or could be used for educational purposes in the context of a virtual fieldtrip. By engaging users in an emotional and experiential journey, this kind of multisensory experience could provide a very different sense of reality. This experimental work in Industrial Design raises many questions that should be addressed in the context of cybercartography. How can cybercartography better capture and convey multisensoral experiences? How might multisensory educational experiences change the way we understand geospatial environments? How might they change the way we conceive of and design cybermaps? More research is needed to address these issues and to better understand the multiple implications of this emerging domain.

As demonstrated above, a user driven cyber-atlas seeks innovative means for conveying information and experiences about the world. For The Atlas to be fully user-driven the metadata that surround the production of The Atlas must also be accessible and understandable for the end user. In other words, systematic information about the data sources, the design technologies, and the individual creators who contributed to the production of The Atlas must be made available, even as The Atlas evolves in a multi-authored, collaborative environment. These metadata could in turn then be accessed and used to better understand the quality and the context of each module. Such information makes more transparent the multiple steps between a reality and its cyber-representation. To become truly meaningful, this type of information must be easily accessible and understandable by the end user through direct integration into the map. By making the process of mapmaking visible in this manner, the map user would be more immediately cognisant of the constructed dimension of the map image (Caquard et al., 2005). An innovative model for recording this type of metadata in the context of the CANE project is under development (See Zhou, 2005).

14.6 Discussion/conclusion: opening the atlas

In light of what has been presented in this chapter, it becomes evident that the project in which we are involved is directed primarily towards the creation of the infrastructure for a cyber-atlas, rather than a particular cyber-atlas, *per se*. In this regard, the authors are less involved in the specific content of this particular cyber-atlas, and more implicated in building the tools, knowledge and experience that could be applied to any pertinent content. Yet we consider human networks and communities to be an essential element in this infrastructure. Certainly, one of the most innovative dimensions of this project is that it draws in multiple communities, including a technological community, a scientific community, and a cartographic community. In relationship to the technological community, we are developing an open source atlas infrastructure as well as a library of open source geo-spatial ‘widgets’. This open source orientation intentionally seeks the future collaboration of the broader open source community in relationship to the continued development of cybercartographic infrastructure. An open source orientation also ensures a certain long term availability for use in other public projects. In relationship to specific content, this atlas has drawn on expertise within the Antarctic scientific community. For example, a team of researchers from the Institut für Physische Geographie (IPG) at Albert-Ludwigs-Universitaet in Freiburg, Germany have authored and designed their own educational modules on the history and glacial morphology of King George Island. They are working toward using the infrastructure and the widgets library to integrate these modules into the cyber-atlas. Finally, in terms of rendering this information meaningful via multiple media and modes, the input from cybercartographers will be needed. As cybercartography has been conceived in this project (interdisciplinary, integrating technology and research), the cybercartographer takes on a new role. Rather than being strictly responsible for the production of maps, they become mediators and facilitators between technology developers, content providers and end users. Within the context, cybercartographers still need graphical and geo-spatial skills and knowledge, yet they need the capacity to translate between multiple knowledge producing communities that may hold distinct perspectives on the world.

With this cyber-atlas we are moving toward a new generation of atlases that directly challenge the boundaries of the cartographic discipline. The possibilities presented by the concept of a cyber-atlas pose new questions, issues and perspectives that should stimulate and benefit the entire cartographic and geographic community. Antarctica, as the only major landmass on Earth still not fully owned by one group of people, provides a unique environment to explore and develop this new generation of community atlases.

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15 The Employment of 3D in Cartography – An Overview

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15.1 Introduction

In cartography, multimedia tools are now widely used as a more effective means of transmitting spatially-related information than static paper products. The popularity of 3D content recently, not only engages users by offering aesthetically pleasing real-world perspectives, but may also play an important role in providing communication support. It is generally suggested that 3D cartographic products provide a more intuitive acquisition of space, due to an explicit use of 3D (Kraak 2002, Brown et al 2002, Cheesman et al 2002). Also, in comparison to the highly abstract coding of height information with contour lines and shading, a direct incorporation of 3D models provide almost no coding of the height information (additional codes/colors for highlighting a precise height may be added). The related user decoding process can cause difficulties (Buchroithner 2002).

However, from a technical point of view, evaluating the rendered graphic as result of camera projection and field of view, various disadvantageous characteristics accompany cartographic 3D depictions. Some of these disadvantages, like distortion due to linear perspective influence or hidden objects, can be diminished by the use of multimedia techniques like the use of orthographic scene rendering or interactive camera movement. Others, like the combination of various scales within one view, may be converted to advantages of 3D visualization by enabling a direct comparison of scales. Very detailed shapes of objects in the foreground (at a very large scale) can be directly compared with smaller scale shapes of objects in the background accompanied with a direct relation to camera position.

The technical incorporation of 3D and its immersing transmission assumes the existence of various preconditions. Whereas ‘pseudo-3D’ applications, the rendering of 2D display graphics to visually simulate 3D content, are applicable on most of user computers as a result of powerful graphic cards and computer processing capacities, ‘parallax-3D’ and’real-3D’ presentations require specific computer to human interfaces. Additional difficulties in distributing 3D cartography occur for the implementation of formats, distribution formats, software requirements for viewing content and sustainability of data/formats.

Designers of 3D environments mainly try to reproduce reality in order to follow concepts of Virtual Reality (VR), a digital reproduction and extension of reality. Intuitive transmissions of spatial information call for a more realistic presentation form so as to keep depth cues for immersive 3D depictions. But, cartographic abstraction dictates processes of selection, generalisation and symbolisation that have to be done in order to highlight important information and make these perceivable. Perceptual tasks are directly connected with the resolution of the interface chosen. Alternative rendering methods should be explored and methods like non-photorealistic rendering can provide additional tools for cartographic communication.

15.2 Perceptive/Cognitive Aspects

Information perception and knowledge building are individual processes, formed through individual interest, motivation, experience and user knowledge. From this point of view, interactive, dynamic and 3D visualizations may be beneficial for transmitting spatially-related content for providing preferred modes of information access. Several theories have a direct influence on the conception of cartographic applications.

According Neisser’s scheme-theory (Neisser 1979), perception and the sequencing processes of knowledge acquisition can be described as a “cycle of perception”. Individual experiences within an environment result in changeable knowledge put into individual memory structures. Thus newly-acquired knowledge is put together according to individual schemata. Experiences and interactions influence stored knowledge by changing, updating and embossing that knowledge, depending on the ‘triggering’ situation.

Over and above the cycle of perception, knowledge acquisition is supported by grouping information and the application of individual organisation and order principles (Zimbardo 1995). Related to cartography, the grouping is based on similarity criteria of shape or temporal behaviour, shared meaning and organisational principles following semantic classification and hierarchical structuring (Buziek 2000). For example, the cartographic depiction of an object class ‘water bodies’ should follow similar codings. The use of different colours according to the characteristic of water bodies will not be understood. For a general understanding, the context of nature and abstraction/coding, the color ‘blue’ is connected with a feature type ‘water’.

The description for creation knowledge and individual organisational structures reverts to the learning theory of Bandura (1987), which builds upon dual encoding. Observations act on the assumption that knowledge creation relies on learning of straight and substitutional experiences, naming the imitation and evaluation of imitation consequences.

The creation of schemata and the adoption of particular behaviour are supported by processes of intensification and motivation. Again according to dual encoding mechanisms, the coding of the same information for various sensual modes may cause intensification and a higher importance for accomplishing the storage of this specific information as knowledge (Dransch 1997). Say, if one element among hundreds catches the attention of the user because of double or triple coding (e.g. using extraordinary colour, shape and sound), there will be a better chance for its knowledge-based storage. The processing area within the brain receives inputs of the same information from different sense organs.

It can be observed that the perception and cognition of information is individually based and driven by interest, motivation, experience and existing ‘knowledge islands’. Knowledge islands are defined within communication theory, where ‘island’ names an individual’s knowledge (Birkenbiehl 2003). Two individuals only may communicate/understand each other when their knowledge islands overlap.

The role of 3D for cartography may be augmented with perpetuation of perceptual behaviours and familiar environment, which may be seen in an active usage of common available communication islands. Each person, varying with the sensual occurrence, learns to move, perceive and build knowledge of the spatial environment around oneself. Therefore, most cognitive processes are automatic. But at least the existence of cognitive processes may be observed with the time consumption, the difference of time between perception and cognition. This value gives some indication for information overload, a situation when too much sensual input is available and cannot be processed before the next sensual input arrives. One strategic plan of the brain in this situation is to leave unprocessed information when new input arrives. From the cartographer’s point of view important information, in form of double or triple encoding, may be left and may no longer be useful for the transmission of content. Information grouping and creation of schemata, both including a further building of knowledge, will be prevented (Kluwe and Schulze 1994). Thus the consideration for information overflow and stimulus satiation becomes important for the semiotic creation process of a map and in particular a 3D environment/application. Systematic integrations and combinations of different codes on various media may lead to extreme stimuli, highlighting specific information components that support and help to control a more effective information extraction.

Subsidiary methods to strengthen spatial knowledge transmission make use of metaphoric application/interface designs. The translation of information to known symbolic values, which means that metaphors for semiotic and/or functionality may be used in order to support the understanding and assimilation of specific information as well as the use of the interface, helps the user to adapt/translate used abstractions to the personal knowledge island. The map itself has been an effective metaphor for the presentation and representation of all types of data, spatial and non-spatial (Fairbairn *et al.* 2001). Data and information that have traditionally been described, enumerated, tabulated and summarised are being mapped to display ‘space’. However, appropriating information provision for 3D cartographic products presents new challenges for the user and designer alike. These products inherently introduce new issues in representing spatial data, management of greater information loads (and generally on-the-fly), user interfaces and navigation amongst other issues.

Cartwright and Hunter (1995) proposed a set of nine metaphoric modes to compliment the map metaphor. They were originally conceived and developed with discrete multimedia products as ‘targets’, with the developers stating that the concept could be extended to distributed multimedia. Other demonstrated metaphoric modes include Goodchild’s (1999) ‘landscape metaphor’ designed for interacting with the Digital Earth project and Fuhrmann and MacEachren’s (2001) flying saucer metaphor designed for improving navigation when viewing terrain models within Virtual Reality Modeling Language (VRML) worlds. The question, is, however, whether they are appropriate for general implementation, and, can they be applied to all 3D cartographic access initiatives? Due to the diversity of these products, it may be impractical to assume an appropriate application of one, or even many metaphors will be applicable.

Cartographers need new design metaphors uniquely suited to their characteristics and requirements. Cartwright et al. (2001) stated that the effective use of an appropriate metaphor requires that both the user and the producer properly understand how to use that metaphor. That is, the ‘expert’ in content production needs to master the ways in which the metaphor should be best applied to the actual problem-solving task and the user has also to master the proper and most efficient use of the metaphor to be able to put the package to its best use. It has also been suggested that the key to the design of these new metaphors may be to identify expectations developed through real-world experiences in common and familiar environments and to use this knowledge to design consistent 3D cartographic interaction metaphors (Ellis 1993).

From a perceptive and cognitive point of view, which means readability and potentiality to psychologically handle spatial related content, 3D presentation techniques may be seen as a connecting element between two-dimensional abstraction and reality. A two-dimensional abstraction may offer best values for geometric correctness of the topographic elements, but lacks supporting human depth cues for spatial cognition. In contrast, 3D presentation forms used for cartographic applications are ‘distorted’ with all characteristics of a 3D environment, including perspective distortion, hidden objects, countless scales within one view and incomparable geometries of objects. But generally this presentation form based on its structure and definition offers support for all kinds of human depth cues, physiological as well as psychological ones, if only the interface provides an appropriate technical construction.

15.3 Technical Aspects

The technical construction of the interface still is a main factor for the ‘quality’ of cartographic products, which primarily has focused on printable resolutions of paper media. When quality issues for cartographic products and communication success are expanded to digital media, it is not only the granularity of the interface (screen, mobile phone display and others) that influences the information content of presentation, but also the factors of immersion, interaction and visualization capacity.

A useful adaptation of information to specific interfaces, where perceptual needs are borne in mind, can be suggested with the help of the two notions *expressiveness* and *effectiveness* (Mackinlay 1986). For cartographic aims (a cartographic transmission holds a special focus on visual information transfer) *expressiveness* refers to visualization capacity of the interface. Mainly it concerns a semiotic question of representing the important and necessary details of map elements in order to preserve their meaning. The presentation of all the required information with the ‘low’ capacity/resolution and ‘few’ communication parameters the interface offers should be possible in order to meet *expressiveness* requirements. For example, if the resolution of the screen is lower than the number of desired detail values, the *expressiveness* criterion will not be met. Then some of the detail values will not be available on the screen, thus not perceivable. Only if the number of 'resolution-pixels' of the interface matches or is higher than the detail values of information, a desired univocal relationship between interface and presented information becomes established and all details of the object will be accessible on the interface. Mapping more detail values onto one single resolution-pixel makes determination of information impossible.

Effectiveness regards aesthetic concerns as well as effective information acquisition, immersive interface use, optimisation processes for data simplification and visual rendering improvement. Relating to perceptive and cognitive aspects, the quality of presentation and success of transmission/communication (communication for highly interactive environments) mainly depends on the understanding and acceptance of the user. A sensual replication of everyday environments, by means of perception, multi-modality and interaction, seems to make a presentation more successful. Here, Egenhofer and Mark speak of 'naive geography', where it is stated that maps provide a very natural means to explore geographic space and that people perceive map space as more real then the experienced actual geographic environment itself (Egenhofer 1995).

Expressiveness and *effectiveness* criteria are essential within 3D cartographic environments, which basically means that chosen elements within an environment play an important role for transmission of spatial-related information, either as primary information carrier, e.g. mediating facts based on the shape or colour, or as a secondary information carrier that influences physiological depth cues due to perspective distortion, texture, shade or surface gradients. The exploitation of depth cues of the interface provides one possible classification for 3D presentations, which then may be called pseudo-3D, parallax-3D and real-3D.

15.3.1 User Interfaces

The user interface as a connecting point of application and human being has to provide and support all senses, which a user needs for almost natural acquisition of space and especially those sensual modes, which were prepared within the application. For real 3D applications all physiological and psychological depth cues of visual space perception should be addressed.

Physiological depth cues describe the human technique of visual space perception and cover retinal parallax, which enables the distance measurement with the help of horizontal parallax of one identical point on the retinas surface, accommodation, the focusing of the eye's lenses, convergence, which describes the angle of the viewing axes, and the parallax of movement, which delineates the different peculiarity of a points movement due to the distance to the eye.

Independently from technical characteristics of the eye, the creation of spatial impression is supported and built from psychological depth cues. These consist of the retinal picture size, the extension of the projected picture on the retina, linear perspective, the virtual alteration of object-size due to varying distance to the eye and perspective influence, atmospheric perspective, the fading of colours due to haze and atmospheric influences depending on the distance to the eye, occultation, where objects become obscured with parts of nearer objects, shades, that provide additional information of the shaded object, the shading object and the light situation, and gradients, allowing to perceive an objects surface by the deformation of a regular pattern (Albertz 1997).

The transmission in 'real 3D' mode uses all visual depth cues. Within this depiction continuous parallaxes in all directions exist. Interface examples are holography (with real holograms) and various forms of volumetric imaging, which implies light emitting volumes (using rotating helix mirrors or rotating matrix displays). Transmissions in 'P3D' (parallax 3D) mode use selected bi- and monocular psychological and physiological depth cues. Main techniques or interfaces are chromo-stereoscopy, the effect of Pulfrich, stereoscopy and multi-stereoscopy, which are implemented in different kind of interfaces, e.g. shutter glasses or lenticular lenses for stereoscopic effects. 'Pseudo 3D' transmissions with their use of solely psychological depth cues are wide spread. All perspective-monoscopic visualizations of cartographic 3D presentations on flat media, like screens, are involved. A larger screen, due to a wider extension on the retina's surface, will basically support immersion (Bollmann et al 2002).

Moreover, near body sensors like fumbling or smelling are added to these visual depth cues, which are a form of far reaching sensors for the exploration of space. That is one reason for interface design of digital 3D environments to combine visual depth cues with near sensual modes, like it was done within the CAVE or Humphrey. The CAVE (Computer Automatic Virtual Environment) builds up on a box of 5 projection surfaces with stereoscopic projection. It is supported by surround sound and tracking of the user's motion, in order to renew the presentation interactively. Humphrey uses a stereoscopic Head-Up Display (HUD) in combination with pneumatic force feedback loops connected to a jump suit. Gravitational forces can be transmitted to the user to provide a more 'real' movement/flight sensation through the virtual 3D environment (www.aec.at).

Visionary endeavours follow a complete different idea, which tries to remove all considerations of sensual techniques and find a direct connection to the brain. In the first successful results test subjects were able to move through a virtual environment by their thoughts (Nicolelis 2001). In reverse, to transmit spatial information direct to the brain would require a detailed knowledge of the brain map (the exact competence centres for activities within the brain). Due to the individual construction and shaping of the brain, this access to a person's consciousness seems not to be available for cartographic communication. But the technique of brain heat measurement, the observation of activities within the brain due to sensory activation, may be an appropriate tool for a direct testing of *expressiveness* and *effectiveness* of cartographic 3D presentations.

15.3.2 Software-Based Aspects

Software-based aspects of 3D cartographic communication cover usable formats for virtual environment and its containing elements, application distribution formats and supported rendering methods. For most systems of digital cartography, sufficient processing power is assumed, especially in reference to the huge market of computer games which also has a big influence on the development of the wide spread usage of personal computers. In addition, the latest developments are establishing mobile games including 3D environments for all kinds of handheld devices.

On one hand, usable 3D formats may be classified by their coding mechanism, which can either be in ASCII code, i.e. readable with ordinary text editors, or binary code, which is normally when the file is put in some proprietary structure. The binary code is mostly used by companies who try to make the file structure as effective as possible by improving aspects of data loading, supporting shading methods or incorporating animations and light situations. This structure is not easily accessible by text editors. From the point of preservation, these formats make it nearly impossible to save the files content for future applications. If the file format becomes unsupported, conversions to the latest readable format version will be needed. Actual undertakings often show different kinds of losses, which may be seen in light situations, camera positions or animations within the scene. A widely used representative of this group is the format 3DS.

ASCII file codes give some insight into file structure and coded file content. Whereas many ASCII coded files follow proprietary interpretable structures, the structure may not be programmed by hand and only interpreted by special applications, some object hierarchic structures became useful throughout technical development. The major applications here are OBJ *Wavefront*, *DXF*, *IV* (Open Inventor) and VRML.

The support of various features within the file format offers another way of distinction. Generally these features imply shapes, surfaces, textures, lights, transformations, cameras, animations and specialties like shadows, dust, triggers, ray-tracing or morphing. Depending on a host of factors, such as the geometric size and structure, interactive devices available and accessibility, an appropriate file format has to be carefully chosen to realise a viable virtual environment project.

VRML became one of the most widespread 3D file formats, mainly because of its positive characteristic of an easily accessible data structure. A whole 3D environment can be build up by using a text editor as programming tool. It allows the describing and storing of shapes, surfaces, textures, lights, transformations, cameras, animations and triggers within the file format. The lack of standardisation and instability of larger files led to new adaptations and developments under the auspices of the Web3D Consortium (www.web3d.org), which aims is to stabilise, standardise and nurture the technology for the entire 3D community. As result of this work, VRML has been superseded by X3D (eXtensible 3D) which was released in 2004 and become ISO standardised in December 2004.

The standardisation of 3D content, its accessibility and dissemination by X-media ideas led to the formation of a 3D industry forum (http://www.3dif.org), which tried to implement their interest in the development of a form of universal standard for all kinds of 3D data, U3D (Universal 3D). The participation of leading 3D industry should ensure a wide compatibility throughout leading software products. For instance, it is now possible to embed 3D content in the form of U3D into Adobe's PDF format (www.adobe.com). Thus 3D becomes X-media, because it may be navigated within the PDF 'presentation' and directly printed at the same time. The use and power of this format for geospatial content and cartographic presentations should be focused over the next few years in order to enable refinements and new developments by geospatial X-media ideas.

Standalone solutions for 3D presentations make use of the operating system and incorporated graphics hardware. Most of these have to be installed in order to run a game engine that may offer extensive support of 3D features (light, shadow, bump mapping and more). Exceptions are executable files that directly play the presentation without installing. In some cases special requirements for graphics performance are requested. The format as well as the potential application provides various possibilities for various features: the form of navigation, rendering techniques like different shading and texturing methods, physical environments and lighting situations. All of them are useful for influencing and guiding a user's cognition, which leads to the main task of cartography, the effective transmission of spatial-related information. According to this, for example, photorealistic rendering has to be confronted with non-photorealistic rendering. Non-photorealistic rendering then provides several tools to manipulate a user's perception and cognition and may help to create an improved cartographic communication model.

15.3.3 Communication Model Creation

The adaptation of primary step models, which result from recording and computer-based modelling, may be done with geometric model simplification, various rendering styles and camera distance management (managing detail of 3D models in relation to the distance to the camera). Geometric model simplification changes the structure and density of the model in order to remove unperceivable details and may enhance characteristics (e.g Akel 2005). Rendering styles provide different shades which may enhance the borderlines or simulate a very diffuse light situation. Also textures may for instance produce a cartoon or newsprint rendition which manipulates the visual impression (e.g. Döllner 1997). "Camera distance management" automatically changes the granularity/density of a model's surface mesh and accompanying objects. Generally this technique is called LOD (Level Of Detail). For cartographic purposes the surface density should not only be simplified, but characteristics of the object have to be highlighted.

This step of data adaptation describes the way from data modelling (models of primary step data) to cartographic conditioning. For some aspects the influence of model conditioning on intuitive 3D environment acquisition and immersion should be considered. Some aim-oriented modifications may be strong enough to damage intuitive impressions, for instance when thinking on orthographic projections for parts of the environment. Then linear perspective will be changed and thus directly influence cognition. Therefore the importance of virtual 3D environments for cartographic use can be seen as a bridging element from communication primary step to secondary step, supporting intuitive content acquisition as well as using generalisation methods for providing an aim-oriented interpreted content.

15.4 Conclusion

The likely future for 3D cartographic products seems to be supported by various fields of work. First of all, technical development of processors, graphics, small devices and alternate interfaces now enable applicability in a ubiquitous manner. Computers are increasingly more powerful, decreasing in size, consuming less energy and becoming incorporable into everyday objects. Furthermore, dissemination becomes exceedingly supported by universal file formats and system independent interpreting software. Several developments already focus their support for various operating systems.

The greatest value from a cartographic perspective may be located within communication support by using the role of bridging VR and abstracted cartographic modelling. 3D cartography needs basic definitions and rules so as to deliver appropriate content in a changing technical environment.

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16 Non-Photorealistic 3D Geovisualization

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16.1 Background and Motivation

With the advent of *non-photorealistic computer graphics* (NPR) a repertoire of illustrative, expressive, and artistic computer graphics techniques offers new ways of presenting and communicating visual information. Non-photorealistic computer graphics turns out to be an enabling technology for designing and implementing effective visualization systems overcoming the traditional mindset established by photorealistic computer graphics. In the scope of geoinformation, NPR allows us to implement abstract, aesthetically pleasant, and adequate geovisualization techniques.

16.2 Photorealism and Its Limitations for Geovisualization

The concepts of photorealistic computer graphics still define principle techniques used for visualizing 3D geovirtual environments. In the scope of *Virtual Reality*, a large collection of algorithms and data structures provide efficient rendering of large, complex 3D terrain data and heterogeneous geo-spatial objects, e.g., optimising rendering of digital terrain models or large collections of heterogeneous 3D objects. These methods focus on efficient rendering and require high quality of texture and geometry data. Numerous optimisations for virtual environments have been developed such as discrete and continuous multi-resolution representations of geometric objects to enable level-of-detail (LOD) rendering and data streaming, view-frustum culling, occlusion culling, billboard clouds and impostor techniques to reduce the geometric complexity of scenes, scene-graph parallelization and optimisations taking full advantage of the graphics pipeline and recently out-of-core visualization techniques, which directly render large amounts of data from external memory in real-time. Akenine and Haines (2002) provide a general introduction to these subjects.

While research in Virtual Reality provides efficient solutions for handling complex 3D scenes, it does not provide alternatives to the *physically oriented illumination models* and graphics designs. For example, the Phong illumination model (Phong 1975), which approximates the physical interaction of light in 3D environments, actually shapes current visualizations – not possible until recently to develop alternatives if real-time rendering was required because it forms part of the hardware-implemented rendering pipeline. This situation changed fundamentally with the advent of programmable computer graphics hardware. Another limitation is *single-pass rendering*. The rendering engine traverses the scene description in a single pass to generate the image and directly sends graphics data to the graphics hardware. However, a large number of graphics designs only become possible by more complex, multiple rendering passes, which collect data, prepare intermediate images and can perform imaging operations.

Looking at graphics quality achieved in the scope of 3D geovirtual environments, inherent limitations of VR techniques also become apparent: Photorealistic rendering techniques require and, therefore, *depend on geometric and graphical detail to achieve impressive results*. For example, a 3D city model without high-resolution facade textures typically remains an inconsistent visual artefact. The lack of sufficient detail is often frustrating–not only because highly detailed data would actually be required at early stages of construction but also because without such detail the visual results are not convincing from a perception's and an observer's point of view. Fig. 1 illustrates this phenomenon on the same 3D city model.

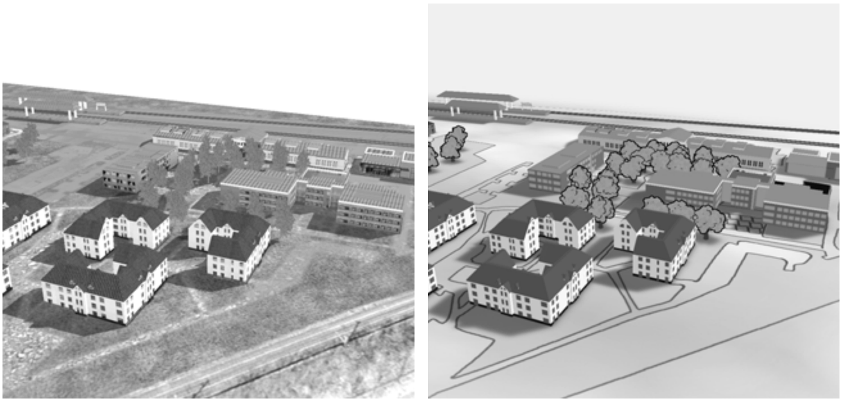


Fig. 1. Near-photorealistic and non-photorealistic visualizations of the same 3D model. (Images: *LandXplorer, www.landxplorer.net*).

In general, photorealistic computer graphics does not provide optimal solutions for *vivid, expressive, and comprehensible visualizations*. In particular, it does not provide optimal means for visual abstraction and, thus, for cartographic visualization as well as for visualizing complex geospatial and non-spatial information spaces. Therefore, photorealistic depictions frequently are neither cognitively adequate nor adequate with respect to the tasks to be supported by interactive applications and systems. As Strothotte et al. (1994) point out, "… perception and understanding on the part of viewers are subjective processes influenced by a variety of factors." They investigate, for example, how architectural drawings implicitly communicate data precision, and how they influence the level of confidence of the viewer.

16.3 Non-Photorealistic Computer Graphics

Most researchers agree that the term 'non-photorealistic' is not satisfying because the notion of realism itself is not clearly defined nor its complement, the non-photorealism. Nevertheless, non-photorealism (NPR) has established itself as a key category and discipline in computer graphics starting around 1990. Non-photorealistic computer graphics denotes the class of depictions that reflect true or imaginary scenes by *stylistic, illustrative, or artistic styles*. In particular, shape representation, colouring, lighting, shading, and shadowing are different from photographic and physically-oriented styles.

As Durand (2002) points out: "… non-photorealistic computer graphics offers *extensive control over expressivity, clarity, and aesthetics,* thereby the resulting pictures "can be more effective at conveying information, more expressive or more beautiful". Strothotte and Schlechtweg (2002) as well as Gooch and Gooch (2001) give a broad introduction to concepts and algorithms of non-photorealistic computer graphics. In general, NPR enables developers to present and depict visual information in a more purpose-oriented and task-oriented way using principles of classical illustration techniques.

Today's 3D computer graphics features a partially programmable rendering pipeline and offer efficient parallel computing power. Graphics programming interfaces (e.g., OpenGL), offer *shading languages* that allow developers to formulate vertex and fragment programs used in the rendering pipeline by a high-level programming language (e.g., OpenGL Shading Language). Generally, multiple rendering passes and a variety of object-specific and effect-specific shaders are used to synthesise a single image.

Programmable computer graphics represents the prerequisite for real-time rendering algorithms both in the fields of photorealism and non-photorealism. In particular, real-time enabled rendering techniques are required by any kind of interactive application. A general introduction to real-time rendering can be found in Akenine-Möller and Haines (2002).

The wealth of techniques comprise stylised digital half toning for simulating handcrafted depictions, such as stippling, hatching, or engraving conveying illumination, curvature, texture, and tone in an image (Praun et al. 2001). Furthermore, techniques exist for generating technical illustrations automatically (Gooch et al. 1998) or for reproducing pencil or pen-and-ink drawings.

16.3.1 Edge Enhancement

It has long been understood that just a "few good lines" (Sousa and Prusinkiewicz 2003) often suffice to encourage viewers to complete a picture by imagining the missing details. In non-photorealistic computer graphics, therefore, edge enhancement is an essential requirement and represents a core technical component in all non-photorealistic geovisualizations as well. Conceptually, it involves two aspects, edge detection and edge visualization. Two fundamental categories of techniques exist: object-space and image-space edge enhancement algorithms (Isenberg et al. 2003).

Object-space edge-enhancement algorithms determine visually important edges for each 3D object based on the object semantics. They provide an analytic representation for each identified edge so that the edges can be visualized by additional 3D scene geometry. This extra geometry represents stroke-like shapes that align loosely to the original geometry (Fig. 2). Northrup and Markosian (2000) as well as Isenberg et al. (2002) implement real-time capable algorithms for edge detection and edge stylization.

a) b) c)

Fig. 2. Non-photorealistically depicted 3D buildings with different object-space enhanced edges. a) Scene without enhanced edges. b) Curved stylized edges. c) Sketchy edges.

Image-space silhouette algorithms extract edges from additional image buffers, called G-buffers (Saito and Takahashi 1990). These buffers store geometric properties of the visible 3D scene on a per-pixel basis, for example, surface normals and depth values. Visually important edges are identified by image processing operators that detect discontinuities in G-buffers. For example, discontinuities in the depth image indicate object borders and silhouettes, whereas discontinuities in the normal buffer indicate surface edges. To visualize edges, we can superimpose G-buffers on the 3D view. Image-space algorithms can be fully accelerated by today's graphics hardware (e.g., Mitchell et al. 2002).

Nienhaus and Döllner (2003) implement a versatile and generic, real-time enabled technique to emphasize edges. This image-space algorithm achieves distinctive rendering of a 3D scene's models by enhancing their visually important edges. For this, the algorithm extracts discontinuities in the normal buffer, depth buffer, and optionally the id buffer. It stores these G-buffers as edge intensities in a single texture, called *edge map*. The edge map can be used subsequently to enhance the 3D scene by superimposing edges in the 3D view (Fig. 3).

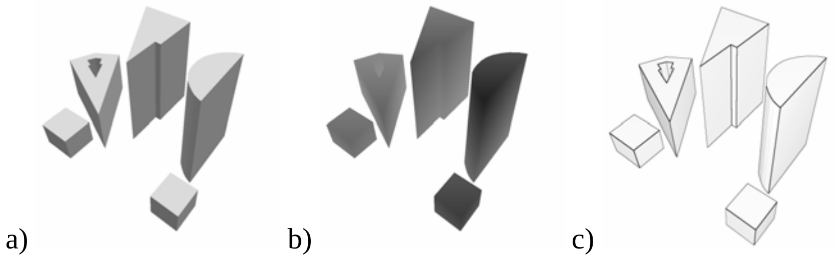


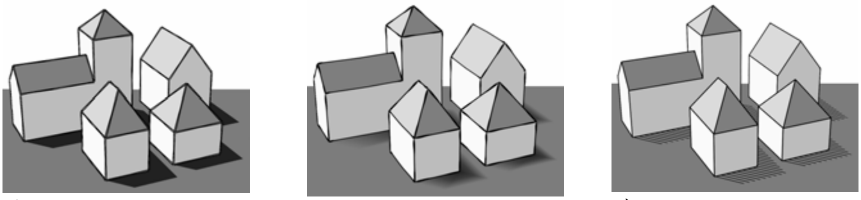
Fig. 3. Example of a non-photorealistic visualization of 3D buildings with image-space enhanced edges. a) G-buffer with surface normals. b) G-buffer with scene depth. c) Resulting image-enhanced 3D view.

Enhanced object-space and image-space edges represent technically different approaches with similar visual results. As key difference, object-space edge enhancement requires explicit edge semantics in the 3D models, whereas image-space techniques operate independently from the individual geometric representation. Both approaches offer manifold applications to non-photorealistic geovisualization.

16.3.2 Non-Photorealistic Illumination

Non-photorealistic illumination represents a broad repertoire of techniques that encompass coordinated colouring, shading, shadowing and depth-cue techniques. A first non-photorealistic illumination model derived from traditional technical illustration was introduced by Gooch and Gooch (1998), "where the lighting model uses both luminance and changes in hue to indicate surface orientation, reserving extreme lights and darks for edge lines and highlights. The lighting model allows shading to occur only in mid-tones so that edge lines and highlights remain visually prominent.” In contrast to physically-based illumination techniques, non-photorealistic illumination uses alternative ways to communicate shape, structure, and composition of 3D scenes than physically-based illumination techniques.

Shadows contribute to conveying three-dimensionality, to clarify spatial relationships, and to improve the comprehensibility of non-photorealistic depictions. The length of shadows cast on the ground, for example, represents a measure for the general heights of 3D objects. In general, shadows should not obscure any parts of the geometry and should harmonize with the rest of the drawing while being clearly recognizable. There are different types of shadows in computer graphics: *Hard shadows* are derived by creating a geometric shadow volume. Within that volume, all scene parts are drawn darker. *Soft shadows* are conceptually similar except that the darkness varies between umbra and penumbra–blurred shadowed areas result (Fig. 4). In contrast to physically-based approaches, soft shadows do not need to be physically correct in order to be convincing for the human observer (Ware 2000). Due to programmable computer graphics hardware, shadowing has become a real-time rendering technique.



a) b) c)

Fig. 4. Three different shadow types in non-photorealistic depictions. a) Hard shadows, b) soft shadows, c) hatched shadows.

16.3.3 Non-Photorealistic Shading

Non-photorealistic graphics frequently uses shading concepts different to those from photorealistic graphics such as Gouraud shading (Gouraud 1998), which provide smooth lighting across surfaces. Two prominent NPR shading techniques represent n-tone shading and hatching.

In artistic drawings of 3D scenes the illustrator usually abstracts from the realistic colours of the 3D objects and greatly reduces the number of colours used. In general only two or three colours and for each colour only two or three tints are used. The choice of the colours is based on aesthetic and other reasons as well as the actual surface colours. The n-tone shading determines the light intensity from the angle of the polygon’s normal and a light direction (Fig. 5). Then, the intensity indexes a colour palette of n tones determining the appropriate tone for shading. Three or four tones achieve a cartoon-like impression. To provide depth cueing, a linear transformation of colour space can be applied to change the colour saturation according to viewer distance: more distant objects are rendered in more desaturated colours whereas the intensities of colours remain constant.

Hatching denotes an artistic technique that creates shading effects by drawing closely spaced strokes, which generally follow the principal surface curvature. Hatched depictions simultaneously express lighting, shape, and material properties. In general, the tone of the shading is controlled by the density of the strokes. Hatching can be implemented as a real-time rendering technique (Praun et al. 2001) and, therefore, becomes a shading alternative that resembles traditional cartographic depiction techniques.

Fig. 5. Example of n-tone shading used for depicting a large assembly of 3D building models using three tones for red (roofs) and grey (walls).

16.4 Non-Photorealistic Terrain Illustration

Non-photorealistic illumination, shading, and edge-enhancement techniques provide the basis for developing domain-specific visualization techniques such as for non-photorealistic 3D terrain illustration.

For realistic landscape depiction a vast amount of geometry detail and appearance information is required. In contrast, the aim of cartographic terrain depiction is the two-dimensional representation of three-dimensional terrain in a geometric precise, illustrative, and comprehensible manner. Non-photorealistic techniques for terrain visualization can be found in architectural landscape illustration and cartography. Their goal is not necessarily the exact representation of the terrain, although they can still provide high topographic quality. The sacrifice of precision might well be compensated by a more vivid impression of the landscape.

Traditional terrain illustrations depict terrain surface in an effective way by means of slope lines and tonal variations. Buchin et al. (2004) develop an algorithm that computes surface measures from which slope lines are hierarchically traced and stored for a given 3D terrain model. At run-time slope lines are rendered by stylized procedural and texture-based strokes, whose density is determined according to the light intensities (Fig. 6). The algorithm is based on two particular techniques: loose lines and hachures illustrations. Loose lines suggest the direction of terrain slope by means of continuous lines with varying thickness and perturbation. Hachures are also lines drawn in the direction of slope but without perturbation and with thickness corresponding to slope steepness or light intensity. In traditional hachure maps they are interrupted at contour lines. The algorithm omits this since in 3D terrain depiction contour lines as quantitative measure of height are not necessary.

Terrain illustrations communicate terrain shape in an image-space efficient way, i.e., strokes do not fully cover the terrain surface. This way, image space remains for visualizing additional thematic information on top of the terrain surface, which represents an important requirement for interactive, explorative geo-data analysis.

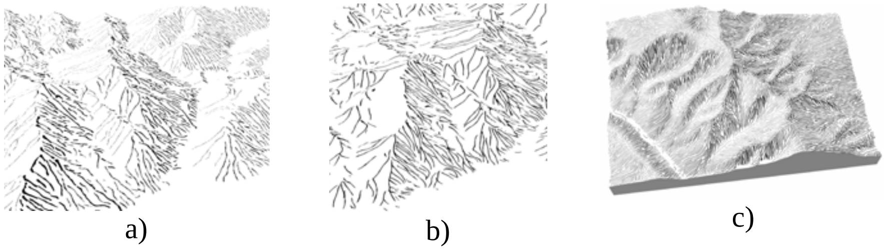


Fig. 6. Examples of non-photorealistic terrain illustration based on a real-time rendering technique by Buchin et al. (2004).

16.5 Non-Photorealistic City Model Illustration

In cartography, the visual representation of city models has a long history and has yielded many principles for drawings of this category. The most prominent examples include panoramic maps of cities and landscapes as well as bird's-eye views of cities. They show a high degree of visual clarity and geometric abstraction–preferring abstraction to realism.

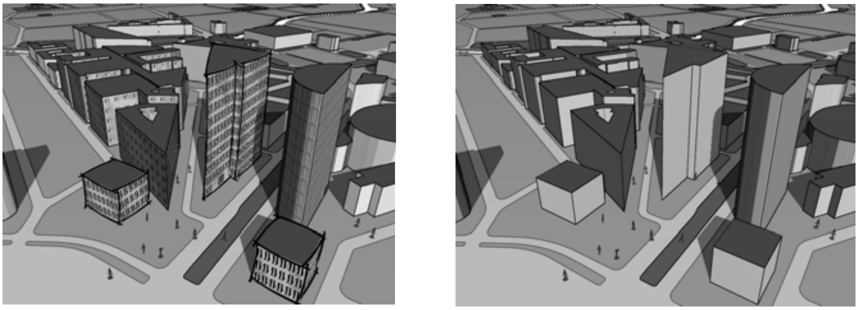
City model illustrations can be considered as map-related 3D representations of urban geodata and georeferenced thematic data. In addition to 2D geodata, such as topographic maps, thematic maps, and 2D ground plans, they include 3D geodata, for example, 3D terrain models, 3D building models, and 3D vegetation models.

In classical bird's-eye views both orthogonal and perspective projections are used. The city depictions of Merian, the Bollmann's maps of many European as well as US cities are well-known examples of 'pictorial city maps'. Traditionally they choose the east or west direction for projection because important, optically dominant landmarks such as well known public buildings and churches are oriented that way. In addition, map designers often attempt to diagonally capture important quarters and streets of houses. Whatever direction is taken, approximately half of the model is not shown in static views. Maps of city models attempt to maximize visual clarity. Most importantly, edges are enhanced to stress the contours of buildings. Colours are chosen according to semantics and aesthetics – they do not necessarily correspond to the natural colours. The overall number of colours is kept small.

The terrain model represents the reference surface for city models. In traditional city maps, the terrain surface is often ignored or just indicated where its morphology is significant. To cope with complex geometry, detail reduction is used both at the technical level by multi-resolution modelling and level-of-detail techniques, and at the semantic level by generalizing buildings to quarters if their distance to the camera exceeds a given threshold. As the sides of buildings provide more characteristic information about them than the roofs, the roofs can be scaled down in height while the main bodies of the buildings are scaled up. This is done in traditional panoramic views of cities to meet the spectator's expectation, who is used to see the city as a pedestrian.

In a complex and dense urban area landmarks serve as means of orientation for the user. Landmarks consist mainly of those buildings that are known a priori to the user–typically monuments and buildings of public interest. Therefore, they require an exact 3D graphics model. The visualization should guarantee that landmarks, even if they are nearly out of the view volume, do not disappear. The multi-resolution mechanism might want to treat them differently from the remaining buildings because the eye is sensitive to even small changes of well-known objects.

Döllner et al. (2005) present a visualization technique that achieves expressive illustrations of large-scale 3D city models (Fig. 7). It defines a collection of city model components and has been implemented by a real-time multi-pass rendering algorithm. It is based on image-space edge enhancement, colour-based and shadow-based depth cues, and procedural texturing. The technique shows that illustrative visualization provides an effective visual interface to urban spatial information and associated thematic information, offering many degrees of freedom for graphics design. Primary application areas include city and landscape planning, cartoon worlds in computer games, and tourist information systems.



a) b)

Fig. 7. Examples of non-photorealistic depictions of a virtual 3D city model with (a) and without (b) facade textures.

16.6 Conclusions

Non-photorealistic computer graphics offers a large potential for developing specialized visualization techniques in multimedia cartography such as for illustrative, artistic, and informal information display. Most importantly, non-photorealism provides excellent means for visual abstraction as a primary technique to effectively communicate complex spatial information and not only allows us to implement traditional cartographic visualization techniques as part of interactive visualization applications, but also offers an excellent foundation for developing new cartographic concepts for visualizing geoinformation such as illustrative city models and landscape models.

Non-photorealistic geovisualization also raises several questions with respect to its impact to map-like and cartographic presentations. What are specific non-photorealistic rendering techniques for interactive map-based depictions? How do non-photorealistic geovisualizations cooperate with photorealistic ones, how to combine them? What are the specific elements of photorealism and non-photorealism in the human visual processing, and how to take advantage of these abilities for a more effective visual communication?

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17 Real-Time Virtual Landscapes

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17.1 Potentials, Limitations, and Challenges

Real-time virtual landscapes serve as interactive, intuitive tools for exploring, analysing, synthesising, and communicating plans, impressions, and simulations of 3D landscape models. They represent a general form of geovirtual environment (GeoVE) and can be constructed by terrain models, building models, and vegetation models. Due to their generality, real-time virtual landscapes can be applied not only in landscape planning but also to a broad range of applications and systems in the geosciences, such as in environmental information systems, disaster management systems, homeland security applications and facility management systems. They constitute, in a sense, an essential user interface paradigm for geospatial information.

Fundamental limitations result from the *human landscape perception*, which is based on a complex cognitive and aesthetic process. Only through the intellectual processing of what has been seen, the visual information of a landscape model turns into what we call landscape. Hence, the processing and interpretation efforts are high (Zube 1987). The cognitive product "landscape" mainly consists of the factors education, experience, and enjoying observation (contemplation). This connection is well known in the landscape planning profession.

In multimedia cartography, effective means have to be investigated to overcome limitations in landscape visualization. For example, abstract and graphically often insufficient maps, imprecise and manipulative perspective presentations, non-representative still pictures (e.g., montage-based imagery), or high-speed fly-throughs from bird's eye views based on cost-intensive, manually modelled 3D scenes neither convince experts nor non-expert users.

Landscape visualization requires understandable and visually interesting presentations and interfaces. Crucial features systems have to support include:

- Real-time photorealistic rendering for large-scale landscape models;
- Convincing representation of complex, realistic vegetation objects;
- Direct manipulation and editing of landscape objects;
- Seamless integration heterogeneous 2D and 3D geodata; and
- Views at all scales (map views, bird's-eye views and pedestrian views).

In a sense, real-time virtual landscapes translate Repton's idea (Daniels 1999) with his Red Books to draw different planning situations from the viewer's perspective into a new, digital media-based dimension. Fig. 1 gives an example of a real-time virtual landscape, the lost Italian Garden of Sanssouci park, Potsdam.

Fig. 1. Reconstruction of historic gardens and parks by virtual landscapes.

17.2 3D Landscape Models

A virtual landscape represents part of a real or imaginary landscape by a landscape model, which is composed in a hierarchical way based on landscape objects. They include the digital terrain model (DTM), 2D imagery data such as aerial photography or topographic maps, 2D planning data such as cadastre data or street networks, 3D building data, and 3D biotope and vegetation data. The landscape model is complemented by georeferenced thematic data relevant to the application domain (e.g., land use data, contamination data, or socio-demographic data) and by meta visualization objects (e.g., annotations, legends, compass and virtual sky).

Landscape objects do not only define attribute data but also functionality represented by their methods. For example, a building object has attributes such as ground polygon, height, roof type, number of floors etc. but it also provides the functionality to construct the roof geometry according to the roof type, the walls according to the building height and ground polygon, and it can calculate building-specific properties such as the number of square meters available or its volume. In particular, object-oriented modelling of vegetation objects has been one of the major innovations required for convincing real-time virtual landscapes. For example, an alley should be represented as a group of trees, placed parallel along a street with defined distances apart. If the course of the street, the distance, or the tree type is changed the alley automatically should re-instantiate its components. In this way, built-in functionality becomes directly available to the landscape modeller and provides higher-level functionality compared to purely virtual reality systems.

17.3 Functionality of Real-Time Virtual Landscape Systems

From a technical point of view, a real-time virtual landscape system is characterized by the following functionality and properties:

- *Real-Time Rendering* – allows us to interactively operate, explore, and analyze landscape models;
- *Vegetation Modeling* – need to be detailed, three-dimensional, and botanically accurate to be convincing and useful landscape objects;
- *Vegetation Arrangement* – includes the instantiation, distribution, orientation, of plant models according to characteristics of plant species, soil type, topography and other relevant parameters;
- *Landscape Editing* – required to directly edit and manipulate landscape model objects without having to switch between a 2D conceptual, map-based view and a virtual reality 3D view;
- *Landscape Interaction* – requires navigation tools and support for orientation in the 3D geovirtual environment, in particular, the user should be able to select between different navigation tools such as walking and flying;

- *Scalability* – the rendering techniques used should be able to process massive data sets, which typically occur even for small virtual landscapes (e.g., aerial photography of 300 GB for a middle-size town in a resolution of 20 cm), using multi-resolution algorithms and data structures; and
- *Interoperability* – requires that geodata can be exchanged in standardized formats. For 3D geodata, e.g., for building models and vegetation models, there are still no standards available but XML-based first approaches exist (e.g., CityGML (Kolbe et al. 2005)).

17.3.1 General System Architecture

The architecture of real-time virtual landscape systems typically consists of two core components, the authoring and presentation systems. In the following, this refers to the *LandXplorer* system, a real-time virtual landscape system outlined in Fig. 2.

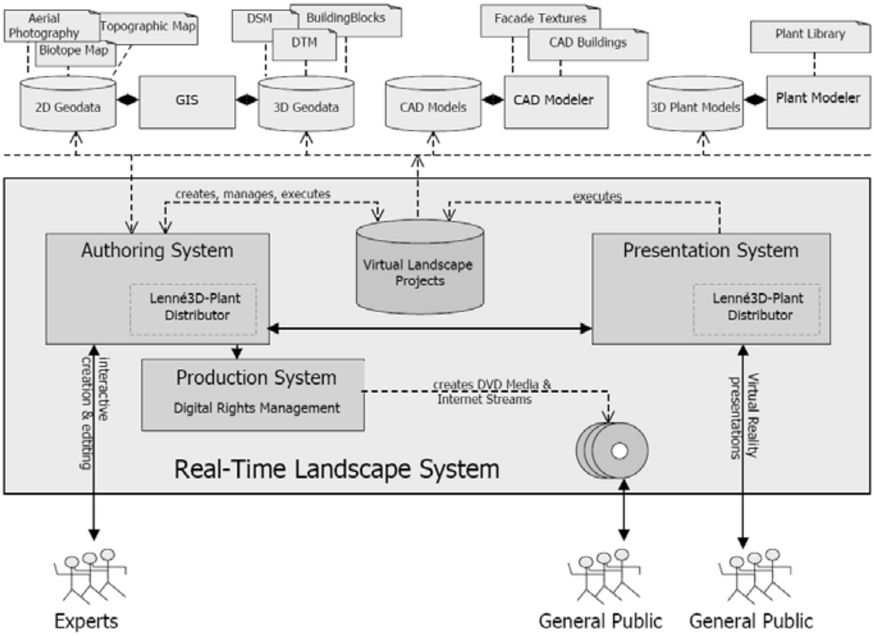

Fig. 2. General architecture of a real-time virtual landscape visualization system (Image: 3D Geo/LandXplorer).

The *authoring system* is responsible for creating, managing, and storing the virtual landscape model and the specification of its presentations. It provides the user interface for the real-time landscape system.

The *presentation system* is responsible for real-time rendering of complex landscape models. It can be used within the editor, also as a stand-alone application. It provides optimized rendering techniques for presenting large-scale landscapes.

Both components rely on the *plant distribution subsystem*, supporting instantiating, placing and configuring vegetation objects. Since plant distributions are determined on-demand, authoring and presentation systems require its services.

The *production system* is responsible for exporting virtual landscape projects to different distribution media, whereby geodata has to be selected, resampled, serialized, compressed and encrypted. *Digital rights management* (DRM) mechanisms need to be included as well, which protect the digital contents of virtual landscapes and, thereby, provide means to control the usage and distribution of virtual landscapes. DRM is a prerequisite for using virtual landscapes for different target user groups to comply with license and usage rights. For example, the production system can encapsulating a virtual landscape into a black-box, executable software unit distributed on DVD.

17.4 Building Blocks of Virtual Landscapes

The authoring system serves as tool for constructing and designing virtual landscapes offering three categories of building blocks:

- *Geometry objects* represent geodata and geo-objects, including multi--resolution 3D terrain models, 3D building models, and 2D raster data;
- *Behavior objects* specify interaction and animation capabilities available to geovirtual environments, including animated camera bookmarks or dynamic textures; and
- *Structure objects* hierarchically organize the components of a geovirtual environment, including component groups and information layers.

Collections of building blocks are arranged in information layers. *Raster-data layers* represent rasterised 2D geodata such as aerial photography, topographic maps or terrain shadings. They are positioned on top of the digital terrain surface according to their geo-coordinates. Each layer can have a different resolution and extension and it can overlap with other layers.

Vector-data layers represent both 2D vector-based graphics (e.g., georeferenced points, lines, polygons and curves) as well as 3D vector-based graphics (e.g., 3D buildings and 3D vegetation groups). Each object contained in a vector-data layer can be identified and directly edited in the 3D view.

2D raster and vector information layers are projected onto the terrain surface and can be combined by defining the imaging operation applied to corresponding textures during rendering, e.g., weighted addition or modulation (Döllner *et al.*, 2000). For example, aerial photography (raster data) can be visually combined with a street network (vector data) on-the-fly (Kersting and Döllner, 2002).

17.5 3D Building Modeling

Building models are fundamental objects from which virtual landscapes are composed, although they are sometimes not the dominant elements in terms of quantity. Four general *levels of detail* are distinguished according to CityGML, a proposed standard for virtual city models (Kolbe *et al.*, 2005):

LOD 1: Box models based on 2D polygonal ground planes with associated heights - representing the simplest type of building, suitable in the initial phase of creating virtual landscapes;

LOD 2: Building models with detail facade geometry and roofs, useful in particular to model far-away buildings such as those in the surroundings - level 1 and 2 buildings can be generated mostly in an automated way, which makes them suitable for large-scale virtual landscapes;

LOD 3: Building models with detailed textures and architectural elements - manual modeling or an automated transformation of CAD models (e.g., ArchiCAD, IFC) are required; and

LOD 4: Architectural building models with interior designs. For virtual landscapes indoor models are of less importance.

To enable real-time rendering of large-scale landscape models, their complexity has to be reduced in order to guarantee high and constant frame rates. For virtual environments, geometry or texture related optimization algorithms are available, e.g., automatic impostor placements (Jeschke, 2005), multi-resolution facade texture atlases (Buchholz and Döllner 2005), or approximating scenes by billboard clouds (Decoret, 2003).

17.6 3D Vegetation Modeling

P*lant modelling*, that is, modelling individual plant types (e.g., an 100-year old oak tree) can be distinguished from *vegetation modelling*, that is, modelling a setting of plant objects in a specific area (e.g., a forest of oak trees).

17.6.1 3D Plant Modeling

Plant modelling represents a challenging task, particularly because botanical knowledge is required and manual processes are involved, for example, to collect images of plant parts, to scan leaf textures, to produce variants of a single plant, and to set up properties for a plant type. Although plants appear in countless computer graphics works, a botanical-based, three-dimensional approach to plant modelling is still an active research area.

Each plant model is defined by its 3D geometry and a collection of textures (frequently captured from real plant parts) used to achieve a high degree of photorealism. Specialised 3D plant modelling systems are available such as *xfrog* (greenworks organic software) and *bionatics*. The *xfrog* plant modeller offers object-oriented building blocks such as nodes for leafs, branches, arrangements, curves, and variations (Deussen, 1998). Based on hierarchical graph-based plant specifications, the resulting 3D geometry of a single plant can be derived.

For the *LandXplorer* system, the Lenné3D library (Paar 2003) is employed. It contains detailed plant models for more than 500 plant species that occur in Europe. For each plant species its state in spring and winter as well as variants for different growth states are provided.

17.6.2 3D Vegetation Modeling

Vegetation modelling is broken down into two stages (Röhricht 2005). In the first stage, pedological maps and/or relief data (e.g., altitude, exposition, slope) or other expert data are combined with vegetation referenced spatial data (e.g., maps of biotope types) to produce more or less homogeneous parts (so-called geo cells) in the landscape. These clippings will then be combined with *relevé* data at the next stage. The dispersion of every plant within the corresponding geo cell is automatically computed, based on the sociability of the particular species or on a manually specified distribution path. Depending on the size of the sample area, hundreds of thousands, up to several billions of single plant individuals can result (Fig. 3), whose locations must be provided to the rendering system.

In the *LandXplorer* system, vegetation modelling is based on specialized information layers, the *vegetation layers*, which contain biotope and land use data together with additional GIS thematic data such as topographic data, history, and soil type information. Based on vegetation reference tables, the plant distributor subsystem calculates the plant distribution for a given area, and it assigns plant models to these distributions. A vegetation layer can also contain explicitly placed and instantiated objects, for example landmark-like trees.

Fig. 3. Example of a vegetation group with a large number of plant instances (Image: Lenné3D).

The plant distributor determines the contents and spatial distribution of vegetation layers by heuristic-algorithmic techniques. The distributor also takes into account additional spatial information such as terrain slope, terrain exposition, or land use type. For example, an area of bushes can be specified by the area polygon, the density in which bushes should occur, and the distribution function, which could specify an exposition range that constrains possible locations for a single bush.

17.7 Real-Time Landscape Rendering Techniques

In general, rendering for complex virtual landscapes is based on real-time, multi-resolution rendering algorithms for 3D scene geometry (Akenine-Möller and Haines 2002). Landscape rendering, in particular, has to cope with two core requirements, 1) handling large-scale terrains and related textures and 2) handling up to millions of individual vegetation objects. Multi-textured, multi-resolution terrain texturing algorithms together with out-of-core level-of-detail algorithms (i.e., algorithms optimized for externally stored, large-scale data) provide efficient solutions. For example, the multi-resolution texturing technique (Döllner *et al.* 2000) operates on virtually unlimited raster data sets; and the virtual landscapes used up to 300 GB of terrain texture data in real-time.

Vegetation rendering is faced with two core challenges: 1) Complex geometry – a single plant model, say a typical tree, commonly contains between 50,000 and 150,000 textured triangles, whereby large parts are spent on leaves. 2) High quality – the human experience in seeing plants is highly developed. Therefore, observers are critical with respect to "fake plants" constructed with billboards, which may be suitable for distant rendering of plants, but do not allow rendering of convincing, detailed trees from a close perspective.

Specialized level-of-detail rendering techniques (Coconu and Hege 2003) are required, e.g. by point-based and line-based simplification schemata. Roughly speaking, only vegetation objects directly in front of the camera are rendered with full detail, whereas all other vegetation objects are approximated by 3D points, 3D lines, or 3D billboard clouds that resemble the overall geometry of the tree. Consequently, virtual landscapes with a high amount of photorealism become possible. To further optimize the scene geometry, the vegetation layers can decide whether to instantiate individual plant objects or to use approximations. For example, once the observer comes close to a lawn area, say up to 20 cm, the individual blades of grass close to the observer are instantiated, in all other cases the lawn area is approximated by simplified geometry and treated as a whole.

17.8 Navigating Through Virtual Landscapes

Navigation is a key factor for user acceptance of real-time virtual landscapes typically suffering from the lack of a proper handling and prevention of confusing or disorientating situations. As Fuhrmann and MacEachren (2001, p. 1) point out, "core problems for users of these desktop GeoVEs are to navigate through, and remain oriented in, the display space and to relate that display space to the geographic space it depicts.”

Local navigation controls are anchored by spatial positions such as defined by the center of the visible part of the landscape. The spherical trackball, for example, simulates rotating a virtual sphere enclosing that visible area. Similarly, the conical trackball supports zooming within the virtual cone. In addition, the walking mode, commonly known from computer games, represents an avatar walking in the virtual landscape and provides a pedestrian’s perspective. As a characteristic element of local navigation, only part of the geovirtual environment is visible, and the camera remains close to anchored objects of the virtual landscape.

Global navigation controls aim at providing a spatial overview and allow for browsing and selecting local areas. In general, the distance between camera and virtual landscape is much larger compared to local navigation techniques. Well-known metaphors include, for example, flying vehicles such as virtual airplane and the virtual helicopter.

Smart navigation controls (Buchholz *et al.*, 2005) help to solve this situation giving user guidance: they interpret user interaction regarding the current view specification, i.e., the parameters of the virtual camera, and determine if the user is about to get into confusing or disorienting situations in an anticipatory way. They guide the user away from situations where usual navigation behaviour tends to fail and they always indicate to the user when the guidance mechanism is operating, so that the user understands the behaviour of the smart navigation strategy. Smart navigation strategies are useful to inexperienced users reducing the need for specific training.

Technically, smart navigation splits common navigation techniques into two steps: 1) The mapping from user interaction events to camera movements takes place; and, 2) the intended movement is checked against several constraints and modified if necessary. Smart navigation controls are composed by interaction constraints (Döllner, 2005) such as:

Spatial constraints: Restrict spatial parameters of GeoVEs such as camera position, orientation, and movement;

Structural constraints: Restrict operations that modify GeoVE components, such as replacing or adding components; and

Redistribution constraints: Define the properties of distributed GeoVEs.

17.9 Case Study: The Lost Italian Gardens

Since May 2002, the joint research project Lenné3D (Paar, 2003) has developed a system for real-time 3D landscape visualization both from map view and from stroller's view. The Lenné3D system is targeted on supporting the dialogue on community landscape planning and decision-making. One core case studies represents the "Italian cultural showpiece", a jewel of the Potsdam-Berlin (Germany) park and garden landscape, which was largely arranged by Peter Joseph Lenné (1789–1866) two centuries ago, and was designated part of the UNESCO world cultural heritage. The garden was laid out in 1834 to the west of the Roman Baths in Sanssouci park to complete the atmosphere of an Italian country villa as created by the Roman baths (Fig. 4) Grape vines and pumpkins once grew like garlands scalloping between elm and mulberry trees, between ornamental and useful plants from the Mediterranean, thus emphasizing the agricultural character of the Roman Baths. Many of the plants used are not winter-hardy in central Europe, their cultivation is demanding and their care is very labor intensive. Within only 50 years after its creation nothing remained of the garden.

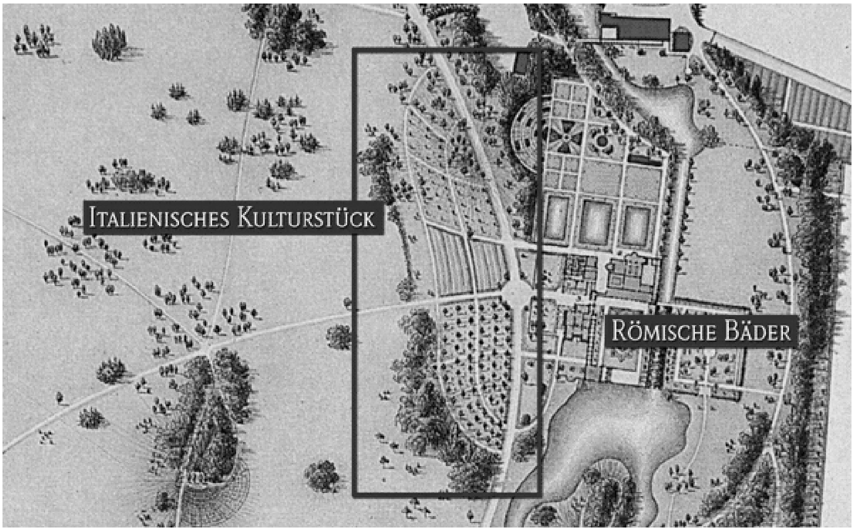

Fig. 4. The historic map of the Italian Garden. (Image: Lenné3D)

Landscape planners, officials, and the general public are recently discussing how to reconstruct the lost garden in the long term. To study and understand its structure, composition, and appearance as well as to provide experts and the general public with an impression of the former diversity of the horticultural garden a real-time virtual landscape was created. In summer 2004, more than 20,000 people visited the exhibition “Prussian Green” where the virtually reconstructed Garden of the 19th century was presented to the public within a virtual reality environment using a concave 180° panorama screen (Fig. 5). By means of a tangible interface, a light wheel illuminating the viewer’s location and viewing direction on a table surface, the visitor, standing in the half circle of the screen, was able to choose his own path through the garden in an intuitive manner and thus immerse himself/herself in the virtual world.

Fig. 5. Panoramic screen used by a real-time landscape of the lost Italian Garden.

17.10 Conclusions

Virtual landscapes rely on an integrated modelling of 3D buildings, 3D vegetation and 3D terrains. Their inherent geometric complexity requires specialized multi-resolution and rendering algorithms. Beside the technical challenges, a subtle, possibly unconscious criterion for user acceptance must be met, that of the visual quality of vegetation presentations. The landscape models also serve to integrate heterogeneous 2D and 3D geodata, in a uniform, broad conceptual frame. This way, real-time virtual landscapes have a high potential for becoming essential geovirtual environment types in multimedia cartography.

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18 Digital Globes

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18.1 Introduction

The era of the globe began with the great exploratory expeditions and has lasted for over 500 years. At the beginning of the third Millennium, and especially under the influence of New Media, the methods of visualization on globes require fundamental re-examination. In particular, animation, interactivity and 3d-technology have a potential that is still hard to estimate. 3D-multimedia systems are the key technology for digital globes, giving cartographers the opportunity to implement a globe in a digital 3D environment where the digital globe appears as a real object to the user, just like an analogue/physical globe. It seems that the abundance of possibilities is limited only by the creativity of cartographers.

18.2 Categories of Digital Globes

The following definition for globes applies in the same way to both traditional analogue globes and digital globes:

"A globe is a scale-bound, structured model of a celestial body (respectively firmament) presented in its undistorted three-dimensional wholeness" (Riedl 2000, p 17).

Furthermore and most importantly, this also applies to digital globes where a three-dimensional model is a fundamental requirement. The term ‘Digital Globe’ should not be confused with the term ‘Digital Earth’ (although a Digital Globe can act as a Digital Earth). Digital Earth is an interface metaphor for accessing/organizing high-resolution global geodatasets. US-Vice President Al Gore coined the term Digital Earth in 1998, when he was Vice-President of the USA during a speech at the California Science Center (USA) (Gore 1998).

In general globes can be distinguished regarding their implementation by three parameters:

- The nature of the cartographic image (analog, digital);
- The character of the globe body (physical, real); and
- The kind of representation space (real, virtual)

If one combines these three parameters this results in eight theoretical possibilities, of which four are realistic. One of the four is the well-known analog physical globe. The remaining three variants represent digital globes which are linked together by their digital visualization techniques. Significant distinctions can be made regarding the actual globe body or the kind of space in which the globe is visualized. Focusing on representation, digital globes can be classified as:

- **Virtual hyperglobes**: Visualization of the digital image on a virtual globe body in virtual space.;
- **Tactile hyperglobes (material hyperglobes):** Visualization of the digital image on a physical (touch-sensitive) globe body in real space.; and
- **Hologlobes:** Visualization of the digital image on a virtual globe body in real space. (Riedl 2000)

Figure 1 represents this classification graphically.

According to how data is accessed, digital globes can be either online or offline globes, or a combination of both. In fact, there is a strong move from offline globes to online globes. This is related to the broader availability of broadband internet and huge databases providing high resolution geospatial information.

According to their ‘degree of reality, virtual hyperglobes can be further classified as either DesktopVR (DTVR) or Immersive (Semi Immersive) Reality (IR). Here, it needs to be determined whether the three-dimensional model is recognized by the viewer as a realistic three-dimensional object (spatially) or as ‘projection’ onto a two-dimensional (screen) plane, which is the case with DTVR. Until recently the latter was the exclusive presentation form for digital globes. Now display technologies can create a convincing optical depth perception using wide-ranging equipment (Schratt and Riedl 2005).

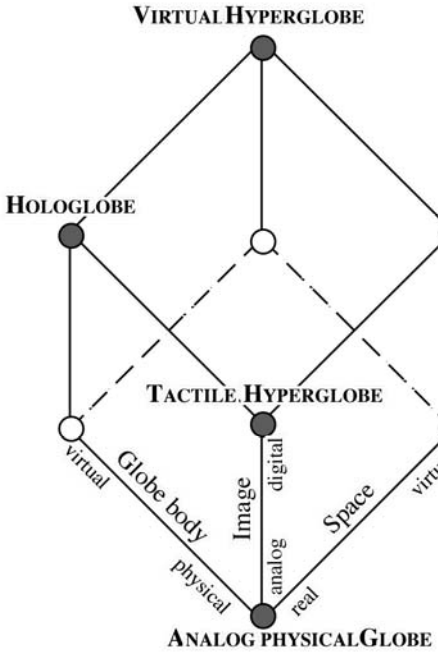


Fig. 1. Categories of (digital) globes

18.3 What makes Digital Globes superior?

The use of multimedia and hypermedia has had a great impact on the presentation and the distribution of geographic information (Cartwright et al., 1997). When it comes to digital globes there exists a physical independence between the visualization surface (screen) and visualization theme (digital data). This allows cartographers to implement a great number of features that would have been impossible with traditional globes.

The biggest advantage of a globe in general is that it is distortion free and shows spatial relationships found in the real world. There simply does not exist another cartographic product that come as close to a globe from this perspective.

If we compare digital globes with traditional analogue physical globes the advantages of virtual globes become apparent. By generating a digital (virtual) model of a globe we do not only eliminate the disadvantages of traditional physical globes, but also preserve their advantages. Many globe specifying parameters can be significantly improved, the basics being:

- **Transportability**: The cartographic images of digital globes are based on digital data and therefore as easily transportable as any other digital information. Of course some of the drawbacks are similar to tactile hyperglobes.

- **Scalability**: Geospatial information can be viewed on digital globes (with online functionality) at any given scale ranging from 1: 500.000.000 to 1: 10.000 and beyond. Current digital globes can only show the whole globe at large scales. But to view and have access to the whole planet at least a part of the Earth's (curved) horizon should be visible. Otherwise the 'three-dimensional wholeness' would be lost and we would not be dealing with a digital globe in the strictest sense.

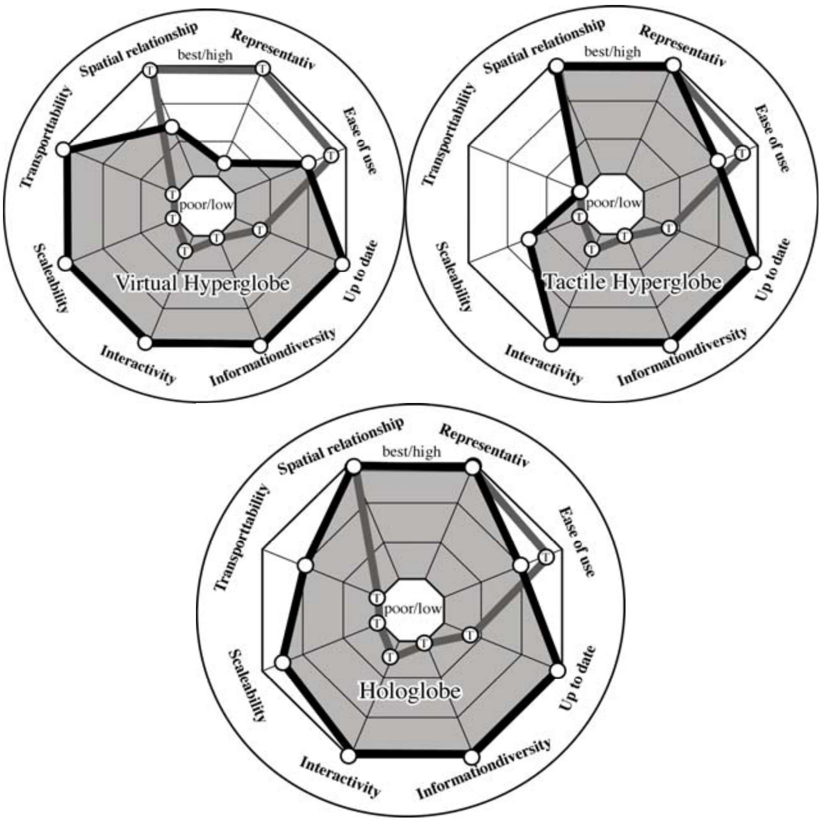


Fig. 2. The typification of digital globes vs. traditional globe (T)

- **Interactivity:** Before the digital era, physical globes had the greatest degree of interactivity of all cartographic products. But the globe's theme was non-changeable. A digital globe has functions that make it possible to receive feedback from the user. This leads to a globe that represents information according to specific user needs. The result is similar to maps-on-demand – a globe on demand (GOD).

- **Choice of topics**: Digital globes do not have the drawback of having to show not more than two different topics as with traditional globes. The ‘surface’ is able to switch between an almost unlimited numbers of global themes stored in geospatial databases. The ‘poor-choice-of-topics’ era for globes is passed once and for all. Interestingly it has to be observed that the number of topics dynamically visualized is equal or even greater than those possible with static presented topics. This is especially true with tactile hyperglobes.
- **Currency**: With digital globes the update period can be any given time span. The update period can be reduced or even eliminated in order to visualize global topics in real time (e.g. actual weather condition). Furthermore we can not only present topics at a given time, but also over a given period of time, providing a dynamic or animated image.

18.4 How suitable is a theme for a digital globe?

Not every subject is suitable for globe presentation. The evaluation of how appropriate a theme is to be presented on a digital globe could generally be called the theme's ‘globe-worthiness’. In view of the possibilities offered by a digital globe, the globe-worthiness of a theme needs to be re-analyzed. The parameters and criteria that can be used to evaluate the globe-worthiness of digital globes (Riedl 2000) are outlined in the following paragraphs:

Freedom from distortion – relation to the shape (geometry) of the celestial body: Aurada (1978) points out that the dependency of globe-worthy themes on the shape of the earth must be so high that the disadvantage of representation by a globe, i.e. the loss of complete overview, is counterbalanced. Due to the possibility of observing the digital globe from more than one position at the same time, this problem is of minor importance. Nevertheless, the dependency of the theme or of the question to be solved using the shape of the celestial body is of central importance even for digital globes. The range of applications covers, for example, illustrating the earth's shape, showing the effects of the inclination of the earth's axis, tracing the great circle between two points, or visualizing dynamic phenomena (like climate, ocean-currents, etc.).

Global availability of data: The theme to be represented must be a worldwide phenomenon and require a global representation. The global availability of data is a basic condition, but it does not imply that the globe is the best depiction method. Depending on the theme, a 'worldwide representation' can, in exceptional cases also be meaningful when the representation is limited to sea areas or landmasses. In order to make causal connection obvious, such topics are usually shown in combination with others. This is expanded upon more in the 'Capability of combination further section later in the chapter.

Representation on small scale – possibility of interpretation in spite of a great amount of generalization: Although digital globes are, in principle, not subject to restrictions regarding the scale, representations at small scale and associated great generalization will nevertheless dominate. The themes shown must retain their impact under these circumstances. It is possible that just by emphasizing single aspects in highly generalized themes that global connections can become visible.

Capability of combination: It is possible that a theme is not globe-worthy in isolation, but it may not be apparent in combination with another theme. Thus to a certain extent combination is required. This is particularly true for themes where content is limited either to oceans or to continents. A combined representation makes hidden relationships visible and thus makes them understandable.

18.5 Examples of Digital Globes

18.5.1 Digital globe illustrations

The simplest and most common globes on the Internet are rotating globes as GIF animations. Due to the fact that those animations consist of several two-dimensional pictures (usually azimuthal projections) and the globe model is not three-dimensional, as needed for digital globes, these globes are not in fact digital globes, but digital globe illustrations or animations.

18.5.2 Virtual hyperglobes

At the beginning of the 21st century digital globes have became common in electronic atlases. However they function primarily as an interface element. The popularity of three-dimensional representations of the earth has resulted in the fact that by 2004 almost every electronic world atlas had implemented a virtual hyperglobe as part of the interface. Similar applications of virtual hyperglobes can be found within GIS software products - ESRIs *ArcGlobe* (first implemented in *ArcGIS* 9, 2004 and 9.2, 2006). Actually there is a strong move away from offline virtual hyperglobes to online virtual hyperglobes. This trend was triggered by Google Earth and advanced by the huge demand for real time information and high resolution aerial and satellite images. A number of examples are illustrated in the following sections.

Table 1 Pioneers of virtual hyperglobes

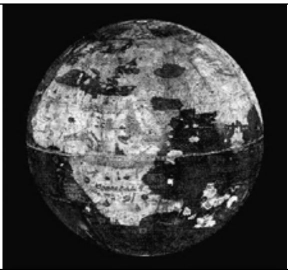
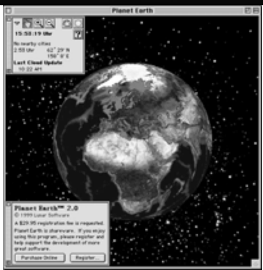
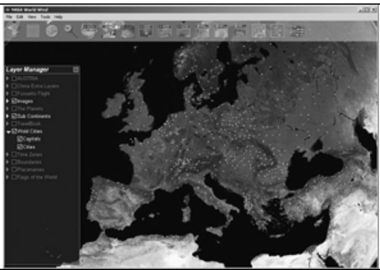
	*Digital Behaim Globe* (Hans Klimpfinger, 1993) One of the first exponents of digital globes was actually a by-product of the digitization of the oldest this existing earth globe on the occasion of its 500th anniversary. (Klimpfinger 1993)
	*Planet Earth* (Giger, 1996) Among the first with real time visualization. With this functionality *Planet Earth* (now *EarthBrowser*) showed a digital globe with the actual weather conditions shown. www.earthbrowser.com
	The *Hyperglobe* (Riedl, 2000) The *Hyperglobe* is based on an in-depth research that focused on how well multimedia is suited for the representation of the world on a virtual globe. www.hyperglobe.info

Table 2 State of the art (online) virtual hyperglobes

	*World Wind* (NASA, 2004) *World Wind* is open source containing freely available add-ons and plug-ins. worldwind.arc.nasa.gov
	*Google Earth* (Google, 2005) Based on Keyhole's .technology and containing the largest global geodatabase (>50Tb). It is freely accessible, including 3D building models of certain cities. *Google Earth* was a breakthrough for virtual hyperglobes, as similar systems existed years before, but remained virtually unknown. earth.google.com
	*Virtual Earth* (Microsoft, 2005) Based on MapPoint technology with much global data. It has a focus on North America. virtualearth.msn.com

With little effort existing virtual hyperglobes can be transformed into a 3D. The new generation of auto-stereoscopic displays from Companies like Opticality Technologies provides 'OpenGL Enhancer' which allows existing 3D applications, using the OpenGL graphics protocol to output to Opticality's auto-stereoscopic displays with no further effort.

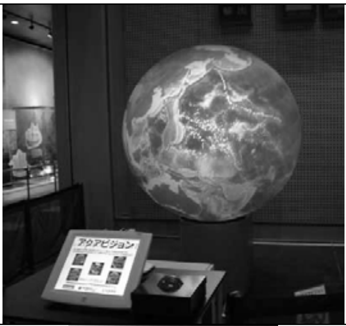
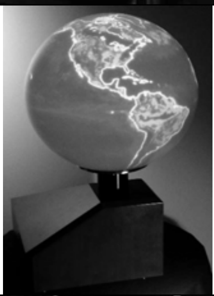
18.5.3 Tactile hyperglobes

With tactile hyperglobes the 3D perception of the globe is achieved by the display's geometry and not from a visual illusion based on stereo images. A special form of display device is a prerequisite for developing tactile hyperglobes. Similar to traditional analogue physical globes the display device has to be globe body and display device at the same time. The display's particular characteristic is its spherical surface, hence its name "spherical display". Currently there are three different (patented) versions of spherical displays in use for tactile hyperglobes. The scale in the table below relates to the earth and the diameter of the globe body. The year relates to the first installation.

Table 3 Pioneers of tactile hyperglobes

	*GeoSphere* (The GeoSphere Project, 1992) *GeoSphere's* globe body consists of an acrylic glass sphere, approximately two meters in diameter. A satellite image is printed onto the translucent sphere. A projection unit inside the globe allows visualization of additional topics. Scale ca. 1:6 000 000 www.geosphere.com
	*TerraVision* (artcom, 1994) This type shows the transition from virtual and tactile hyperglobe. . A 50 cm ball acts as navigation device. Movements of the ball are passed to the digital globe displayed on a wall. www.artcom.de
	*ag4 Globe* (ag4 mediatecture, 2000) The *ag4-Globe* represents the technical pinnacle of tactile hyperglobes. The image is retrieved from a LED video wall and projected via 110 000 fibre optic cables onto the globes hemisphere. The interaction between the user's hand movements and the globe is controlled by video cameras and image recognition software. Scale ca. 1 : 7 500 000 www.ag4.de

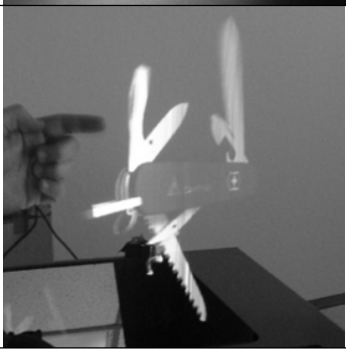
Table 4 State of the art tactile hyperglobes

	*OmniGlobe* (ARC Science Simulation, 2002) With this system a world map is projected from one or two video projectors located in the base through a hole at the sphere's bottom via a special convex mirror onto an acrylic spherical screen. ø 0.8m, ø 1.5m, ø 2m - scale from 1 : 16 000 000 to 1 : 6 000 000 www.arcscience.com
	*Magic Planet* (Global Imagination, 2002) *Magic Planet* uses one video projector to display images projected through a hole at the sphere's bottom via special lenses onto an acrylic glass ball. ø 35cm, ø 46cm, 61cm, ø 91cm, ø 1.22m - scale from 1 : 36 000 000 to 1 : 10 000 000 www.globalimagination.com
	*SOS - Science on a Sphere* (NOAA, 2002) NOAA's SOS uses video projectors to display images on the outside of a sphere. It uses 4 video projectors, each driven by a computer. A fifth computer is used to control the operation of the display computers. ø 1,8 m - scale 1 : 7 000 000 sos.noaa.gov

18.6 Hologlobes

The category of hologlobes is still in the early developer stage and much research needs to be carried out until a feasible solution is available. Nevertheless science-fiction ideas have matured from the first promising prototypes as the following examples show.

Table 5 Volumetric and free space display

	*Perspecta* (Actuality-Systems, 2002) *Perspecta* is the first commercial spatial 3D visualization system. The image on the left shows a photomontage. ø 50.8 cm www.actuality-systems.com
	*Heliodisplay* (IO2 Technology LLC, 2005) The current version of the first commercial interactive, free-space display (FSD) projects a diagonal image into mid-air, floating above the device. It's not yet a volumetric display, but a virtual image in real space. It is interactive, like a virtual touch screen. 22" to 42" (depending on model) www.io2technology.com

18.7 Conclusion

There are numerous possibilities arising from the potential presented by globes, New Media and display technology. Many scientists and engineers are already involved in the development of digital globes and this illustrates a broad interdisciplinary collaboration. Examples and developments, as illustrated will lead to a significant variety of digital globes never seen or imagined before.

Digital globes are used primarily as an interface that acts as gateway to more comprehensive geospatial information. In the age of globalisation a global point of view is necessary so as to better understand interweaving and interdependences. Digital globes will also help to motivate users to work with globes, and thus encourages the examination of global topics and their possible relationships. A digital globe offers the potential for providing a tool that could act as a geographical knowledge transmitter. It seems that for globes a bright future exists.

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19 Augmented Reality as a Medium for Cartography

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19.1 Introduction

Augmented Reality (AR) is a radically new user interface paradigm, which aims to amplify a user's sensory perception directly by supplementing computer generated, mostly visual information. Computer graphics elements are superimposed in the user's field of view. This approach is particularly powerful when trying to aid human users in their everyday activities, and in combination with mobile computing. This chapter explains the basic technology of AR, and discusses examples of how AR can be applied as a medium for cartography.

In contrast to Virtual Reality, which completely immerses a user in a computer-generated virtual environment, Augmented Reality (AR) aims to amplify a user's senses with additional information, letting them experience both real and virtual information at the same time. Technically, this is often achieved by superimposing computer graphics in the user's field of view through optical or electronic combination of real and virtual images. The widely accepted definition of AR according to Azuma (Azuma 1997) requires the following three characteristics:

- Combines real and virtual;
- Interactive in real-time; and
- Registered in 3D.

Note that while this definition rules out non-interactive media such as film or television, it does allow for non-visual augmentation (e.g., audio AR) as well as mediated reality environments, where a part of reality is replaced rather than augmented with computer-generated information.

Fulfilling all three requirements of Azuma's definition is a challenging task, which has fuelled over ten years of intensive research and development. The combination of real and virtual requires that an AR system must include input and output devices which are capable of achieving such a combination. An output device such as a head-mounted display (HMD) can present perspectively correct three-dimensional computer generated images wherever a user is looking. It must be combined with a tracking device which can accurately measure the position and orientation of the user's head, to control the virtual camera used to render the images presented to the user. Accuracy of registration between virtual and real objects highly influences the realism of the AR experience as perceived by the user. Achieving such high registration accuracy despite problems with systematic errors and noise in the tracking devices, miscalibration of the HMD or viewing device, and latency in the processing is subject to past and ongoing research.

While registration is an important research topic for AR, the field offers many other interesting research challenges. The primary motivation to develop AR is to establish a more natural user interface by exposing abstract information properties of the real world or associating it with phenomena encountered within the real world such as space and time. An important part of any AR user interface is 3D interaction. Humans know how to interact with real objects, how to handle and manipulate them. The augmentation of the real world with artificial objects tries to leverage that knowledge and extend it to the artificial information objects.

In doing so, AR blurs the distinction between the real world and the user interface in a way similar to the ideas of ubiquitous computing as described by Weiser (Weiser 1991). While ubiquitous computing focuses on the computer becoming invisible among the objects of everyday life, AR seeks to add to the experience of reality, thereby creating new forms of interaction between humans and computers. Mobile computers running AR applications can provide such ubiquity.

AR is useful in every situation where a human operator requires additional information, such as a doctor desiring to look "inside" a patient, or a maintenance technician referring to a technical manual. Obviously, the objective of cartography is to provide humans with additional information regarding their surrounding, such as navigation or cultural information. Consequently, AR can make a useful new type of user interface for computer-mediated cartography. In particular, delivering 3D geo-information directly at a task location makes new applications of cartography possible.

In the following, we discuss basic enabling technologies for AR, and case studies of stationary as well as mobile AR applications for the visualization of geo-information.

19.2 Augmented Reality technology

Most AR systems use graphics as their primary output medium. To support the presentation of visual AR content, and to combine this content with the real world, various display systems have been introduced.

Piekarski gives a useful summary of technological, perceptual and ergonomic issues of AR displays (Piekarski 2004). Technical issues are overall latency from user movement to image update, resolution and optical distortion of the image, field of view and registration quality. Perceptual issues are the number and quality of the provided depth cues such as occlusion, perspective, motion parallax or depth of field, as well as other quantitative image properties such as color, brightness, and contrast. Ergonomic issues concern such things as weight, tethering, safety concerns (when navigating potentially dangerous environs while using the display), and support for non-augmented peripheral vision.

Generally, AR displays can be split into head-mounted displays, handheld displays and projection displays, the latter being stationary but potentially able to accommodate multiple users.

Head-mounted displays are worn by the user on her head, and provide two image-generating devices, one for each eye. Since the display surface is located very close to the eye, additional optics have to be provided to move the focal point further away from the user, allowing the eyes to focus on the environment and the overlay at the same time. HMDs are suitable for stereoscopic display, delivering separate images to each eye. However, only high-end HMDs support stereo, while the low-end devices simply duplicate a single input image for each eye.

For image generation and merging with the real world, two approaches can be distinguished: Optical see-through systems, which allow the user to see through the display onto the real world, and video see-through systems, that use video cameras to capture an image of the real world and provide the user with an augmented video image of her environment.

Optical see-through systems use optical image combiners (usually half-silvered mirrors) to blend together virtual and real content. Due to their working principle, not all of the light of the environment will reach the user’s eye, resulting in a slightly attenuated view of the world, comparable to wearing sunglasses. The computer-generated images shown to the user always appear semi-transparent and cannot fully replace or occlude the real world.

Video see-through systems do not allow a direct look onto the real world. Instead, one or two video cameras at the front of the device capture images of the real world, which are mixed with the virtual content and then displayed to the user's eyes through two monitors inside the device. By overlaying the video images with the rendered content before displaying both to the user, virtual objects can, in contrast to optical see-through solutions, appear fully opaque and occlude the real objects behind them. The drawback of video-based systems is that the viewpoint of the video camera does not completely match the user's viewpoint. Although the brain can adapt to the new situation, for security reasons these systems cannot be used in applications where the user has to walk around or perform complex or dangerous tasks, since judgment of distances is distorted.

Hand-held displays also use a video-see through technique. They consist of a portable display with an attached video camera, essentially the same technical configuration as in a video-see through HMD. However, hand-held AR displays can be built from consumer devices such as tablet PCs, personal digital assistants (PDAs) or even cell phones. All these devices represent combinations of CPU, display and camera at extremely competitive price/performance ratios. In addition to this advantage, they are also lightweight and discrete, and have therefore recently become popular with AR researchers.

Projection-based AR displays use video projectors for directly casting images on surfaces in the environment. There are a number of options for configuring such projection systems: They can show monoscopic or stereoscopic images (stereo through the use of LCD shutter glasses for eye separation), employ front or back projection and use either video augmentation or physical surface augmentation. Video augmentation is essentially the stripped down version of a video see-through HMD, displaying the image of an external video camera augmented with computer graphics on the screen. Physical surface augmentation works by projecting light onto arbitrarily shaped real-world objects (Raskar et al. 1998). This technique can be used to dynamically illuminate real objects in the scene, or to simulate alternate surface texture properties. In both cases, to produce correct results, the geometry of the target object for projection has to be known in advance for perspectively-correct rendering.

Well-established standard computer input devices such as the keyboard or the mouse are practically useless in AR applications – often, users are moving around freely in space, or even roaming through buildings or outdoor areas. This leads to the requirement that input devices must either be ubiquitous; being able to follow the user's input without a fixed spatial location, or wearable, so that the user can carry the input devices with her.

Finding out where the user, her hands or some artifact she is handling is located in space is called tracking, and is probably the most important type of input to be fed into an AR system. Typically, tracking devices used in AR applications deliver data about the Six Degrees of Freedom (6DOF) of a tracked point in space: three position coordinates and three rotation components, plus optional action buttons. Furthermore, there are several properties of tracking hardware that are important to consider for AR applications:

- The range of operation. Some devices work only in a given radius from a central unit, for others the targets must be within the field of view of a camera;
- The update rate, measured in Hertz (updates per second). For the primary interaction devices, this should ideally match the frame rate of the display, but at least 10-15 Hz for interactive applications. Additional information, such as user or environmental context, can be delivered with lower update rates, depending on the application;
- The accuracy of the measurement, measured in relative (percent) or absolute average or maximum deviations from the correct result;
- The confidence whether a tracking target has correctly been identified. This applies primarily to optical trackers;
- Whether the tracked target has to be tethered (connected with a cable), or supplied with electrical power; and
- Finally, also the effort to set up and calibrate the device has to be taken into account when considering different tracking technologies. Some products come pre-calibrated, others have to be calibrated after installation, some even regularly.

The desire to fulfill as many of these requirements as possible has lead to a number of technical approaches for tracking technologies. To date, no solution without significant restrictions exists; therefore it is important for practical applications to consider the trade-offs.

Optical tracking is the most accepted technique for AR, since it allows leveraging ongoing developments in computer vision and substitute computational intelligence for sensor performance. Optical tracking systems use one or more cameras and advanced computer vision software to detect targets (often called markers) in the camera image and calculate their position and orientation information from that camera images.

An infrastructure of cameras permanently mounted in the environment can observe humans or physical artifacts instrumented with inexpensive passive fiducial markers. Multiple cameras with overlapping field of view can not only provide superior pose estimation through multi-view geometric analysis of the observed scene, but also provide better robustness against marker occlusion. Alternatively to stationary cameras, a mobile computer can be equipped with a single miniature camera, which is used to deliver images for both video-see through augmentation and optical tracking.

The range of available solutions for marker-based optical tracking ranges from highly professional systems provided by commercial companies such as Advanced Real-time Tracking or Vicon to inexpensive open source solutions working with a single consumer camera such as *ARToolKit* (Kato and Billinghurst 1999). Finally markerless tracking relies on natural features detected in the environment, and does not require any physical infrastructure. However, 3D tracking from natural features is currently not robust and fast enough for widespread commercial use.

One of the older methods is tracking by electromagnetic sensing. An emitter generates an electro-magnetic field, which is detected by the electronics in the tracking targets and results in accurate 6DOF tracking information. The main drawbacks with magnetic tracking are that the targets are tethered, and the whole system is very sensible to metal in the environment.

Acoustic tracking uses time of flight of an ultrasonic signal to calculate the distance between emitter and receiver. For three-dimensional tracking information, three emitters in the environment and one microphone at the target are required. If 6DOF information is needed, three microphones on the target must supply independent measurements. Although ultrasonic devices need not be tethered, the targets have to be equipped with active electronics and require batteries and radio transmission facilities. This makes the targets bulky and expensive, which, besides the low update rate, limits the number of targets that can be used simultaneously.

Inertial trackers measure linear acceleration or angular velocity. The obtained rate information is integrated per time step, resulting in the measurement of the current position and orientation of the device. While inertial trackers tend to suffer from drift resulting from integration errors, they are an excellent complement to other types of trackers such as optical or acoustic technologies.

Finally for outdoor applications, the global positioning system (GPS) can deliver rough positional data. For accurate positioning, GPS systems have to be accompanied by electronic compasses and inertial trackers, which allow for efficient dead reckoning between successive GPS measurements. While GPS is primarily designed for coarse location information used in ubiquitous computing applications, careful setup of a GPS system allows using it for AR as well.

19.3 Augmented reality visualization

Visualization for augmented reality focuses on two aspects: the realistic merging of artificial objects and effects with reality and the appropriate presentation of abstract information. The first aspect typically involves techniques from computer graphics such as correct illumination, image-based rendering and advanced transparency and shadow creation. The second has more in common with visualization in general and is of more interest to us here, as cartography also deals with visualization of abstractions.

Augmented reality user interfaces typically employ simple rendering styles such as uniformly lit lines and surfaces, strong primary colors, transparency and regular textures to distinguish abstract information from the real world. Proximity, call-out lines and correct depth interaction using occlusions establish relationships between real objects and augmented information. Note, that while real objects can easily occlude virtual information by not rendering the virtual part, occluding real objects is much harder and relies on special hardware (Kiyokawa et al. 2003) or illumination control over the environment (Bimber and Fröhlich 2002).

Abstract information displayed in AR user interfaces still registers in 3D with the real environment. However, the same visualization properties labeling information as abstract contradict the natural depth cues of human perception. As a result, simple computer graphics often appear to be situated on a virtual screen between the user and the environment rather than merge with it. Several projects have investigated appropriate visualization techniques to overcome this problem. Furmanski et al. conducted a study comparing three visualization methods for representations of occluded objects (Furmanski et al. 2002). Livingston et al. expanded this work by comparing a number of different factors such as color, brightness and rendering style on the depth perception of occluded virtual objects (Livingston et al. 2003).

A common approach to deploy augmented reality is to create interactive workspaces. Using head-mounted or projection displays, a system overlays dynamic information on static real world objects such as plain pieces of paper, maps and models of cities and buildings. An early example is the metaDESK that annotates a plain paper worksheet on a tabletop with projected information (Ullmer and Ishii 1997). A camera captures user input such as numbers written down for summation or copy and paste gestures on parts of the worksheet. The system reacts to such inputs and computes sums or projects copied parts back on the sheet. A more extensive system for urban planning applications is Urb which annotates a small scale city model with output from wind simulations and shadow and reflection computations (Ishii et al. 2002). Users can move physical building models and perceive the updated results of the simulations.

Similarly, head-mounted display-based systems allow to present 3D information in the context of plain 2D artifacts. Hedley et al. present an interesting system for visualization of geographical data in an AR environment (Hedley et al. 2001). This research group developed a system called AR PRISM that presents the user geographic information on top of real maps, viewed with a head-tracked HMD. The system allows collaborative work of multiple users (via multiple HMDs) and gesture-based interaction.

19.4 Case study: Augmented map system

The augmented map system developed at Cambridge University (Reitmayr et al. 2005) is a direct combination of cartographic maps as basic artifacts and augmented reality as user interface. Paper-based cartographic maps provide highly detailed information visualization with unrivaled fidelity and information density. However, printed maps are static displays and while computer-based map displays can support dynamic information, they lack the positive properties of real maps identified above. The restrictions are overcome by projecting digital graphical information and user interface components directly onto the physical map. User interaction with the both the original map and displayed information is mediated through a set of tangible tools.

The overall system centers on a tabletop environment where users work with maps. One or more maps are spread out on a table or any other planar surface. A camera mounted above the table tracks the maps' locations on the surface and registers interaction devices placed on them. A projector augments the maps with projected information from overhead. A computer vision based localization system tracks both the maps and interaction devices on the table surface. An image browser interaction device lets the user quickly view images that are associated with locations on the map. A rectangular prop consisting of a white piece of cardboard with a black border is placed on the map. The pointer in the middle of one side of the rectangle is used to denote a specific location and orientation on the map. The white area on the prop itself is used to project the retrieved image. Both location and direction of the pointer influence the displayed image. The direct display of the images enables seamless operation because both the query and the result are visible to the user within the same area.

Fig. 1. (Left) a user interacting with an augmented map, (right) overview of the individual tools and example augmentation of the expanded river

A second interaction device provides control over entities referenced to map locations. A *Windows CE*-based Personal Digital Assistant (PDA) device is located using the screen rectangle which appears almost black in the video image. Again a pointer is present on the top of the device to accurately determine a location. An active entity referenced to a location presents a dedicated user interface on the PDA. Typically the user interface is persistent on the PDA until a new one replaces it. Therefore users can pick up the PDA from the table surface again and operate it in a more comfortable hand-held manner.

The system was demonstrated with a flood control application for the City of Cambridge (UK) to demonstrate possible features of augmented maps. The River Cam running close to the town center of Cambridge regularly floods the surrounding areas, which are lower than the water level of the river in a number of cases. In the event of a real flood, the water line needs to be monitored, threatened areas identified and response units managed. Information provided by local personnel helps to assess the situation. An augmented map provides the ideal frame for presenting and controlling all the relevant information in one place.

A map of the area of interest is augmented with an overlaid area representing the flooded land at a certain water level. The overlay changes dynamically with the water level. Certain endangered compounds are highlighted in red with an animated texture when the water level reaches a critical level. Other information sources include images provided by ground personnel at various locations. Dedicated icons represent the locations and directions of these images. Using the image-browsing prop an operator can see the image and assess the local situation immediately. An emergency unit represented as a helicopter is visible on the map as well. By placing the PDA next to it, a corresponding graphical user interface appears on it to present more status information and give orders to the unit. Here its direction and speed can be controlled.

19.5 Mobile Augmented Reality

While AR in a stationary environment allows the construction of interesting new user interfaces, the ultimate goal of AR is to provide a computer-augmented environment anytime and everywhere, without restrictions. In particular, making mobile outdoor AR work outdoors pushes the envelope of what is currently possible with AR technology.

The first example of a mobile AR operating in an outdoor environment is the *Touring Machine* (Feiner et al. 1997) developed at Columbia University. The *Touring Machine* consists of a backpack assembly with a mobile computer and various sensors and peripherals. Images are delivered through an HMD that includes its own tracking technology for orientation. The positioning system is delivered by a GPS with a correction system that allows an accuracy of about 1m. This work has been inspiring for many research groups, and several of them have started developing their own backpack systems.

The follow-up developments, Mobile Augmented Reality System *MARS* (Höllerer et al. 1999) and *Situated Documentaries* (Höllerer and Pavlik 1999), further explored the user interface aspects of such systems for interactive presentations and campus tours. Tour guide applications and navigation aids are a recurring theme for mobile AR applications, for example *BARS* (Julier et al. 2000a), *Archeoguide* (Vlahakis et al. 2002), *GEIST* (Kretschmer et al. 2001) or *TOWNWEAR* (Satoh et al. 2001). Also related is a prototype for visualization of subsurface features (Roberts et al. 2002) developed at Nottingham University.

The *BAT* system developed at AT&T research lab in Cambridge (Newman et al. 2001) is unique in its coverage of a very large indoor area (a whole office building) with a custom high quality ultrasonic tracking system. This technology enabled the researchers to develop an infrastructure for “sentient computing”, providing a permanent suite of tools to mobile AR users: The system knows the whereabouts of its inhabitants, and can for example provide visual aids to locate a person or route telephone calls to the nearest phone.

Another popular mobile AR system is *Tinmith*, developed at the University of South Australia (Piekarski and Thomas 2001). *Tinmith* supports indoor and outdoor tracking of the user via GPS and fiducial markers. Interaction with the system is brought by the use of custom tracked gloves. The display of overlays is delivered by a video see-through HMD. The main application area of *Tinmith* is outdoor geometric reconstruction. Through the mobile AR system, its user is enabled to interactively create and inspect digital live-size reconstructions of natural and architectural features. The position of the user in the world as well as geometric operations such as constructive solid geometry provide input to a computer aided design application operating on a full-size model of the real environment. Distance interaction techniques allow the user to cover far away or out of reach regions. This application is noteworthy since it represents the rare attempt at creating content for AR systems on-line rather than merely browsing existing content from an immutable data repository.

Mobile AR user interfaces pose a number of challenges to the interface designer. The area covered by an outdoor AR system is potentially very large, and may contain an overwhelming number of information items that can be potentially displayed. Constrained viewing and operating conditions require a simple user interface with a high degree of autonomy and context-sensitive behavior, and prohibits complex user interactions. Therefore, several research projects have investigated algorithms that determine appropriate content and style for augmented views automatically. For example, an interactive filtering algorithm selects objects to be shown based on user defined priorities and proximity (Julier et al. 2000b). Label placement techniques are responsible for avoiding display clutter and unwanted occlusion of real objects by augmented labels and annotations (Bell et al. 2001).

19.6 Case Study: *Signpost*

The needs and requirements of a tourist are a suitable starting point for testing location-based applications. Consequently, a number of mobile AR demonstrators focus on the needs of a tourist as discussed before. Here we will discuss the design of a particular example in greater detail. The *Signpost* system is a prototypical tourist guide application for the City of Vienna covering both support for large-scale environments and collaboration (Reitmayr and Schmalstieg 2004).

Signpost covers both outdoor city areas as well as indoor areas of buildings. The system uses different tracking technologies in each individual type of environment and switches transparently between them. Outdoors a combination of differential GPS and inertial tracking is used, while a computer vision-based localization system employing fiducial markers was developed for indoor environments (Reitmayr and Schmalstieg 2003). Different levels of accuracy can be achieved by varying the density of fiducial markers.

The basic function of the system provides a navigational aid that directs the user to a target location. An information browser displays location-referenced information icons that can be selected to present more detailed information in a variety of formats. Both functions support collaboration between multiple mobile users.

In navigation mode the user selects a specific target address or a desired target location of a certain type such as a supermarket or a pharmacy. If the user is within a building a destination room is selected. The system then computes the shortest path in a known network of possible routes. It is interactive and reacts to the user's movements. It re-computes the shortest path to the target if the user goes astray or decides to take another route.

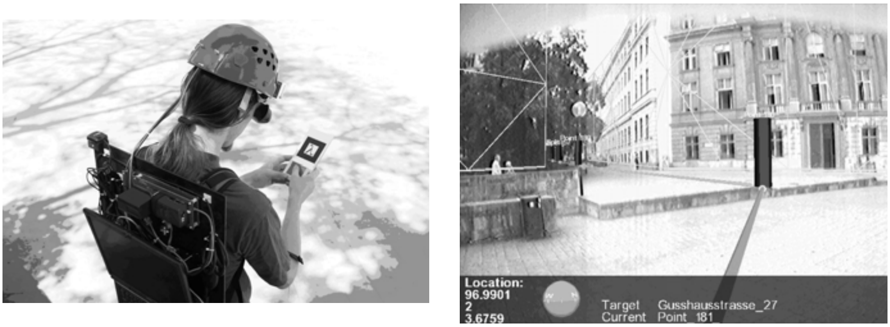

Fig. 2. Left) User interacting with a mobile AR system, (Right) Outdoor navigation display leading a user down a street

Outdoors, the information is displayed as a series of waypoints that are visualized as cylinders standing in the environment. Arrows indicating the direction the user should take between waypoints connect these cylinders. Together they become a visible line through the environment that is easy to follow. Buildings clip the displayed geometry to enable additional depth perception cues between the virtual information and the real world. Finally, the system displays simple directional information, if the user is not looking into the direction of the next waypoint.

Indoors, the system continuously provides the user with two modes of visual feedback: a heads-up display with directional arrows and a world in miniature model of the environment. The heads-up display shows a wire frame model of the current room superimposed on top of the real view and an arrow shows the direction to the next door. The application also presents a world-in-miniature model of the building to the user in the lower area of the heads-up display. The model shows an overview of the user’s current environment including the complete path.

In information browsing mode the system presents the user with location-based information. Location-referenced information icons appear in view and are selected by looking at them. Once activated, they present additional information associated with that location. The application conveys historical and cultural information about sights in the City of Vienna.

19.7 Conclusion

Augmented reality promises to merge the interactive nature of computer generated user interfaces with real objects and environments that create the every-day experience of users. New forms of cartography already build on the flexible access to online data and adaptive presentation of geographic information. These recent innovations combine well with interactive augmentations enabled by AR.

Stationary workplace systems can improve the users' performance because of the natural interactions they afford. The shared space between users is reused as output channel for digital and dynamic information, thereby naturally enhancing collaboration by providing the relevant information in place rather than in the confining context of traditional monitors.

With the advent of powerful hand-held devices, applications of AR are becoming mobile and ubiquitous. Contrary to stationary systems the workplace now becomes a large-scale environment. Moreover, information need not be abstracted completely from its location anymore, because users can perceive and manipulate it directly within its original setting.

We believe that these features of AR closely match potential future applications of cartography and therefore invite researches to take it into consideration. While the past research focused on the technological underpinnings of AR, future directions must come to a better understanding of efficient and practical methods to displaying spatial information. Therefore methods for AR could draw as well from the knowledge and experience of cartographers.

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20 Virtual Reality in Urban Planning and Design

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20.1 Introduction

This chapter will describe some potential applications for Virtual Reality (VR) within the urban development/urban planning industry. It draws on the combined work of Urban Futures Consulting and RMIT University's Virtual Reality Centre. Since 2001 they have been co-operating to develop and market visualisation products that meet the needs of this industry. Urban Futures is an independent consulting company with expertise in planning and urban design. RMIT provides the technical and research support that has allowed Urban Futures to carry out a wide range of commercial visualization projects from strategic planning to supporting planning tribunals through to 3D real time design studies.

RMIT established the Virtual Reality Centre in 1999 with the installation of a three projector curved screen 'reality centre' theatre. Utilising military specification optics this theatre allows simulations to be displayed with a high degree of accuracy utilising active stereo to enhance depth perception.

The combination of accurate optics and real time movement (allowing viewers to move naturally and choose their own viewpoints) and an independent approach with transparent use of data provide a high degree of authenticity to the visualizations. Portable display options and PC-based applications now allow VR presentations to be highly mobile. The work leverages advances in the fields of real time simulations, Geographic Information Systems (GIS) and computer games.

20.2 A User focus, not technology lead

Urban Future's simulation work has been shaped by our commitment to focus on what the user needs and demands rather than what the latest technology can do. We are interested in how digital visualisation can contribute to better planning and urban design outcomes.

Project work and research undertaken suggests there is also a growing demand for the use of visualization within the planning industry. The community is now more visually literate through film and multimedia. And, exposure to computer games is generating an expectation that similar techniques could be used to show what a future city will 'look' and 'feel' like. Figure 1 shows an example of a typical product.

Fig. 1. Screenshot from the real-time model of Melbourne, Australia.

Governments and local authorities have been slow to react to this demand partly through fear of cost and partly because the decision makers are furtherest from direct experience with visualisation advances. Unlike the games, film or military industries budgets available to the planning sector in Australia are not large. This means there is a critical need to deliver affordable, practical solutions.

20.3 Town Planning in Australia

Planning Schemes in Australia have generally followed a model based on the United Kingdom model. In this a 'Scheme' sets out to control future development generally by first controlling land use and then providing a number of development controls to regulate built form. Most of the scheme is in the form of legal text backed by tables and charts.

In all this the primary use of visualization is presently illustrative, mainly 2D diagrams. More specific images are much more likely to be found outside the Planning Scheme, in Guidelines, Policy or Strategic

Planning documents. Presently digital output is treated in the same category as “Artists’ Impressions”.

The result is a Planning Scheme that is likely to be quite effective at controlling or limiting particular uses or built form issues- such as height, an issue that always attracts attention - but is quite poor at predicting what the future built environment might look like and is ineffective at encouraging complex outcomes such as mixed use developments. And while the Planning Scheme can become very complex with multiple layers it is generally very difficult to link many issues together and to comprehend the potential inter relationships between built form, land use, social and cultural activity, economic outcomes and movement and access issues.

The Planning process we have inherited has served quite well while cities were expanding primarily by outward growth; however the contemporary planning environment is arguably a different urban paradigm with new pressures that demand new solutions and better design and communication tools.

20.4 Pressures for Change

There are a number of factors that reinforce the suggestion that urban planning has entered a new paradigm. . Issues such as urban competitiveness brought on by mobile communications (because people and industries can now locate relatively freely) and environmental sustainability are pushing towards more complex multi-centred cities. Development is now more likely to take place within existing communities rather than on large ‘greenfield’ sites. The complexities of developing within existing urban environments requires effective consultation and management particularly if there is not to be a community ‘backlash’ against changes seen as necessary by policy makers to respond to pressing environmental or economic needs.

Our experience suggests that relatively simple visualisations when run in real time and backed by authenticated data are a cost effective way of communicating the complex interaction of costs and benefits that this new paradigm implies. An example illustrating our approach is a series of visualisations prepared for the City of Manningham of the Doncaster Hill Activity Centre. The visualisation is based on a terrain model with ground details presented by aerial photography draped over the terrain. Most buildings in the scene are represented by simplified envelopes accurate to footprint and height. A number of key buildings have been modelled to a higher level of detail picking out large details and using digital photography images applied as textures. Examples of this are shown in figure 2.

Fig. 2. Examples from the Mannigham Doncaster Hill, Australia visualisation

Initial envelope studies were later followed by more detailed studies where actual proposals were inserted onto key sites. The Council design team then used the application to develop and show a series of proposed building controls. These were viewed within the Virtual Reality centre by the planning panel leading to their adoption as planning controls. Also included in the visualization were extensive tree planting and paving proposals and eventually proposed changes to the shopping centre.

The visualisation was used as the main input for a consultative video, in a number of workshops with the stakeholders in the VRC and as well various still images were used on the Council website. The outcome has been broad community acceptance of the proposals and a successful planning amendment.

This example along with similar studies for the City of Melbourne (West Melbourne Height Study, Queen Victoria Markets built form study, Bourke Street Mall design study) showed that a real time model developed from data can have a high level of acceptance by both authorities and community even with detail limited to building envelopes and a small number of textured elevations. In fact it was suspected that where visualisations attempt to provide a 'photographic' level of reality viewers may be distracted by detail or minor errors that are not relevant to the question of the study. (See the previous chapter by Döllner that discusses issues related to non-realistic 3D)

More recent projects by Urban Futures and RMIT advanced the process. Developing entirely on PCs and using open source applications based on Open Scene Graph (OSG). We procedurally generate as much of the content as possible. The visualisation of the Maribyrnong Valley for the Department of Sustainability and Environment, Victoria and five local municipalities is an example of this approach. Most buildings, all trees, electricity pylons and cables and street fittings are procedurally generated.

Only a small number of landmark buildings were modelled with architectural details and textures to assist wayfinding. This enables both a cost effective visualisation (eg more that 35 km of river valley and over 5000 buildings visualised) and provides authorities with a strategic tool where design studies and development proposals can be quickly simulated and tested. Figure 3 shows a number of scenes from the Maribyrnong River Valley, Australia project.

Fig. 3. Screenshot from the Maribyrnong Valley Visualization.

20.5 Towards a 3D Planning Scheme

In essence, it is suggested that 3D VR models, when derived from data that can be authenticated, can play a far more important role within the planning process than acting as illustrations. Because of their ability to communicate with minimal interpretation, they could effectively become the 'preferred outcome' against which all proposals could be assessed.

The proposition is that planning processes will move to a scenario where the visualisation will precede the text based controls. Effectively we will be able to show the future city as it is intended to be; the role of text will be to describe what processes to follow should a proposal that doesn't meet the visualisation be considered.

In order to make this leap it will be vital that the base visualisation is built up from data bases and these will have to be maintained by multiple inputs. By developing on top of data bases, there will be other advantages including the ability to call up any form of data, from spatial statistics through to detailed models of buildings or locations. The theory of how to do this is well established – the relational database as described by Codd (1970) and Egenhofer (1994). The following sections discuss some issues and solutions of marrying relational database theory with modelling, simulations and input from the computer games world.

20.6 Modelling and Simulation; oh….and games

While we propose greater use of visualizations there is a distinct departure point from the artist’s impression into the Modelling and Simulation (M&S) world. This ultimately brings with it a collection of responsibilities as weighty as the statutes it hopes to represent as we enter the realm of the visual image as legal document. Unlike an artist’s impression or a game, it is necessary to precisely define what to visualise and apply processes and levels of accuracy to ensure the output is fit for the purpose intended.

The United States Department of Defense; Defense Modeling and Simulation Office (DMSO, 2005), has an extensive glossary which scrutinises the semantics of almost every term we could hope to use in this field. As a starting point:

Modeling: Application of a standard, rigorous, structured methodology to create and validate a physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process; and
Simulation: A method for implementing a model over time.

The DMSO has a fair interpretation of what M&S means to military situations. Civilian parallels are obvious for us to imagine. We also are considering the efficacy of M&S. Again, the DMSO covers this ground adequately with the concepts of verification, validation, accreditation, fidelity & resolution. Or to use their laypersons terms: “Did we build it correctly?”, “Did we build the right thing?”, “Does it meet my needs?”, “Does it act like the real thing?” and “Does it look like the real thing?”

Our target communities are not alone in observing the compelling communication and learning power of computer gaming technology. There is a synergy of interests between the civilian and military worlds in this space as most of the military demands, with the exception perhaps of the mission objectives, are congruent with research rigour and educational efficacy. Both military and civilian applications are exploring the ongoing need for rapid, effective and inexpensive simulations by leveraging the growing repositories of GIS databases. An important consideration is that gaming technology is being reincorporated into the superset of modelling and simulation, from where it evolved and is then subject to the same rigours as above.

Current gaming technology also has a modest and diverse user base under the ‘serious gaming’ banner whose primary purpose is something other than to entertain. While its parameters are restrictive and based on greenfield development, the compelling popularity of the computer game SimCity™ outside of the classroom is well observed. Rejeski (2002) challenges our policymakers to consider the era they are making decisions in.

The driving factor today is cost, particularly for applications such as planning that will have a limited number of users. For all the credibility a simulation can have, if it simply too expensive it will not be used. An affordable reality is sought as a balance of application efficacy to the critical nature of decisions being made.

20.7 RMIT approach to (ever) larger scale visualisations

20.7.1 Scale and resolution : single precision arithmetic

The direction being taken implies we need to visualise whole parts of a city if not an entire metropolitan area. The Visualisation of geographically large areas has historically leveraged clever techniques in computation. The concept of 'large' in the context of computer graphics is also a moving target as it appears to be keeping pace with Moore's Law. Despite the capacity of a system to deal with large volumes of data by brute force, if the extents or the range in scale change dramatically, the reliance on single precision arithmetic for computational speed will eventually force another strategy.

At the time of writing, commodity 32 bit processors are capable of computing highly detailed scenes of arbitrary large extents with double precision arithmetic. The underlying core rendering tools such as OpenGL are basically single precision calculators for painting a small 2D image. Hardware rendering pipelines are now so fast that the transformation matrix from database coordinates to something sensible for the processing pipeline can be transparent to the user. What this means is that map grid coordinates or decimal degrees can be preserved as the primary unit for computation and query without the usual visual artefacts of floating point roundup error.

20.7.2 Performance & interactive use of data

As we are interested in the interactive navigation of our visual scenes, the complexity of the scene data or detail obviously comes into play when scaling our extents in order to maintain fast rendering. Again, brute force could never provide an enduring solution as detail is a worthy adversary.

Levels Of Detail (LOD) techniques are insufficient on their own as they are ultimately limited by a system's resources. As above, clever techniques usually involving the asynchronous paging in and out of data as is required by the user's proximity were deployed on systems with massive bandwidth.

In 2000, the release of the *Playstation 2* console changed the way we envisaged future applications could go. This device could successfully page through a tiny performance aperture from a DVD. It had no hard drive to cache with and 32Mb of memory to manage the compelling action and extensive scenery of real-world places. *The Getaway* (2002), a game developed by Team Soho and set in inner London was an audacious title in this space as the streets of London and their detail are so recognisable by a global audience. Big iron computing had had its day and it was time to invest in wisdom. Rather than looking for brute force computing, we now utilise a similar approach to the Getaway, paging data into the scene only as it is needed. Effectively, a visualisation could be infinite in extent.

20.7.3 Configuration and management :scene complexity and data organisation

For project data to be reusable we required some methodology for the creation and storage of files. The limitations of a 'project' based file system became apparent when two unrelated projects share a similar proximity. Scaling our file system schema to be authority or boundary based when a project seeks contextualisation across two authorities is an obvious problem. Further to this we wish to receive data from a range of sources: individual consultants, local, state and federal authorities as well as utility institutions. It became clear that any configuration tool we could devise that was based on a hierarchical file system would be of finite use. The problem is not new and we believe a large part of the solution lies in indexed data where a hierarchy is just one set of relationships.

20.7.4 Future-proofing?

Change and new technologies are a feature of the contemporary urban simulation environment. This is a field that is 'blending' inputs from old technology and formats (eg. Virtual Reality Modeling Language (VRML) and 3DS) and emerging ideas such as from the computer games area. The popularity of commodity games consoles and simulations has, in our opinion, a benefit in freezing technology for a time allowing a deeper exploration of it use.

Our approach in urban simulation is two fold;

- Do as much as possible by clever assembly of data prior to processing in any visualisation application, ensuring that data at least can be readily used in new applications or for other uses; and
- Use Open Source / Open Standard applications keeping open the possibility of third party involvement.

20.8 Parallel Developments

A major trend in defence thinking today is data interoperability. This is driven by several factors. People and systems now collaborate in joint tactical decisions and exercises. Collaboration exists across forces, nations and the military and civilian realms. The need for shared, consistent information in these environments is critical. Safety and security aside, the driving factor is cost. The technological challenges in urban simulation for urban planning are similar and focus on the importance of GIS databases. Project work with industry partners has highlighted these relationships and influences the importance of implementing data models that conform to an organisation's internal databases, while considering the interoperability desire for quality data access held by interests such as homeland security. One of the first examples of this collaboration is the Boston Preparedness Pilot Project (Applied Geographics, Inc. 2003).

20.9 Directions

At the time of writing our current visualisations remain 'project'-based, effectively simulating a particular urban place to test a set of propositions or to test development proposals in context. An example is work for construction company Thiess-John Holland in Victoria, Australia, where a complex tunnel entrance arrangement has been simulated and used to both develop the design, bringing the many players together into the one interactive environment, and then to communicate the concept to the community affected by the development. In this case, the environment was heavily treed and it was important to visualise carefully the location and type of all significant trees within the key viewlines (see Figure 4). This project is now proceeding to visualise the tunnel itself, including testing sightlines at the nominated traffic speeds.

The flexibility of the data-based model as a preliminary design tool was tested within the Parramatta municipality visualization that was developed for an earlier set of height studies. In a collaboration between Urban Futures Consulting, the City of Parramatta, Parramatta, New South Wales, Australia, Artist Marian Abboud and the Sydney Powerhouse Museum, a preliminary design study was carried out for a site on the Parramatta River and then used within a design hypothetical workshop. Initial ideas were quickly tested in real time within the visualization, by inserting a range of test footprints and varying these in height, applying a variety of textures, and adjusting their location of the site. In fact, several sites were tested and considered, including a mock up of a country town. This exercise amply demonstrated the value of having a data-based model that can be applied for new uses. Scenes from the OSG based visualisation, as flown in the hypothetical, are shown in Figure 5.

Fig. 4. Thiess-John Holland project visualization.

Fig. 5. Hypothetical Design Study for a major Arts Facility, Parramatta, New South Wales, Australia.

The next stage of the City of Parramatta visualization will be to simulate all the major buildings and key streets within the City's Central Business District. In this stage, a further step towards the integrated database model is being made, adding identifiers to each building volume that will allow a link back to the City's corporate GIS. The conceptual arrangement, suggesting that data can be displayed from information above and below ground, and allowing data from statistics to CAD models to be called up, is shown in Figure 6.

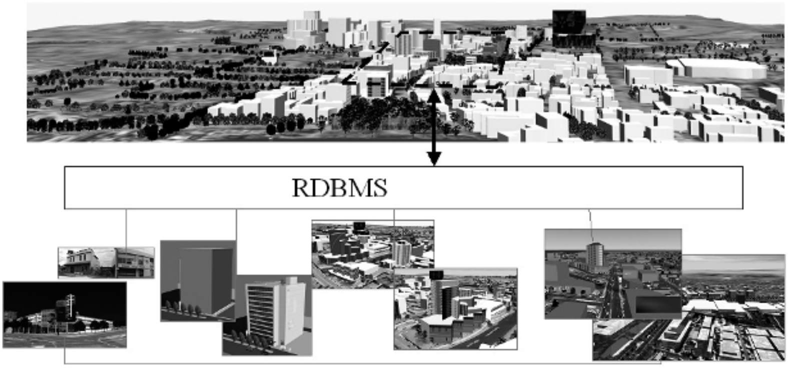

Fig. 6. Visualization of the City of Parramatta Central Business District.

20.10 Conclusion

Visualisation technologies are poised to play an increasing role within the planning and development industry. We propose that a visualisation drawing on a relational database could become an integral part of planning and design. 2D GIS is becoming accepted and iteratively deployed by non-experts such as planners. From an information management perspective there is little difference between 2D and 3D data, and from a user perspective there need be little difference between 2D and 3D desktop metaphors.

There are many issues that need to be addressed. We touched on the need to establish adequate levels of content control; the need for effective detail management; and the value of providing for data interoperability. Other issues that require consideration include the establishment of maintenance and verification procedures and data storage & integration issues.

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21 Education and E-Learning with Virtual Landscapes

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21.1 Introduction

This chapter introduces 3D virtual landscapes as a means for E-Learning in the geosciences. The use of the World Wide Web (Web) for distributing information and knowledge to learners has become a major subject in recent years. The Open Courseware-Initiative of the MIT[1] is certainly one of the most publicised examples. In many countries the development of Web-based learning approaches has been actively promoted as part of large projects like the "New Media in Education" initiative in Germany.

Key benefits claimed for Web-based E-Learning approaches are:

- flexibility of the learning with respect to time and space;
- adaptation to individual interest and previous knowledge;
- interactivity and dynamics;
- more effective presentation through multimedia;
- increased motivation (cp. educational gaming, edutainment);
- support for different learning styles and learner types, i.e. variety in the conceptual design of materials;
- access to distributed data;
- world-wide availability of education on highly specialised subjects; and
- the establishment of learning-communities that overcome the isolation of traditional distance education.

In terms of the technical design of the material, sophisticated media and concepts have become popular under the heading of 'multimedia'. Despite technical advances and many options currently available online learning

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1 http://ocw.mit.edu/index.html

materials have not yet realised the full potential of the Web such as interactivity, dynamics, use of distributed data and multimedia – envisioned by proponents of E-Learning. Especially the employment of deep interaction combined with multimedia for the creation of exploratory learning environments in which users can learn by experience has been demonstrated in a number of prototype-projects. However, it has not seen mainstream use so far, mostly due to the difficult and expensiveness of creating interactive content and the difficulties of delivering it to diverse output devices over the internet in a practical way.

The use of multimedia by education was one of the early applications of this different method of providing information. It is now timely to expound about how cartography and the geosciences are using multimedia as an educational tool. Lessons learnt from education's use of multimedia can be applied to the design and production of more efficient and usable products.

In this chapter we propose an approach to address this situation based on two key features:

The concept of virtual landscapes as an experimental learning environment that exploits the combination of pedagogic ideas, simulation, 3D graphics and other features to provide learners with means of practical exploration and experimentation; and

The use of standardised formats for the delivery and presentation of the data and content that not only enables use on a wide variety of current and future hardware but also fast integration with new geo-data from standardised sources.

21.2 Related Work

In the following discussion we focus on E-Learning materials and systems targeting at geosciences. Examples of "lecture note"-like E-Learning materials in geosciences and geoinformatics include:

- *geoinformation.net* (Plümer and Asche, 2004),
- *GITTA* (Lorup and Bleisch, 2003) and
- *e-MapScholar* (e-MapScholar team, 2003).

Some projects attempt to go beyond lecture notes and implement interactive, explorative learning environments. Examples for such an approach include the *Virtual Field Course* (Dykes *et al.*, 1999), *Ocean Science Learning Environment Virtual Big Beef Creek* (Campbell *et al.*, 2002), *EarthSystemVisualizer (ESV)* (Harrower *et al.*, 2000) and *gimolus* (Müller., 2004).

The Virtual Field Course (VFC) Project was an inter-departmental effort involving subjects such as geology, biology, geography, planning and architecture at the University of Leicester/UK. It was undertaken to address the use of virtual environments and information technology in teaching fieldwork. The project Web site[2] still is available but appears not to have been further developed.

A collaborative three-dimensional online learning environment was provided within the *Virtual Big Beef Creek* project (VBBC) at the University of Washington. The environment enables users to navigate through a data-rich representation of an estuary on Washington's State's Olympic Peninsula. The learning environment should give users a better sense of the overall watershed before they venture out in a fieldtrip. Another goal was to provide an online repository for geo-referenced data obtained through fieldwork. Currently, a suite of products for university client needs is under development. The goal is to provide a VBBC-like shared desktop VR environment for earth science dataset learning. The focus is on integrating the visualization products with information systems that describe and automate visualization processes for learning. Current work focuses on creative means of data presentation. Thus no Web-accessible system is currently available.

The *Earth System Visualizer* is a tool for visualising the global weather with the goal of explorative data analysis. The tool is still accessible on the pages of the GeoVISTA center[3].

gimolus provides learning materials for students from environmental science using a complex Web-architecture that is largely based on commercial products. Using terminal-client students can log on to an application server that provides GIS services. Using a wide variety of data from distinct area learners can carry out exploration and analysis for several relevant issues within the same area. At the moment all courses[4] are accessible, but the applications do not work permanently due to the lack of financial resources needed for licensing and maintenance.

These projects, which are representative for many others, illustrate the great possibilities. However, they also show that sustainability and interoperability of complex E-Learning environments remains a big issue. Also problematic is the fact that many projects are restricted to either a certain issue and/or a certain area, which in turn restricts their application and hence sometimes does not legitimise the cost of implementation.

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2 http://www.geog.le.ac.uk/vfc/index.html

3 http://www.geovista.psu.edu/index.jsp

4 http://www.ilpoe.uni-stuttgart.de/cgi/caya/index.php?id=3&loc=en

Our concept of the virtual landscape aims to address these issues through exploitation of standards in the technical sense as well as in the conceptual and textual sense. The use of advanced technical possibilities including 3D visualization, interaction and simulation distinguishes the approach from online lecture notes while the standard-based, content-independent architecture avoids many of the problems of existing learning environments.

This chapter presents our approach in detail and is structured around three main areas. First we introduce our concept of the virtual landscapes as a teaching tool for the geosciences. We motivate our approach by providing background information on didactic considerations, namely constructionist learning, and discuss the specific requirements of learning in geosciences. The respective potential benefits of interactivity and 3D presentations are addressed in some detail before the “virtual landscape concept” with its learning scenario is introduced. The subsequent section on “Fundamentals for delivery and presentation of virtual landscapes” addresses the necessary technical foundations for the practical implementation of virtual landscapes like data sources, delivery mechanisms, presentation and interaction as well as analysis methods. The final section on “Future developments” concludes the chapter and enumerates issues that still have to be addressed to make virtual landscapes teaching tools that are effective for learners and viable for educators.

21.3 Background on Constructionist Learning

The term ‘constructivism’ was first introduced by the Italian philosopher G. Vico (*1668). Nowadays it is mostly used in terms of didactic concepts and is based on the developmental psychology of the Swiss philosopher and psychologist Jean Piaget (*1896). The constructionist learning method is build upon the idea that reality may not be considered as external. Therefore, every learner has to build their own knowledge structure starting from their own needs and previous knowledge. This is because humans can understand only what they have constructed themselves. Riedl and Schelten (2002) state that cognition and cerebration will only be a complete action when implemented in practice. Human action is mentally tested before acting, depending on cognition and cerebration. The comparison of the mental plan with the real action will feed back on the mental map of the active participant. The back coupling to cognition and cerebration will alter and extend the existing mental map as well as evolve new cognitive structures. Riedl and Schelten (2002) further reason that learning without execution of actions remains at the state of a mere mental action and therefore stays distant from real acting.

- General theses on constructivism may be summarised as follows (Reich, 1998)
- Didactics should no longer be a theory of mapping, memory and real reconstruction of knowledge and reality, but a constructionist environment of individual learning in reality;
- Didactics becomes an open process of contextual and relational mediation and
- It is not longer considered helpful to prescribe a certain way of teaching, with a greater focus on learning, but allow learners to go their own way of knowledge construction.

In his famous speech “Constructionism vs. Instructionism” the E-Learning pioneer Seymour Papert (1980,) emphasised the constructivist (vs. instructionist) idea when he stated: “Well, *teaching* is important, but *learning* is much more important”. This means that within the constructivist paradigm, the accent is on the hands-on experience of the learner rather than on the memorization of abstract facts provided by a teacher. Papert's constructionist approach later turned to rely on the computer for realization. He states that the computer as an interactive simulation tool will change "learners´ relationship with knowledge" producing a revolution comparable to that of the "advent of printing and writing". He imagines a machine he refers to as "The Knowledge Machine" which would allow learners a rich exploration of the world. Early examples of practical implementations of this Knowledge Machine concept include "interactive video", "electronic books" and "virtual reality" (Papert, 1993).

Support for action-orientated learning is the main didactical requirement of such a system and has been employed successfully in a number of E-Learning systems. Existing systems motivated by constructivism, some of which have been discussed earlier, have demonstrated the value of interactive exploratory environments in which learners can actively experiment. The virtual landscape therefore also follows Papert’s vision of a Knowledge Machine and aims to support active, self-directed work with the simulated real world content. However the target of such a learning system must be named explicitly: is it either aimed at learning about underlying geo-processes and phenomena by virtually inspecting the landscape and being supported by additional textual learning material, or learning occurs by applying given processes to solve a problem, e.g. the planning process of a railway line. (In this case we must distinguish the interaction facilities for the process to be carried out (e.g. Geographic Information Systems (GIS) analysis) as opposed to the interaction method used to learn about the components of the process (e.g. feedback).) Learning to use complex software packages like GIS could also be the issue to learn, but will not be considered further in this treatment on virtual learning landscapes.

The virtual landscape provides the technical means for such a process by not only supporting deep interaction (covered in the section on “Interactivity and Interaction”), but also through 3D representations that establish a close mapping to reality and respond to the learner’s action (see the section on “3D representation”).

21.4 Interactivity and Interaction

As previously stated, interactivity and interaction are essential characteristics of (constructionist) learning systems. It therefore seems worthwhile, to closely look on these terms.

The term interaction comes from social sciences, where it is defined as interplay between two people. In computer science interactivity is used to describe the interdependency between the computer and humans. In learning programs interactivity constitutes the user’s ability to control and intervene with the system (individually).

Strzebkowski and Kleeberg (2002) distinguish interaction for controlling a (learning) application (e.g. navigation and dialogs) and didactical interactions (e.g. activities for presentation of information, edit-functions for presented content and possibilities to edit the database). When stressing the distinction between controlling/navigation and textual, possibly didactical interaction, it is helpful to define distinct terms for both ways of interplay. In terms of software use, interactivity refers to the navigation and application control. Interaction in contrast stands for the interplay with content (Schulmeister, 2002). To avoid confusion about the terms “interactivity” and “interaction” we adopt this definition for this chapter, in which ‘interactivity’ refers to user actions outside the actual learning content and ‘interaction’ is limited to learner actions within the virtual landscape.

While benefits of interaction in learning processes are generally assumed and seen as an important advantage of E-Learning environments the number of studies to support this claim is still limited. Paelke (2002) gives some examples on meta-analyses and studies on that issue. On elementary interactivity only the general conclusion, that there are benefits for interactive systems could be drawn. More complex interactivity has been found an effective learning tool in a range of disciplines. However, careful design is needed to avoid so-called negative training. Interactivity relating to illustrated content (what previously was called interaction) was found beneficial for understanding and retention, whilst system control interactivity (previously called interactivity) that had no relation to the content was found to be detrimental (Paelke, 2002). Regarding the amount of interaction it can be summarised that interaction is beneficial only as long as the cognitive load created by the interaction remains within a certain limit.

Works focussing on interactivity in the geosciences have so far mostly concentrated on navigation and system control, e.g. Mach (2005) or Oster (2005). However, initial work to understand the impact and effectiveness of interaction with geodata has also been done. Suggestions on how to categorize content-related interactions in a sort of taxonomy, with respect to typology were done by Asche and Herrman (1994), Monmonier (1994), Buja *et al*. (1996) and Crampton (2002). Such taxonomies are useful development tools because they support designers in the systematic exploration of the available options. In our virtual landscape we build on these results to provide appropriate interaction functions to facilitate effective learning.

21.5 3D Representation

The importance and value of visualization in 3D and perspective presentation for the effective communication of spatial content has been generally motivated by many authors, e.g. MacEachren *et al*. (1999), Verbree *et al*. (1999), Petschek and Lange (2004), Tiede and Blaschke (2005).

We believe that learning systems that target 3D phenomena can especially benefit from the inclusion of 3D content and presentation. Potential benefits are:

- direct presentation of geo-spatial information;
- immediate visibility and better understanding of results; and
- removal of forced abstraction and indirection. (Abstraction is not inefficient in every case. However it is desirable not to be restricted by technology, but be guided by didactical arguments. Flexible change between realism and abstraction may possibly help to bridge between both dimensions.)

Whilst these factors have been the driving force for the development of 3D GIS, 3D city models and the proliferation of 3D visualisation in the geosciences in general they can be especially useful in E-Learning for learners because they allow users to establish a more direct correspondence to physical reality.

The virtual landscape is a special form of virtual environment with educational content. Virtual Environments, often also referred to as Virtual

Reality (VR), are models of (physical) environments that are simulated with software. Virtual Reality originally referred to systems in which users are completely immersed in the simulated world using stereoscopic displays (e.g. Head-Mounted Displays – HMDs or projected environments) and possibly other output modalities (audio, haptics and olfaction). However, in recent years simulated 3D worlds presented using non-immersive displays have become popular as “desktop VR”. Such virtual environments can be realised with standard hardware and widely available software like Virtual Reality Modeling language (VRML) or *QuickTimeVR*. Web-examples of implementations of such environments for learning purposes are e.g. CNN’s visualization of a hurricane[5] or the “Nerve Garden”[6] (Damer *et al.*, 1998).

These examples show what is technically possible. However, most existing virtual environments stress the aspects of exploring the space and thus act, as in the case of the display of geodata, as ‘just’ a multidimensional variation of a traditional (topographic) map. Very few of such environments have integrated the textual dimension in terms of additional learning content.

Some systems offer sophisticated analysis tools for 3D data and can be referred to as “3D-GIS”. Such software provides useful tools to explore and analyse 3D data but is not designed to support learning. The knowledge of how to work with the system and the data must be brought into the process by the intelligent user of the software. Integration of feedback or instructional knowledge etc. is not envisioned.

For learning situations we need a system, which offers more than ‘just’ exploration and analysis tools by tailoring it to the learning-situation. One requirement in this regard is that it must be possible to restrict the interaction functionalities in a way that the user may not get lost, as a beginner in complex software like a GIS might. Whilst the system must provide adequate (and realistic) possibilities for making mistakes so as to force decision processes and trigger the learning process, it must also be capable of providing some form of user guidance on demand. To balance these needs we have to provide clear definitions of what is about to be taught and how to convey these definitions in an effective way.

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5 http://www.cnn.com/SPECIALS/multimedia/vrml/hurricane/

6 http://www.karenmarcelo.org/ng/siggraph/

21.6 The concept of virtual landscapes

'Hands-on' learning in geosciences has been hindered in the past both by the difficulty of information access and the lack of implementation of interaction concepts with textual data and thus the impossibility of experimentation. This is due to the fact that direct access to information from real-world environments is impossible in most learning situations (excepts excursions). Abstracted information collections like maps and GIS have traditionally been the main means of work. While it is practically impossible to observe the results of 'what-if' experiments in reality and the use of traditional maps, GIS may be used in this way. Virtual landscapes take this approach a step further and utilise a perspective 3D representation of a physical environment that is augmented with learning information. Users of the virtual landscape can:

- explore information directly by navigation in the virtual landscape using 3D representations to establish a close link to spatial reality;
- see the results of analysis operation directly in their spatial context;
- manipulate features in the landscape to directly observe the impact of changes, thus enabling hands-on learning; and
- be guided by additional annotations or illustration techniques to ensure a productive experience.

The implementation of a system that addresses these requirements and operate on a wide variety of Web platforms requires an approach relying on standards, in terms of techniques and content. Our concepts and ideas for addressing these needs are described in the remainder of this chapter.

Such a virtual landscape may be integrated in the ideas of modern cartographic applications. Traditional maps and their use have moved from static to dynamic, even 'intelligent' means of work, illustrated by the variety of applications of Location Based Services (LBS). (The chapter by Furey and Mitchell provides a detailed coverage of one operating system in Australia.) Peterson (1999) termed these changes a paradigm-shift as they entail new possibilities like using geodata in learning situations. Geodata available in a learning environment may be individually prepared for distinct content and learning scenarios and learner level of interest and knowledge. This is similar to the user-centred approach that modern map use demands. An intelligent' learning environment may react to a user's action and provide feedback, like any action-orientated learning process.

21.7 An example scenario for the virtual landscape

The focus group for using virtual landscapes in this example were students in Earth Sciences, such as Geodesy, Geoinformatics, Geography, Environmental Studies, Landscape Planning as well as students of Computer Science. These students have to learn how the landscape evolved, how the processes in it work and are interrelated, as well as how to make decisions concerning the landscape and how these forms and processes may be represented and analysed with (digital) data. Based on fundamental questions raised during the exploration of the virtual landscape, learning material for a special example issue for study is attached that explains the relevant phenomena or provides the necessary background for students. This learning material is attached manually for every distinct situation.

As illustrated in Fig. 1, prototype application basic courses are provided as text-based units, enhanced by animations, interactive illustrations and tests. They are designed to provide base knowledge to work with geodata in general and to work in the so-called 'modules' specifically. These are designed to guide students through application tasks within the virtual landscape, to provide background knowledge for the use of the virtual landscape and to understand how to employ the techniques and the data in the virtual landscape. A module is placed on top of the virtual landscape. It provides the environment where a student can learn following an action-orientated learning concept. To work with a task in a module the virtual landscape supplies datasets and tools for exploring and analysing data.

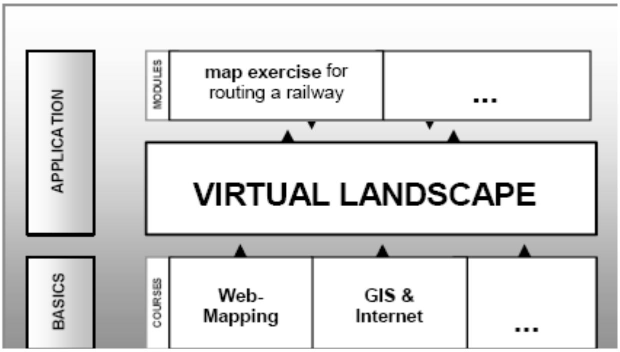

Fig.1 Components of the project.

As an example for a module a map exercise of a planning process for routing a railway line is introduced (see Box 1). The planning process is practiced within the virtual landscape using a blended-learning scenario.

Box1: Prototype Scenario

The process of planning a railway line requires a set of steps. The student first will be asked to choose the right work steps from a list of options and put them in the right order. The list will be only accepted when the steps were put in the right order. Then the learner has to carry out these steps within the virtual landscape-learning environment. For that appropriate data is provided. The choice of data was done by a tutor who compiled the learning scenario be-fore. (For advanced students the access to the data services could be provided. Thus the choice of data would be a single working step.)

The learner then will carry out the working steps, e.g. exploring the area by using interaction tools of the environment (e.g. pan, zoom, fly, comments/ links on mouse over, etc.) as well as simple analysis tools (e.g. select by attribute, etc.). For analysis the learner had next to assign sensibility indices to every land use type. Based on those areas with lowest sensibility against the intervention are to be calculated. Different weights to the subject of protection have to be assigned to express a valuation of protection needs. For that some basic analysis tools (attribute-based assignment of values and calculation of the total value for ever object) must be provided. Further on the student should calculate buffers to analyse the range of the effects of noise. For that a tool for calculating buffers must be provided. (If the student is interested to learn more about the buffer operation he may switch to a text-based course, where GIS operations are introduced.) Based on the buffer a resistance value can be as-signed to areas still much affected by the noise.

Overlaying areas and calculating their resistance should enable learners to identify the respective values of possible routes. Possibly intersected areas have to be investigated in terms of the need of compensation actions. Areas of compensation must be roughly digitized and assigned by attributes about further measures.

The result must be cartographically visualized in the virtual landscape (i.e. the possibility to change graphic variables must be given) and the course of the route may be explored in the perspective view. The final (perspective) map and some verbal evaluation on the route and problems involved in the solution must be submitted as result of the task.

A discussion of the results will be part of a course where every student has actually to be physically present. The commented outcomes will stay available

Box 1 Prototype Scenario.

Basic geodata and the data of a landscape framework plan are provided. The latter contains data like different soil parameters, areas of groundwater regeneration, water protection areas, flooding areas, areas of biotope protection, areas of recreation, noise corridors etc. Tools for exploring and analyzing these data are supplied in the virtual landscape. For visualization and analysis 2D and 2.5/3D-views are used. For some applications, mainly in the field of analysis, 2D data is not only reasonable but also easier to handle. However, for many other tasks that rely on spatial properties perspective views are better. Typical tasks are visibility analysis, the inspection of the spread of noise or visualizations etc.

As illustrated in Figure 1 the virtual landscape is laid on the top of the course content. In most cases it may be directly accessed from the learning materials. Depending on a special task dealt in the material, a distinct view upon the landscape will be opened. When carrying out a map exercise for planning tasks, things like the data of sanctuaries are provided. Analysis of soil erosion potentials can be done using data of soil type, soil texture, description of soil horizons or precipitation and so on.

21.8 Fundamentals for delivery and presentation of virtual landscapes

The proliferation of high performance 3D graphics cards in desktop PCs provides a major prerequisite for the use of 3D graphics in E-Learning applications. However, on the software side the need for an interoperable solution that works on a wide variety of platforms poses a serious problem for developers. Low-level graphics libraries like OpenGL are not suitable for direct use in Web-based applications. Higher-level libraries and graphics-engines also require the installation of special software and are therefore unsuitable for a wide variety of learning scenarios. Currently there exists packages like *LandExplorer* (Döllner *et al.*, 2003) and the *G.VISTA Suite* (Nebiker *et al.*, 2004) for 3D online geovisualisation, but they are not targetted to the application in learning situations and thus do not (yet) stress the aspect of interaction with content. Other platforms with which virtual landscapes could possibly be realised include GIS applications and 3D visualization software. However, standard GIS applications provide too little functionality to foster didactical learning actions. Thus, limited possibilities for access to GIS functionality over the Web constitute a major problem for the direct use of GIS systems as the basis for such learning environments. Existing 3D modelling and visualization programs were designed for other applications and either lack support for in-depth interaction (e.g. programs aimed at film animation) or the integration of educational content. While such systems are valuable tools in the construction of learning environments based on the concept of the virtual landscape they are not suitable for the distribution and delivery to end-users.

A Web-based system can therefore only rely on 3D technologies that are designed for seamless integration into Web content and are widely available. Without giving an exhaustive review of the available options we will focus on two popular approaches: VRML (and the related X3D) and Java (3D).

VRML is an ISO standard for the delivery of 3D content over the Web. Since it is widely used we assume that readers are familiar with the basics of VRML. Introductions to VRML and its features can be found in a wide variety of publications, e.g. Reddy *et al*. (2001), Hartman *et al.* (1998), Abernathy *et al.* (1998), VRML (1996) or Fairbairn and Paisley (1997). The basic functionality of VRML for geo-applications is quite limited, thus an extension for the specific requirements of geo-spatial content has been proposed for a geoVRML extension, but has seen limited activity since (Reddy et al. 1999). However, VRML provides the possibility to extend its basic functionality (Kim *et al.* 1998). For the GOOVI3D-prototype Coors and Flick (1998) describe a way of deriving VRML based on a Java-application. This approach is based on an idea similar to the prototype introduced in this paper. While VRML is the most well known among the Web3D-techiques it did not succeed in the way it was originally envisioned. Possible reasons include the limited functional range of the modelling language as well as the heterogeneity of the available clients. Standardized, native VRML support is still not integrated into the major Web-browsers and the available plug-ins vary widely in their quality and their support for more complex features. Despite these shortcomings VRML is still widely used because of its openness, simplicity and the machine- and human readable code of the format. The Web 3D Consortium has proposed X3D[7]as an XML based successor for VRML and aims to address some of the major shortcomings, but it has so far failed to achieve support from the major software vendors.

Some experiences of Web distribution of 3D content, even within the GIS field, were made with Java and Java3D. An example of functions for analysis within 3D Internet GIS 'Solid Object Management System' (SOMAS) based on Java and Java3D is given in Devanthéry and Fopp (2002). While Java has been successful as a cross-platform language for Web applications the same cannot be said for the various extension libraries like Java 3D, and applications that build on these libraries loose their platform independence. Several proprietary 3D packages have been proposed by various vendors, e.g. Macromedias *Director*/*Shockwave3D*, *Cult3D*, *Second Life* and *Active Worlds* but they have so-far failed to become quasi-standards that can be assumed to work on all delivery platforms.

21.9 The prototype of the virtual landscape

Independent of the selected base technology it is generally very time-consuming to build distinct scenes for some (or just one) application(s). Hence it would be desirable to define interfaces for such an environment to be able to use interoperable data services. Therefore, standards of the Open

[7] http://www.web3d.org/x3d/

Geospatial Consortium (OGC)[8] must be taken into account. In this context much work was put in the formulation of standards and the implementation of reference systems.

The main developments in the field of 3D-data retrieval are two specifications, at the time of writing as discussion papers at the OGC. One is the Web Terrain Service (WTS) (OGC, 2001). The WTS extends the Web Map Service (WMS), which covers the specification of how to deliver raster images of geodata via the Web. It allows the display of maps in perspective views by defining a 3D arrival point, an azimuth and the pitch of a virtual camera. Digital Elevation Models can be integrated as well as maps or orthophotos and 3D objects. The problem of that system is that only raster images are generated and different layers of raster images cannot be overlaid. More importantly, interaction with and navigation in the WTS is not possible (Kolbe, 2004; OCG, 2001). Thus, an important feature for our purposes is missing in the WTS. The second development is the Web 3D Service (W3DS) (OGC, 2005). In contrast to the WTS the W3DS combines all geometric objects in a scenegraph before rendering as the last step of the visualisation pipeline. The introduced virtual landscape follows pretty much this idea of combining all objects before rendering. This idea applies to 2D and 2.5/3D data. The result of the combined objects is an output as a GML3-file. Some further technical requirements, regarded as compulsory for a learning environment, may be derived from such architecture:

- allowing easy data access to possibly distributed data sets;
- visualization of data in 2D;
- visualization of data in 2.5D/ 3D; and
- basic analysis tools in 2D (and 2.5D/3D).

To implement such a system a server side Java-environment was chosen. Java provides the functionalities to work in the Web on the one hand. On the other hand there exist some libraries, e.g. JUMP or JTS, which supply with appropriate data structures (e.g. Class Coordinate or Class FeatureCollection) as well as GIS functionalities (e.g. Class Overlay or Class Buffer). An architecture, according to the OGC conform visualization process – described by Cuthbert's Portrayal Model (cp. Fig. 2) – was set up. Figure 3 gives an overview over the architecture used for the prototype. More details are given in Katterfeld and Sester (2005).

To explore the delivered 2D- and 2,5/3D-data elementary interaction functionalities like Pan, Zoom, Select and Query is provided. Zooming and panning are features included in the SVG- and VRML/ X3D-Viewers.

[8] www.opengeospatial.com

Queries can be implemented using JavaScript, triggering a database query based on addressable objects in a scenegraph. For spatial analysis, functionalities like buffering or clipping are needed. To this end, a buffer-operation has been implemented using the JUMP and JTS-library. Figure 3 illustrates the principle of how the system works. Additional desired functions are overlay-operations, like clipping or union. Selection either based on geometric objects or attributes is a further issue to be addressed. Similar to the buffer operation, these functions can be implemented using the JTS library. The virtual landscape thus aspires many of the central functionalities of a GIS. The full feature set of a GIS system is not required since advanced analysis does not have to be carried out in a Web-based environment. However, a set of basic functionality is useful, as within the educational setting students might not have access to GIS-software at the required time or place. For these situations an introduction into the ideas and basic functionality of a GIS should be provided, for which the designed architecture is very suitable.

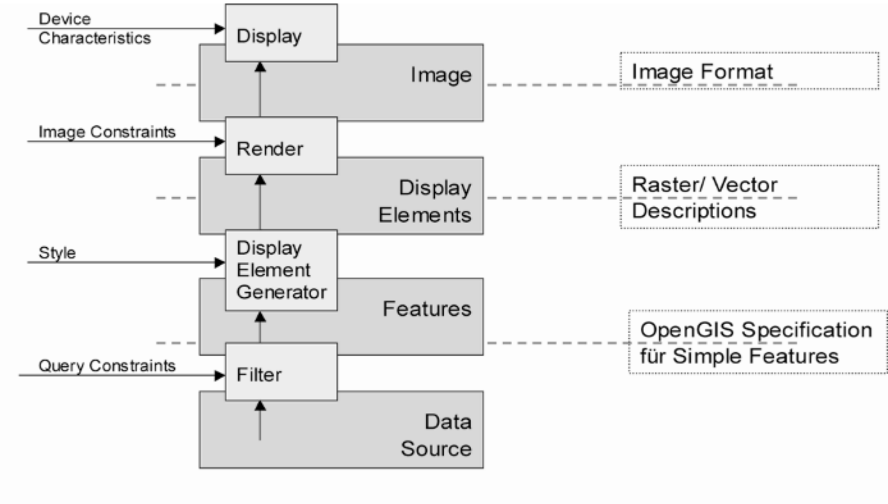

Fig. 2. Cuthbert's Portrayal Model – reference for the visualisation pipeline (from May *et al.*, 2003; Fitzke and Greve, 2002 after Doyle and Cuthbert, 1998)

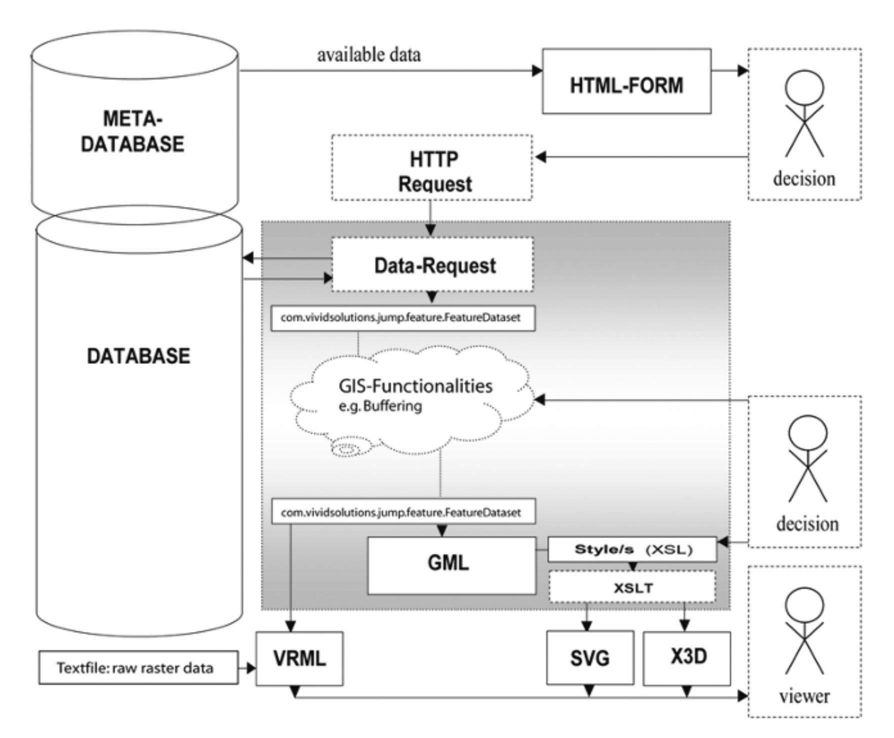

Fig. 3. The architecture of the system, delivering vector data

21.10 Future developments

In the previous section a technical approach to generate 2D- and 3D-models for virtual landscapes was outlined. The importance to integrate content in such a learning environment is obvious. Also, the value of interaction was discussed in one of the former sections. But how to integrate those information in an 'on-demand' environment? How to implement such content requirements?

The answer is subject for future work. First ideas aim at providing exchangeable and hence standardized descriptions of the content to be learnt as well as standardized descriptions of the kind of interaction needed to convey distinct information. These descriptions can be seen as kind of learning-augmentation, where objects and tools "know" information about themselves. These augmentations could be used in different technical and conceptual versions of a learning system as long as the interfaces are well defined and supported across platforms.

Up to now, the sequence of the learning process and the assignment of learning content have been provided manually for the different scenarios. To overcome this application dependent manual process, and to achieve a certain re-usability of the educational content, we propose to provide structured information on learning contents in terms of ontologies for the domain to be taught, a so-called ‘EduOntology’, which ensures a common understanding of the content. This allows to enrich notions or processes with appropriate learning content. In the easiest case, e.g. the notion of a “buffer” would automatically be related to a description of the technical background and algorithmic solution of buffer operations, as well as the necessary parameters. In the EduOntology learnable objects are defined, which can automatically or semi-automatically be linked to a process description given about the problem. Thus, the contents or learning objects must be defined in a serial manner for the learning process. From this a “learning script” with the annotated learning content for the generation of the virtual landscape is derived. The EduOntology could be formalized in XML or in the Web Ontology Language (OWL[9]), respectively.

The same applies to information on interaction. Some approaches have been undertaken to categorize interaction with geodata and to come up with something called a ”Typology of Interaction” (e.g. by Buja *et al.*, 1996; Crampton, 2002; Harrower and MacEachren *et al.*, 2000; Kraak, 2001; Monmonier, 1994 and Peterson, 1999). Such a typology, also termed taxonomy, could help to understand the strengths and weaknesses as well as the way of application of different types of interaction. This knowledge – e.g. structured in a kind of “Interaction Dictionary” – should be used to give recommendations or even the base for (semi-) automatic application of a kind of interaction to be used in a special learning situation.

Integrating the appropriate interaction with the EduOntology for a distinct domain or process to be learnt then will result in a final script of the concrete learning process. A learning system then must have a possibility to “load” a script to generate the specific environment with which the user will interact.

As stated in the section about constructionist learning, the learner should construct the learning situation as much as possible on his own to better build an individual representation of the issue to be learned and to fit it into his personal experience. Hence the learning situation will become very individual and thus rather unpredictable. This raises some problems on the technical construction of the learning environment. Many different possibilities of learning situations must be considered and prepared. This will

9 http://www.w3.org/TR/owl-features/

probably result in difficulties and thus require further ideas on the conceptual level when designing general structures of EduOntologies as well as on the technical level when designing architectures and – finally – integrating both. Future work has to approach this issue.

21.11 Conclusion

Even if there is still some way to go, we have proposed how to go part of the way. We have identified key requirements of a learning system for the geo-sciences and proposed possible solutions to address these needs:

- For the didactical requirement we focus on the facilitation of interaction to support constructionist learning styles. This approach will be further extended in the future by providing ways to integrate interaction in a structured way by means of the 'Interaction Dictionary'.
- The production of educational content and its integration into virtual landscapes will only be viable on a larger scale if appropriate processes and tools are available to educators in order to create such learning experiences with little overhead for the handling of technical details. To address this challenge we will further develop the concept of EduOntologies in future work.
- The framework for the technical requirements, such as interoperability, support for 3D content and the availability of distribution over the Web is already provided by the proposed OGC-architecture that will be further refined in the future.

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22 Cartography and the use of animation

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22.1 Introduction - Why cartographic animation?

Visualization of spatial data is inextricably linked to maps. Maps are the ultimate tools to give insight in spatial relations and patterns. Maps are the result of the cartographic visualization process. This process is considered to be the translation or conversion of spatial data from a database into maps and map-like products such as those linked to multimedia, virtual reality or animation. During the visualization process, cartographic methods and techniques are applied.

However, as soon as the amount of spatial data to be displayed becomes huge a creative approach is needed in design to keep the map readable. This is especially true when the map must to express spatial processes. Most GIS users study processes and require means to visualize these for a better understanding or presentation. If limited to single maps, overly complex maps can result. Alternative solutions are to split the processes in smaller events and show these events as individual maps. These map series, however, are difficult to deal with, especially if presented individually on-screen. An interactive dynamic display is one solution to the complex requirements of the cartographic display.

An expressive form of dynamic visualization in the context of the spatial data handling process is cartographic animation, which indeed allows for the representation of very complex processes. Additionally, they can have a great impact on the viewer. They can deal with tangible data, such as terrain surfaces or urban environments, as well as with abstract or conceptual data, such as data on climate or population density. Animations not only tell a story or explain a process, they also have the capability to reveal patterns, relationships or show trends which would not be clear if one would look at the individual maps only.

The demand for animation arises largely from the need to deal with real world processes as a whole or simulations of those processes, rather than single time-slices. Static paper maps are limited in their capacity to visualize models of for instance planning operations. However, the on-screen map does offer opportunities to work with moving and blinking symbols and design options as transparency, and as such is very suitable for animations. Animations representing geospatial data can depict change in space (position), in place (attribute), or in time. Cartographers have been tempted by animation for many years, even before the demand from fellow geoscientists. During the sixties the non-digital cartoon approach was followed (Thrower, 1961) During the eighties technological developments gave a second impulse to cartographic animation (Moellering, 1980)while a third move on animations is currently ongoing as a result of a new form of distribution created by the World Wide Web.

Animations are a challenge to cartographers. They are about change. Peterson said: "what happens between each frame is more important then what exists on each frame". Since cartographers have mainly developed tools and rules for the design of static maps, this statement should be a cause for concern. We now have to answer question such as: How can we deal with this new phenomenon? Is it possible to provide the producers and users of cartographic animations with a set tools and rules to create and use animations? Currently a great deal of research is associated with animation in cartography, and issues related to representation, user tasks and the nature of the data to represent are subject of discussion. Current research tries to answer questionrelated to these issues (Blok, 2005; Fabrikant and Goldsberry, 2005; Harrower, 2003; Midtbø and Boro, 2005; Morrison and Tversky, 2001).

22.2 Spatial data and the type animations

For many, a cartographic animation is the depiction of change over time. The division in temporal and non-temporal animations is often taken for granted. The temporal animation is used to display time in a temporal sequence. The non-temporal animation is used to explain spatial relations by presenting individual map images in a sequence that is not related to time. This last category can be sub-dived into animations that represent a successive build-up and those that offer a changing representation of a phenomenon. It is the relation between spatial data's components and display time (the moment a viewer sees the animation), which distinguishes the three categories from each other (Kraak and Klomp, 1995)– see figure 1. It is thought that interaction and cartographic animation are coupled under every circumstance if one intents to use them efficiently.

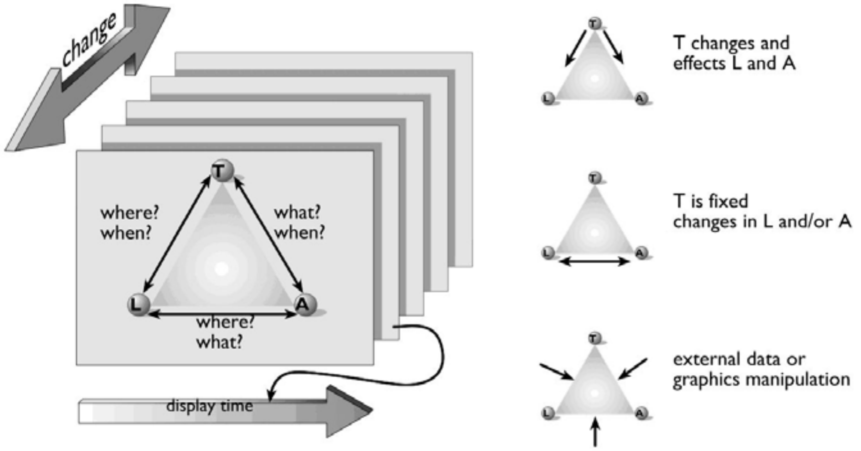

Fig. 1. Animation are about change, change in spatial data's components location, attribute and time. The nature of the change in the components can be used to classify the animations. The upper left diagram shows the type of changes that defines a temporal animation. The middle left diagram shows the nature of change that represents animation with a successive build-up. The lower left diagram shows that animation of changing representations is influenced by external changes.

Animation and time series

These animations show change of spatial pattern patterns in (world) time. Since time is plotted against display time a transition between individual frames implies change in the data's locational and/or attribute component. Time units can be seconds, weeks, or years. Temporal animation can also deal with time aggregates, for instance, the display weekly cycles. A weather broadcast provides samples of both: Animation with the moving clouds or changing temperatures. Other examples of these animations are those of the Dutch coastline from Roman times until today or a country's boundary changes during the last three centuries

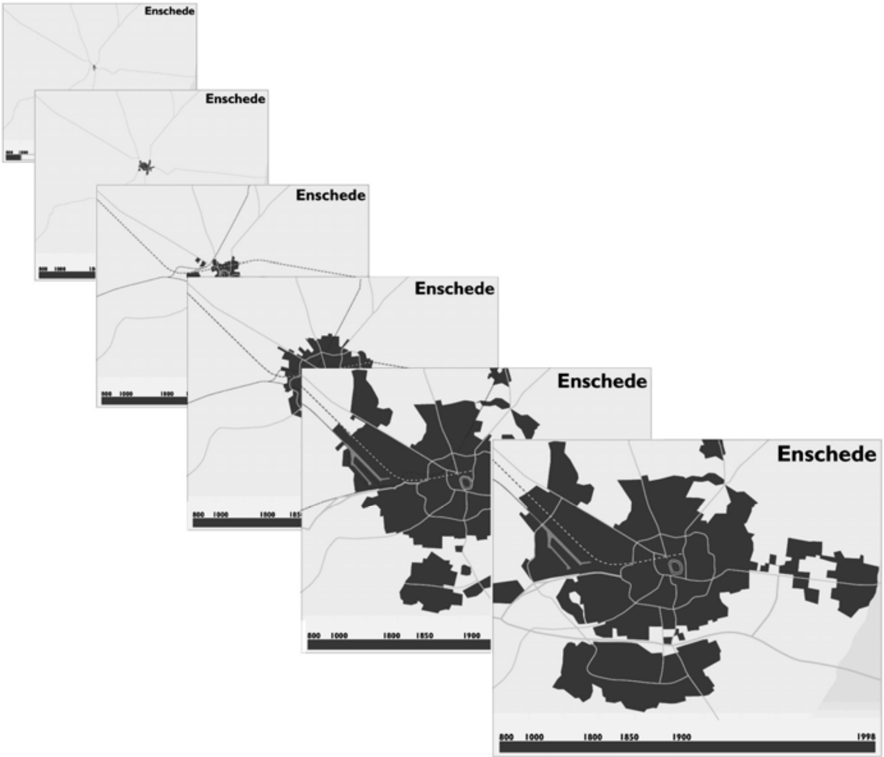

Fig. 2. Animation and time. The example shows frames from a sequence representing the urban growth of the city of Enschede in the Netherlands. Each frame displays the extent of the build-up area in a certain year. Lack of data can result in abrupt changes between the frames.

Animation and successive build-up

Maps often represent complex processes that can be explained expressively by animation. To present the structure of a city, for example, animations can be used to show subsequent map layers that explain the logic of this structure (first relief, followed by hydrography, infrastructure, and land use, etc). Another example is a map showing population density in which alternating classes are highlighted to show for instance the distribution of low and high values. Throughout this type of animation, spatial data's temporal component is fixed, while location and/or attribute is/are plotted against display time. Changes in location or attribute take place and can affect each other.

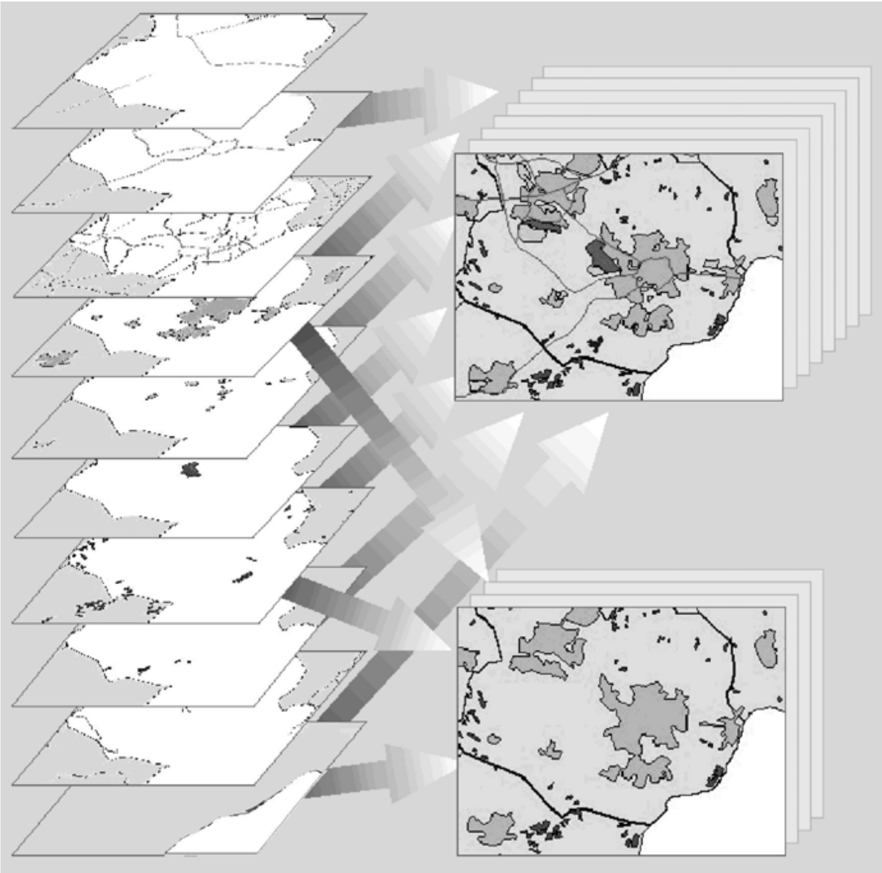

Fig. 3. Animation and successive build-up. Here a user has selected several layers from a database from the Twente region. The maps have been put in a sequence that can be played back and forward to get an understanding of the regions spatial patterns.

Animation and changing representations

This type of animation offers the viewer an extensive look at a particular data set. In these animations, location, attribute and time are fixed. The same data are shown, but from a different graphic or classification perspective. Samples are the maps with blinking symbols to attract attention to a certain location or the simulated flights through a landscape that give the user a changing viewpoint on the landscape. Also an animation displaying quantitative maps based on different classification methods or to displaying the data set by changing the graphic representation belong into this category.

Fig. 4. Animation and changing representation. The change can be due to data or graphic manipulation. The fly-through of a mountain area in the south of France is represented here with two frames, and is an example of the last category. To create the animation the user can define a path in a map and set the distance between the locations in the landscape where the subsequent frames will be generated.

22.3 Cartographic animation environment and visualization strategies

What should be the environment where each of the above mentioned type of animation can be used? Aspects to consider in the user environment are the interface, the design of the map image, the legend and a link with the database. The environment to create the animation will not be examined here. But, it should be realised that in an exploratory environment the producer of the animation is the same person as the user. Animation is being used to provide a better insight by the person trying to understand particular geographic phenomena. It can be imagined that in such cases the animation is created based on queries to a database.

Interface

For the user of a cartographic animation, it is important to have tools available that allow for interaction while viewing the animation. Seeing the animation play will often leave users with many questions of what they have seen. Just a re-play is not sufficient to answers questions like 'What was the position of the coastline in the north during the 15th century?' Most general software to view animations already offer facilities such as 'pause', to look at a particular frame, and '(fast-) forward' and '(fast-) backward', to go to a particular frame. More options have to be added, such as a possibility to directly go to a certain frame based on for instance a temporal query, or the ability to re-ordering individual frames based on a attribute query. Both options require a direct link with the database. This becomes especially relevant if we realise that animation will not only be used to present spatial data, but will be increasingly used in an exploratory environment. In such an environment the animation is just one of the alternative view one has available to study the data at hand (Dykes et al., 2005).

Map image

Maps in an animation are not necessarily different from any other maps. But because of performance reasons most animation will cover only part of a screen and as such are small in size. This might have implication on the information content of the map, since animation maps also have the task to inform (DiBiase et al., 1992; Harrower, 2003)).

Legend

Just as any other map, an animated display also need a to explain the meaning of the map symbols. However, the legend can have a dual function. Besides being a tool for explanation it can be a tool for navigation. In a temporal animation it can let the user travel through time. In an animation which frames are ordered based on attribute values, it allows one to travel from high to low values. A 2D-index map with a 3D flyby gives the users the option to move to any position in the flyby and start or continue their trip. The combination of legend as an interpretation device and an interface control tool allows the user to answer far more interesting questions then just looking at the frames passing by ((Kraak et al., 1997)).

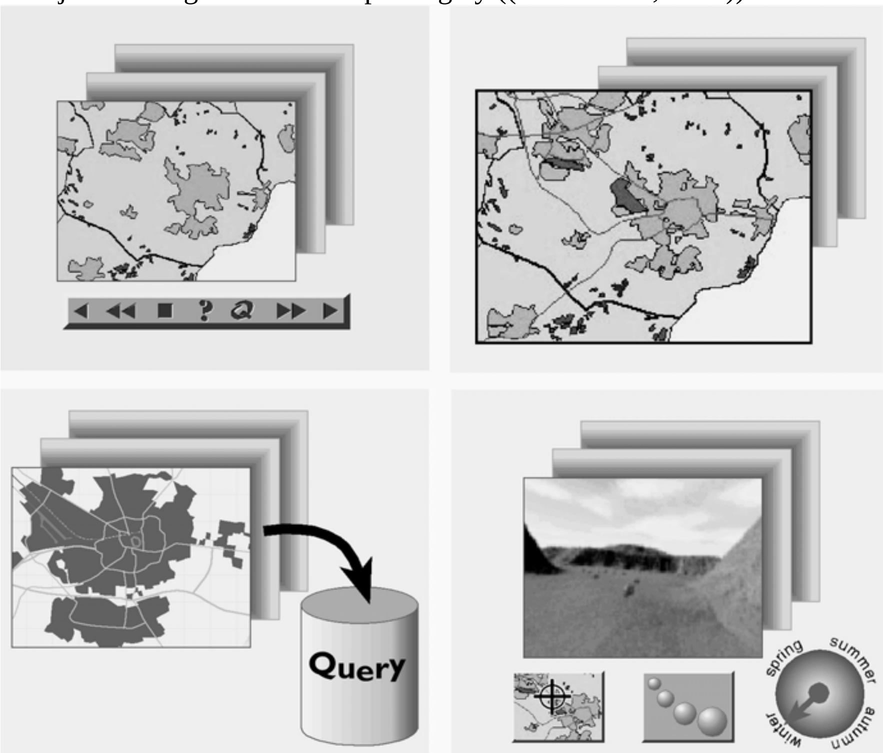

Fig. 5. Cartographic animation environment. The diagram shows the most important features of the user environment: upper left: the interface to move through the animation; upper right: the map image showing spatial pattern; lower right: the legend for navigation and explanation; lower left: the link with the database to query the map images.

Link to database

The link between the database and the animation seems to be a necessity. The extent of this link, however, depends on the visualization strategy (e.g. presentation vs. exploration). In an exploratory environment, querying the database ideally should produce the animation, and provide the user with access to the animation from any point in the animation. For some presentation purposes, such as the daily weather report, it is less relevant.

22.4 Conclusions

Animation offers the user the opportunity to see and query changes spatial patterns. Depending on the nature of the data one can apply different design techniques, or change the viewpoint on the data. Animation will offer a better insight to mapped phenomena. However, this will only work when the user environment has the proper options for interaction. In an exploratory environment the animation will be one of the strong alterative views on the data that supports knowledge discovery.

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23 Multimodal Analytical Visualisation of Spatio-Temporal Data

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23.1 Introduction

The concept of multimedia cartography has appeared as a natural response to the new opportunities provided by computer technologies as compared to the paper-based technologies of the past. It is generally believed that multimedia can convey the multifaceted and dynamic character of the spatial environment much more adequately than paper (Peterson 1999). The scope of multimedia cartography includes not only combination of maps with images, sound, movies, etc. but also dynamic (animated) maps, interactive maps, linked maps (e.g. in electronic atlases), three-dimensional images and virtual reality. In principle, combination of maps with statistical graphics can also be viewed as a kind of multimedia cartography; however, this does not seem to be a quite traditional view.

By looking at the current topics and trends in the research on multimedia cartography, one may observe a shift towards one of the major roles played by maps, namely, communication of spatial information. The other important role of maps, to model the reality for the purposes of exploration and analysis, seems to get less attention.

An opposite shift can be seen in another part of the cartographic research community, which is lead by the ICA Commission on Visualisation (see http://www.cartoweb.nl/icavis/) with the research agenda stressing the role of highly interactive maps in hypothesis generation, data analysis, and decision support (MacEachren and Kraak 1997). Combination of interactive maps with other instruments for data analysis, including statistical graphics and other visualisation techniques as well as data manipulation and computational tools, is among the mainstream topics in geovisualisation research. It is generally recognised that exploration of non-trivial datasets requires the data to be viewed from diverse perspectives, which is supported by multiple dynamically coordinated displays of various types.

Currently, it is not usual to apply the term “multimedia” to such display combinations (which indispensably include maps when spatial data are dealt with). Therefore, we have used the term “multimodal visualisation” in the title of our paper, which tells about using diverse types of interactive displays for exploration of spatio-temporal data, i.e. data having both spatial and temporal components. Although the research topic represented in the paper cannot be viewed as mainstream in multimedia cartography, we hope to provide a useful complement to the traditional themes. At least, we do not see any particular reason for the interests of multimedia cartography to be limited to presentation and communication of known information and not include the use of multiple media to support exploration of spatial data and discovery of previously unknown patterns, trends, and relationships. So, we consider ourselves as representatives of an ‘exploratory trend’ in multimedia cartography, and our paper is about the use of interactive and dynamic maps in combination with other types of data displays for exploration of spatio-temporal data.

Cartographic representation of time attracted the attention of cartographers and map designers for a long time (Bertin 1983, Vasiliev 1997). Starting from the pioneering work of Tobler (1970), computers are used for creation and distribution of dynamic maps, in which display time is used to represent real time. However, it is now generally recognised that dynamic maps alone are insufficient for a comprehensive exploration of spatio-temporal data. Hence, there is a general research problem of devising combinations of tools that could adequately support data exploration. Choice of tools depends on data structure and characteristics.

There are three basic types of spatio-temporal data according to the type of changes that occur in time (Blok 2000):

Existential changes: appearing, disappearing, reviving objects or/and relationships;

Changes of spatial properties of objects (location, size, shape); and

Changes of thematic properties, i.e. values of attributes.

In this chapter, we focus on the exploration of changes of thematic properties of spatial objects. More precisely, we consider data consisting of multiple spatially referenced time series of numeric values. Visualisation of such data in a dynamic map supports perceiving the pattern of spatial distribution of the values at any moment in time and the evolution of the pattern over time. However, this technique is inadequate for such exploratory tasks as analysing the temporal behaviours of the values in various places, understanding the spatial distribution of these behaviours and detecting behaviours with particular characteristics. The objective of this paper is to suggest visualisation techniques and tools that can support the exploration of the temporal behaviours. In combination with dynamic maps, these techniques and tools enable comprehensive exploration of the various aspects of spatially referenced time-series data.

In the next section, we briefly review the methods for visualising and exploring time series developed in cartography and other disciplines. In the sections following this, we define the exploratory tasks relevant to the exploration of temporal behaviours and propose ways to support them.

23.2 Visualisation of Spatial Time-Series in Computer Cartography and Statistical Graphics

Visualisation of spatio-temporal data has been in the focus of many researchers in computer cartography. Thus, Peuquet (1994) proposed a conceptual framework for the representation of spatio-temporal dynamics. Koussoulaku and Kraak (1992) refined the theory of Bertin concerning the types of questions that can be asked about spatio-temporal data. Harrower et al (1999) considered human-computer interaction issues and developed a powerful and convenient user interface for temporal focusing and temporal brushing that accounts for linear and cyclical nature of time. Some researchers study the opportunities provided by emerging technologies such as Tcl/Tk, Java, and SVG (see, for example, Dykes et al 2005). Current approaches to visualisation and exploration of spatio-temporal data are surveyed in (Andrienko et al 2003). The most commonly used techniques include

1. Representation of several time moments/intervals on multiple maps;
2. Dynamic maps, with various possibilities for user control;
3. Change maps, which represent differences between situations at two time moments (Slocum *et al* 2000); and
4. Space-time cube, a 3D visualisation where two dimensions represent geographical space and the third dimension represents time (Hedley et al 1999, Kraak 2003).

Such methods have been applied, in particular, in electronic atlases (Cartwright *et al* 1999) providing access to historical data to a wide community of users and stimulating users to explore such data.

The cartographic community is not the only group of scientists interested in methods to represent and explore time series data. Numerous computational methods have been developed in data mining (Keogh and Kasetty 2003). Researchers in statistical graphics, information visualisation and human-computer interaction proposed time series interactive visualisation techniques. Unwin and Wills (1988) and Hochheiser and Shneiderman (2004) introduced basic graphical and interaction facilities for enhancing time series plots / time graphs analytical capabilities:

1. Interactive access to values through graphics by pointing on a line;
2. Tools for overlaying lines to enable their comparison, which allow the user to align, smooth, stretch, and shrink the lines for a better correspondence;
3. Possibilities to select lines with particular characteristics - specific values at a given time moment or interval, specific profiles, etc. ; and
4. Dynamic linking between a time graph and other information displays (scatter-plots, histograms, maps etc.) by identical marking of visual items corresponding to user-selected objects.

The objective of this chapter is to find such a combination of techniques that could adequately support the exploration of a spatially referenced collection of time series (temporal behaviours). To do this, we apply a task-analytical approach, i.e. start with identifying the potential exploratory tasks pertinent to such data.

23.3 Visualisation of Local Behaviours

We use the term ‘local behaviour’, or simply ‘behaviour’, to denote the temporal variation of attribute values in a particular place. A dataset consisting of attribute values referring to a set of spatial locations and a sequence of time moments can be viewed as a collection of local behaviours, where each behaviour refers to one of the locations. This is not the only possible view. The data can also be treated as a sequence of spatial distributions of the attribute values, where each distribution refers to one of the time moments. While proper consideration of both aspects is required for a comprehensive analysis of the data (Andrienko and Andrienko 2005), this paper focuses on the former view. Moreover, we further limit our focus to behaviours formed by values of a single numeric attribute.

In the course of the exploration of a collection of spatially distributed behaviours, an analyst may be interested to find answers to various questions:

– What is the general dynamics of values over the entire territory?
– What are general features of the local behaviours in a given area and how do they compare to the behaviours on the remaining territory?
– What spatial clusters have similar behaviours.
– What locations with the behaviours having specific features? Are these locations neighbours, or, in other words, do they form a spatial

cluster? (Here some examples of the features that may be looked for are: persistently low (or high) values; high value fluctuations; continuous increase (or decrease) of values during a given time period).

Let us look what tools and techniques may be helpful to a data analyst in finding the answers. For our investigation, we shall use the dataset containing the statistics of crimes in the USA published by the U.S. Department of Justice. The data is available at the URL http://bjsdata.ojp.usdoj.gov/dataonline/. This dataset contains values of 21 numeric attributes referring to 51 states of the USA and to 41 time moments, specifically, the years from 1960 to 2000. The attributes include the population number and the absolute numbers and rates of the crimes of different types, for example, burglaries, motor vehicle thefts, murders, etc.

For studying a single temporal behaviour, the visualization of the data on a time graph is typically used. The behaviour of a numeric attribute often appears on such a graph as a line, which results from connecting the positions corresponding to the values at consecutive time moments. When multiple behaviours are explored irrespectively of the geographic space, they can be represented in a single display as lines drawn in a common coordinate framework. Figure 1 shows a time graph with 51 lines corresponding to the behaviours of the attribute ‘Burglary rate’ in all the states. This representation can be used for getting the first rough idea about the dynamics of the burglary rates over the entire country: overall increase until 1980 followed by a period of gradual decrease. However, the cluttering and overlapping of the lines make the display hardly legible.

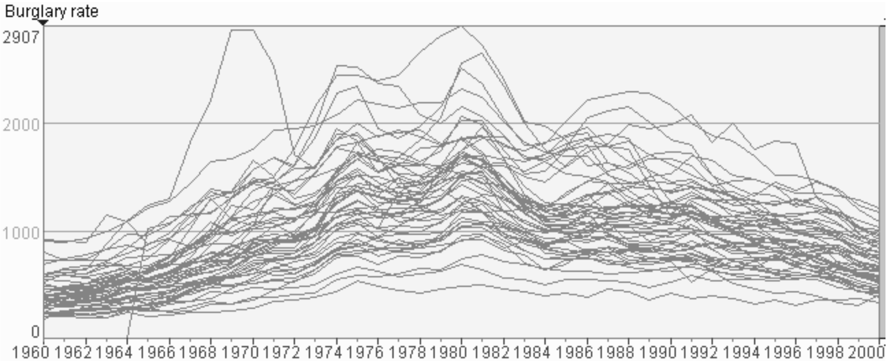

Fig. 1. Behaviours of the burglary rates in the states of the USA are represented on a time graph display as multiple overlaid lines.

The time graph can be dynamically linked to a map display: positioning the mouse cursor on a line or clicking on it can result in this line being specially marked (highlighted) as well as the corresponding state on the map.

The link can also work in the opposite direction, i.e. selection of a state on the map highlights the corresponding line on the graph. By selecting several states, one can find answers to questions concerning the general features of the local behaviours in this or that area. However, since the user can only see which behaviours correspond to the selected locations but not where the remaining behaviours are situated in space, it is very difficult to understand how the character and distinctive features of the temporal behaviours vary over the whole territory.

A suitable graphical representation for the latter task is shown in Figure 2: the local behaviours are represented by symbols superimposed on a map according to their spatial references, i.e. at the locations of the respective states. The form of the symbols is a modification of the time graph technique: the coordinate frame is omitted and the lines are complemented to closed shapes with internal filling for a better visibility against the cartographical background.

In such a map, we can see how different behaviours are distributed over the territory of USA. Thus, we can observe that the states in the north-central part of the country had lower burglary rates than in the other states during the whole time period from 1960 to 2000. Another observation is that the states on the west and southwest have higher peaks in the middle of the time interval than the states on the east (with a few exceptions). It is possible to see some spatial clusters of states with similar temporal behaviours of the burglary rate: (1) west-southwest-south, (2) middle north, (3) the area around the Great Lakes, (4) centre and southeast, except for Florida. The clusters are roughly outlined in Figure 3. By visual inspection of the map, an explorer can also find locations with the corresponding behaviours having specific features and, naturally, immediately see whether these locations form a spatial cluster. It is also possible to detect essential common features of behaviours in a certain area.

In the examples we have considered in this section, a purely visual exploration has been quite effective due to the small dimensionality of the data in the spatial, temporal, and thematic aspects. Thus, we have dealt with a single attribute, short time series, and a small number of spatial locations. Therefore, we have been able to review and compare all the local behaviours represented on the map. However, for the exploration of more complex data, it is necessary to use more sophisticated methods or combinations of techniques. Consideration of multiple attributes is not within the scope of this chapter. For the remaining complexities, i.e. the length of the time series and the number of different locations, we propose some new methods that shall be discussed in the next section. Although we use the same example data, the methods are also applicable to substantially larger data volumes.

Fig. 2. A cartographic representation of the spatial distribution of the behaviours of burglary rates over the USA

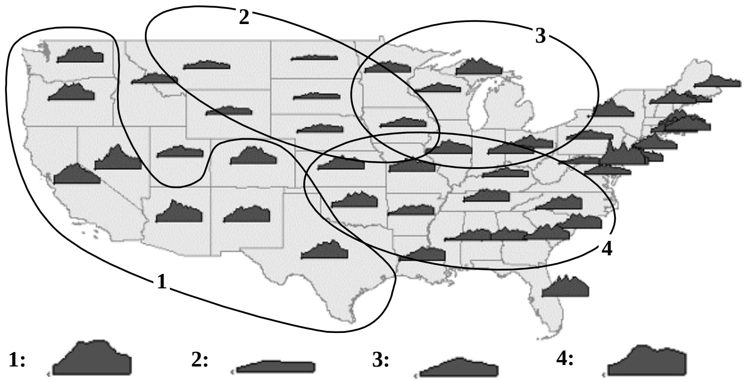

Fig. 3. Spatial clusters of states with similar temporal behaviours of the burglary rate. Below the map, the typical behavioural patterns for each cluster are schematically shown.

23.4 Combining Tools for Behaviour Exploration

One possibility to overcome the dimensionality problem is to use methods of computational statistics and data mining. For example, an explorer can use cluster analysis for replacing numerous spatial locations by groups made of locations with close characteristics. Spatially aware clustering methods can create geographically continuous aggregates. However, this solution entails several problems. First, such methods usually require significant efforts for data preparation. Second, the outcomes are very sensitive to method parameters. An explorer needs to do multiple trials with assigning different values to the parameters and then choose the most appropriate result. Third, execution time may be rather long. Finally, the results are often difficult to interpret.

The approaches we are going to suggest are based on simple, easily understandable calculations enhanced by interactive dynamically linked data displays. We shall demonstrate that, despite of the simplicity, these techniques can be quite effectively applied to large datasets.

23.4.1 Getting the General Picture of the Behaviour on the Entire Territory

In Figure 1, we have demonstrated a time graph display with multiple overlaid lines. Already with fifty local behaviours, this display suffers from cluttering and overlapping. It becomes completely unusable when this number increases to hundreds or thousands. In Figure 4, bottom, we propose an aggregation-based alternative to a time graph display representing multiple behaviours.

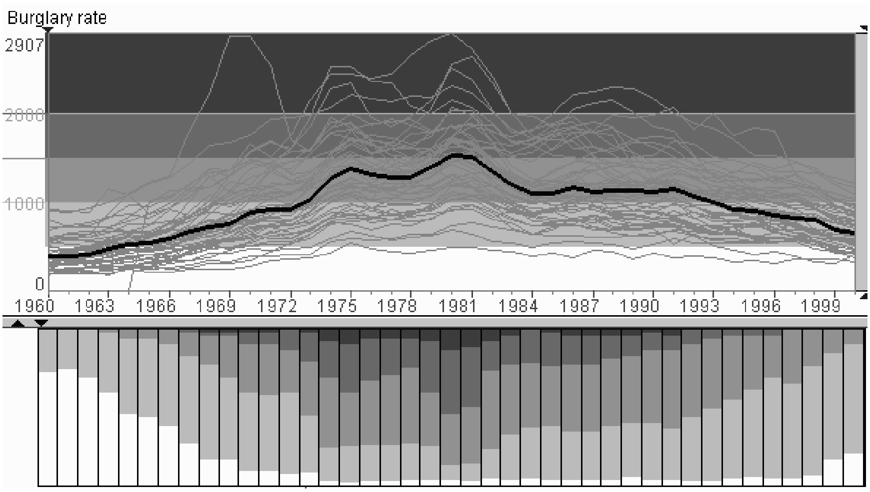

Fig. 4. The value range of the attribute has been divided into intervals. The segmented bars show for each year the proportions of values over the whole country fitting in these intervals.

For producing this visualization, the value range of the attribute “Burglary rate” has been divided into 5 intervals by introducing breaks 500, 1000, 1500, and 2000. For each year, the display contains a segmented bar with the differently shaded segments showing how many values in this year over the whole country fit in the corresponding intervals. The white segments correspond to the values below 500, the light grey – to values between 500 and 1000, and so on (the higher the values, the darker the colour). The background shading of the time graph display above the segmented bar display visually illustrates the principle of the aggregation and the current division of the attribute value range.

The aggregated display at the bottom allows us to do important observations concerning the general behaviour of the burglary rates on the whole territory over the time. Thus, we can see that in the early 1960s the burglary rates in most states were below 500 and in a part of states (from one-fourth to one-third) between 500 and 1000. Starting from the mid-1960s, the burglary rates over the whole country increased and reached their extremes in 1980 and 1981, when the proportions of the states with the rates below 500 and between 500 and 1000 were the smallest and the proportions of the states with the values between 1500 and 2000 and more than 2000 were the largest. After 1981, the situation improved slightly and remained more or less stable until the beginning of 1990s, when it started to gradually improve. This trend was preserved until the end of the time period under study. However, the low criminality level of early sixties was not reached again.

The thick black line on the time graph above the aggregated display connects the yearly countrywide median values and thereby provides an additional generalized view of the dynamics of the burglary rates over the country.

The aggregation technique can be combined with various transformations of the original attribute values, such as computing the changes from year to year, as is shown in Figure 5. Here, the burglary rates in each year have been transformed into their ratios with respect to the values in the same states in the previous year. The resulting values higher than 1.0 correspond to annual increase and values below 1.0 – to decrease. The time graph at the top of Figure 5 represents the transformed values instead of the original ones.

As in the previous case, we have applied the division of the whole range of the transformed values into intervals. This time, choosing two breaks, 0.95 corresponding to 5% decrease and 1.05 corresponding to 5% increase, and thereby obtained 3 intervals. The resulting aggregated display is instrumental in finding years and periods of significant countrywide increase or decrease of values. The light grey colour corresponds to the decrease by more than 5%, white – to the changes between 5% decrease and 5% increase, and dark – to the increase of the values by more than 5%. It may be seen that 1974 and 1980 were the years of almost overall rapid increase and 1999 was the year of general rapid decrease. Starting from 1992, the crime rates mostly decreased or changed by less than 5% in comparison to the previous year.

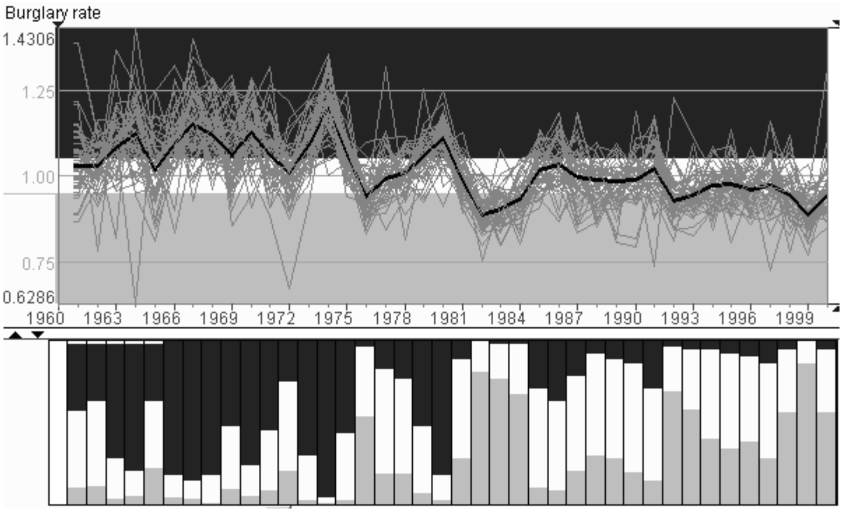

Fig. 5. The time graph has been transformed to show the annual changes in the individual states. The lower image aggregates the changes for each year.

Hence, this simple aggregation technique proves quite useful in application to both the original data and the transformed ones. The technique is scalable in respect to the number of objects and to the length of time series and the computational complexity is linear with regard to both dimensions. The limitation for the visualization is the screen size and resolution. The time graphs accompanying the aggregated displays in Figures 4 and 5 are not necessary for the sort of exploratory tasks considered and may be omitted.

23.4.2 Finding Spatial Patterns of Similar Local Behaviours

Another way of aggregating the same data is illustrated in Figure 6. The display contains a so-called ‘envelope’, that is, a polygon enclosing all the lines representing the local behaviours. Actually, the lines themselves are not needed for building the envelope but only the minimum and maximum values over the country in each year are needed. The envelope therefore shows how the range of burglary rates changes over time. In addition to the value range in each year, the median and quartiles are shown. The positions of the corresponding positional measures in consecutive years are connected so that the original envelope is divided into four polygons. The polygons are shaded using alternating light and dark grey, which makes them clearly visible and distinguishable.

In principle, there is a danger that a viewer may consider these polygons as containers of certain subsets of lines whereas they are just indicators of the positions of each year’s median and quartiles, and individual lines may cross the boundaries of the polygons, as may be seen in Figure 7. Perhaps, it would be less misleading to mark somehow these positions without connecting them, but such a display would be much more complex to perceive.

Providing that the meaning of the polygons is understood correctly, one can effectively use them for data analysis. The display gives us a summarized picture of the countrywide situation with the burglary rates in each particular year and allows us to compare the situations in different years. We can also get an idea of the overall trend of the burglary rates over the country during the whole period from 1960 to 2000 or any of its subintervals. Thus, an increase of median and quartile values indicates the overall increasing trend of the burglary rates, and the same for decrease. For example, a clear decreasing trend can be observed on the interval from 1991 to 2000. Moreover, using the properties of the positional measures, we can isolate this observation by giving some numeric estimation. In 1991, more than a half of the states had burglary rates over 1000, whereas in 2000, the burglary rates in more than 75% of the states were below 1000. We can easily see the period of the highest burglary rates from 1977 to 1982, when the rates in at least 75% of states were over 1000. The synchronous peaks of the values of the median and the quartiles in 1975 and 1980-1981 may be also worth attention as well as the rather steep decrease from 1981 to 1984.

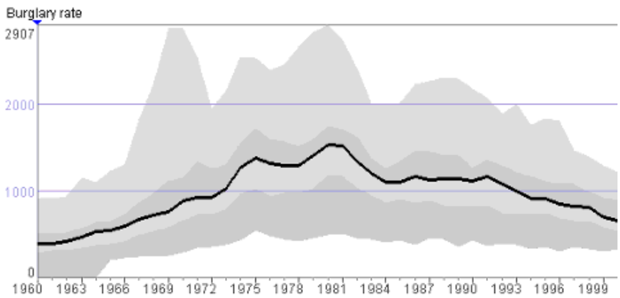

Fig. 6. The aggregate time graph represents the changes of the value range and the quartiles over time.

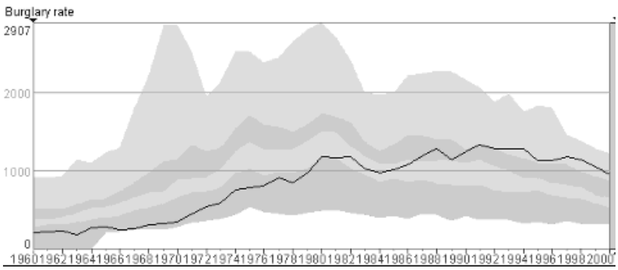

Fig. 7. The line representing the local behaviour in Mississippi is superimposed on the aggregate time graph.

The computed yearly medians and quartiles can be further used for data simplification. The original numeric values can be replaced by the numbers of the respective quarters. Thus, the line of Mississippi in Figure 7 was in the lower quarter of the value distribution from the beginning of the time period until 1980, i.e. for 21 years. Accordingly, the original values of the burglary rates in this state for the years from 1960 until 1980 are encoded into the value 1. Then, from 1981 up to 1986, the burglary rate values were in the second quarter and, hence, are encoded into 2. Analogously, the values for the years 1987-1991 are encoded into 3, and starting from 1992 – into 4. In the same way, the values for all other states are transformed.

For each so transformed time series, the occurrences of each quarter number are then counted. For example, the counts for Mississippi are 21, 6, 5, and 9, respectively. The counts are presented in Figure 8 by bar charts positioned on a map. Each symbol consists of four bars corresponding to the quarters with the sizes of the bars being proportional to the respective counts. Additionally, the shading of each state corresponds to the dominating quarter, i.e. having the maximum number of occurrences among the four quarters. Thus, the dominating quarter for Mississippi is 1.

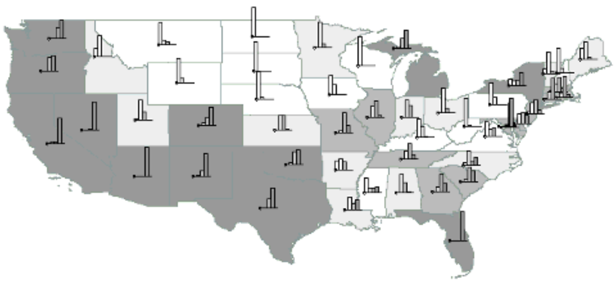

Fig. 8. Computationally supported detection of clusters of similar local behaviours

It may be noted that, in the result of this automated procedure, we have received spatial clusters (groups of neighbouring identically shaded states) very similar to the clusters in Figure 3 revealed ‘manually’.

The transformed data can also be analysed in another way. For each local behaviour, the average (mean) quarter and the variance can be computed. In Figure 9, bottom left, these values are represented on a scatterplot. Using the dynamic link between the scatterplot and the time graph, one may find and explore behaviours with particular characteristics in terms of the average and variance. Thus, in Figure 9, the scatterplot has been used to find the behaviours with low variance and the values being mostly either in the lowest or in the highest quarter. The corresponding lines are highlighted on the time graph. Similarly, in Figure 10, the states with high variability of values have been selected through the scatterplot. The map fragment shows only the eastern part of the country where all the selected states are located.

It may be noted that the time graph displays in Figures 7, 9, and 10 combine an aggregated representation of the entire set of local behaviours and a detailed representation of selected behaviours. This technique compensates for the deficiencies of both representations being used separately. Despite the aggregation, individual data can be viewed in sufficient detail and compared with the general characteristics of the entire dataset. Since the detailed representation is only applied to selected items, cluttering and overlapping of display elements is considerably reduced.

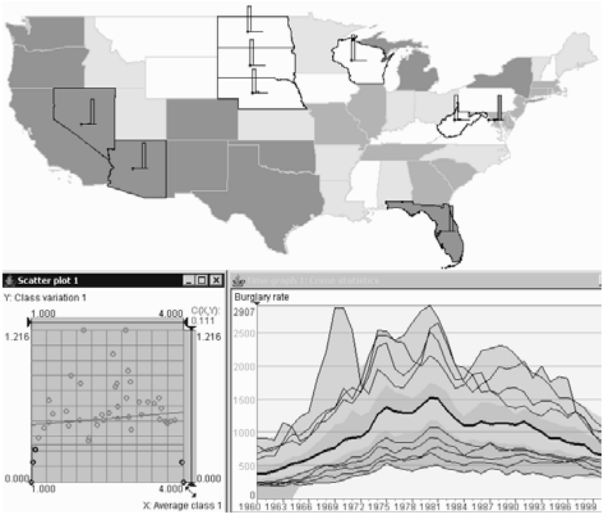

Fig. 9. Selection of the states with consistently low (shaded in light colour) and consistently high (shown in dark) burglary rates

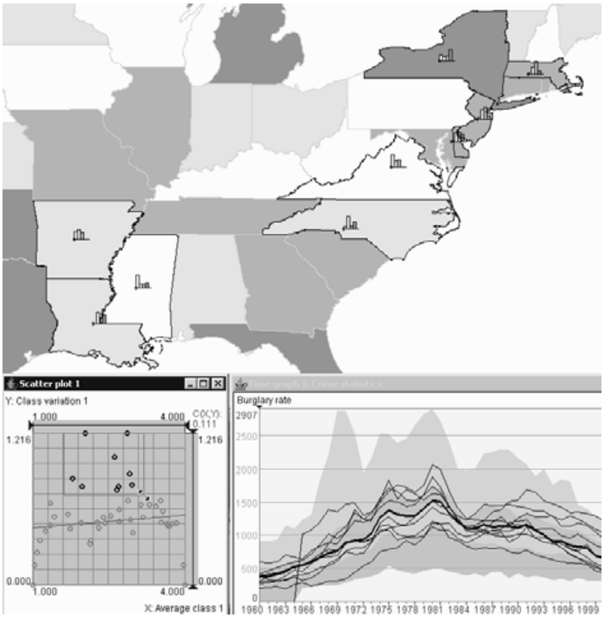

Fig. 10. Selection of the states with high variability of values.

The analytical instrument we have described allows the user to choose arbitrary percentiles for the value range division and subsequent replacement of the original values by the interval numbers. It is possible to apply the computations to the complete time period or to any sub-interval. The user can dynamically change the selected time interval. In response, the computations are automatically re-applied and the visualization of the results updated. It is also possible to use the provided counts of increases and decreases of the interval numbers inside the time series.

The proposed method can be applied to rather large data sets. It has a linear complexity in respect to time and *n*log(n)* complexity in respect to the number of locations. The visual representation is based on aggregated characteristics, and only selected individual data with specific characteristics are shown in detail.

23.4.3 Detecting Spatio-Temporal Patterns of Similar Changes

The geometrical representation of temporal behaviours provides interesting possibilities for data exploration through dynamic querying. The idea, which is demonstrated in Figure 11, is to show only line segments having a certain inclination. The inclination may be specified through setting the lower or/and upper limits for the degree of absolute or relative change (i.e. difference or ratio) in comparison to the previous moment.

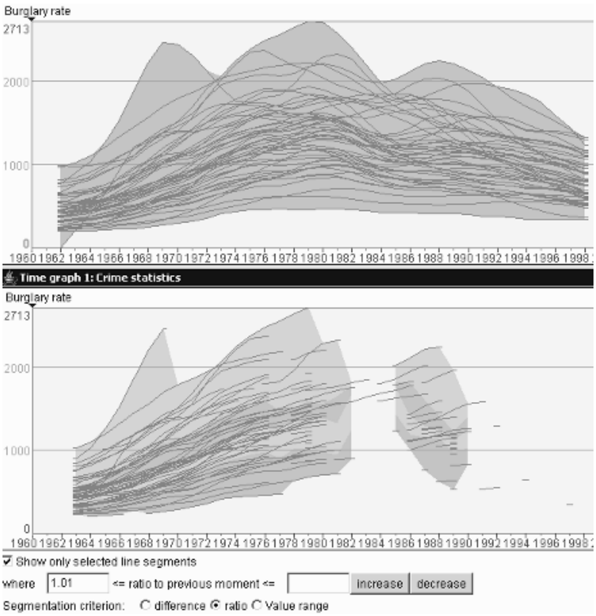

Fig. 11. The time graph shows only the line fragments corresponding to value increase by 1% or more.

Thus, in Figure 11 (lower image), the user has specified the lower limit for the relative change to be 1.01, which corresponds to 1% or more increase in a current year in comparison to the previous year. In response, the tool shows only the line fragments complying with this specification; all other line fragments have been hidden. Prior to the filtering, the lines had been smoothed using the 5-year centred moving averages and appeared as is shown in the upper image in Figure 11.

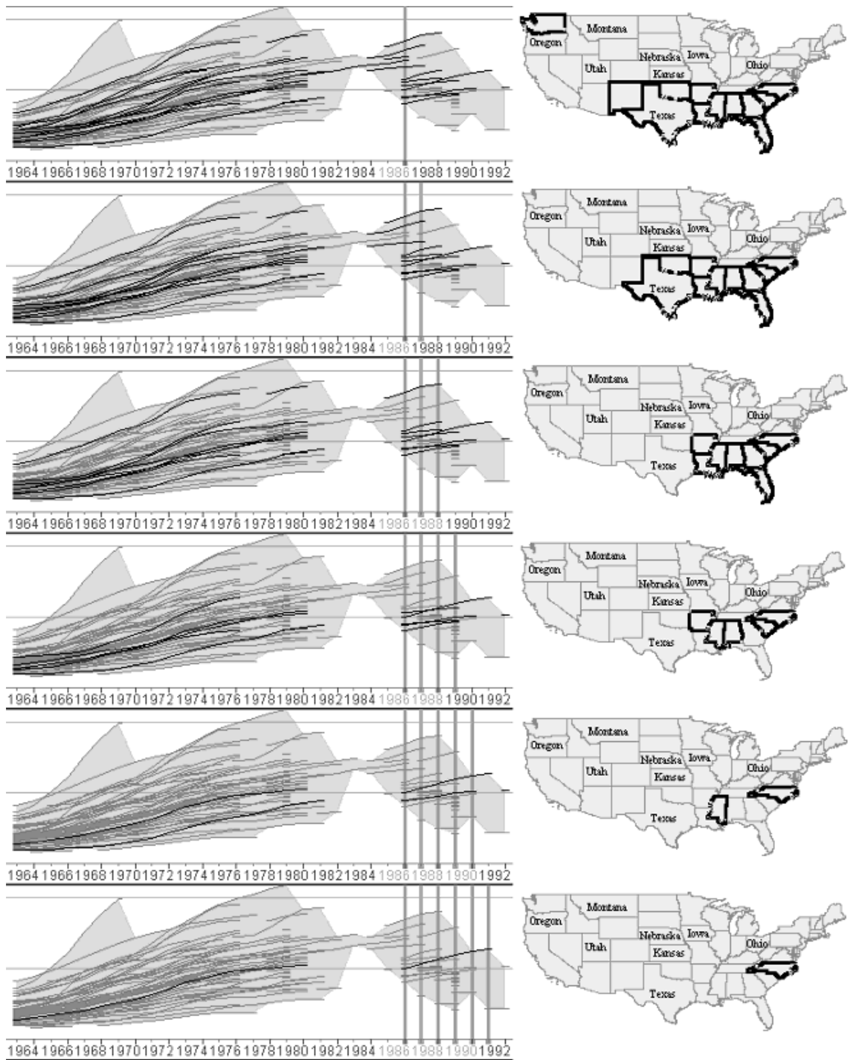

Fig. 12. Looking for states with 1% or more increase of the burglary rates in consecutive years starting from 1986.

Now, it is possible to apply direct manipulation querying in order to find out which states had no less than 1% increase of the burglary rate in particular years. This can be done by clicking on the line segments, but there is also another opportunity: the user can click on the years, that is, on the positions corresponding to different years below the horizontal axis of the graph. In the result, the lines with no less than 1% increase in these years become marked, and so do the corresponding graphical elements on other displays, in particular, the outlines of the states on a map display. Selection of two or more years marks the lines with specified inclination in all years.

Figure 12 demonstrates the effect of a series of successive selections. The vertical lines on the time graph indicate the selected years. Marked by black colour are the lines with the specified degree of increase in these years. On the right of each time graph, there is a map with the corresponding states being marked by thick black boundaries.

First, we selected the year 1986 and observed on the map what states had the specified increase of the burglary rates in this year. After that, we clicked on the next year. In the result, marking of two states disappeared, and only the states with increase in both 1986 and 1987 remained marked. Then, we clicked on the year 1988, and so on. With each subsequent selection, the number of marked states decreased. At the end, when six years from 1986 to 1991 were selected, only one state remained marked. It may be seen from the graph at the bottom that the corresponding line fragment (shown in black) ends in the year 1991, and, hence, the selection of the year 1992 would remove the last marking.

This technique is useful for answering analytical questions like: “Find spatial clusters of states with continuous increase of values during a given time period”. In this method, a direct manipulation user interface supports interactive testing of the sensitivity to variation of the time period and the threshold for increase. The technique can also be applied to much larger data sets: due to the filtering, the overlapping is significantly reduced.

23.5 Discussion and Conclusions

In this paper, we proposed several interactive methods for visual exploration of spatially distributed time-series data. The first method is based on data aggregation and supports the overall view of the value dynamics on the entire territory. The second method supports finding spatial patterns of similar temporal behaviours. This method is based on data simplification: the values within intervals determined by user-selected positional statistical measures are treated as equivalent. Understandable calculations such as counting of value occurrences and finding the most frequently occurring value in a time series are then applied to the transformed data. The results are presented on dynamically linked displays that allow easy selection of objects with specific characteristics for a detailed visualisation. The third method is instrumental for detection of spatial patterns of similar temporal changes and for studying sensitivity of the procedure. This method is based on data filtering and interactive manipulation of multiple coordinated visual displays.

The essence of our approach is in combining easily understandable methods of data transformation and aggregation with interactive manipulation of linked data displays that represent the results of these methods. In the displays, the representation of aggregated characteristics of the entire dataset can be combined with viewing detailed information for selected individual instances.

An important feature of the proposed methods is their potential scalability. Although we use a small dataset in the examples presented here, almost all of the proposed methods can be applied to large data sets as well (see a related discussion in Andrienko and Andrienko 2005a). We have an experience of applying these methods to datasets of different sizes. In all cases, the results were useful and stimulating.

Besides presenting the tools, one of our objectives has been to demonstrate a task-analytical approach to choosing techniques for exploratory data analysis. There is a general problem: how to determine what combination of techniques would be necessary and sufficient for the exploration of a particular dataset or a class of datasets with similar structures and properties. Task analysis is a way to solve this problem: before starting to choose and link tools, it is necessary to identify the range of the exploratory tasks that need to be supported. The task-analytical approach is also relevant to the design of various multimedia presentations (in the more conventional sense of this term).

In the book (Andrienko and Andrienko 2005b), we present theoretical and methodological foundations for defining the tasks pertinent to the exploration of a dataset or a class of datasets, choosing appropriate tools and methods to combine the tools, and performing the exploratory analysis of the data in a systematic, comprehensive way.

As to the directions for further research, it is clear that substantial progress is required in tools and methods to support exploratory analysis of spatio-temporal data, in particular, analysing multiple attributes simultaneously, dealing with very long time series, and detecting structures in temporal behaviours (e.g. cyclical phenomena). However, there is another research problem, extremely serious and urgent, which may be called ‘Usability Problem’ (Andrienko and Andrienko 2006). The essence of the problem is that potential users are often incapable or unwilling to use the tools and techniques offered to them.

The Usability Problem involves many aspects. One of them is the users being unfamiliar with the innovative ideas and approaches such as interactive maps or multimedia maps. Another aspect is the imperfection of the existing tools, mostly research prototypes. This refers not only to the design of the user interface but also to the functionality. On the one hand, the tools are quite complex for the user (e.g. because of involving multiple displays or novel visualization techniques); on the other hand, they are still insufficient since they do not cover the full range of potential user’s tasks. Besides, the users are not given any facilities to test the hypotheses they might have generated by using the exploratory tools as well as tools to register their findings and to report the results of exploration.

Since the Usability Problem is very complex and, at the same time, very critical, coordinated efforts of researchers in different disciplines are needed to solve it. We are going to contribute to this by finding approaches to ‘embed’ intelligence into software tools for data exploration so that they could adapt automatically to data under analysis and user’s goals and assist the user in choosing and applying appropriate techniques.

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24 Games and Geography

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24.1 Introduction

In the 1990s a substantial part of Virtual Reality and Scientific Visualisation research was based on extremely expensive and complicated machinery and software, out of the reach of the home user or school classroom. Yet in recent years the increasing power and affordability of personal computers, gaming consoles, and real-time rendering engines have dramatically changed the field.

However, the development of far more accessible technology has not yet meant that we have a full understanding of contextually appropriate and engaging digitally mediated environments. The often cited failure of virtual environment technology to create accessible, engaging and educational experiences may be attributable not just to deficiencies in technology or in visual fidelity, but also to a lack of contextual and performative-based interaction, such as that found in games (Walsh and Bourges-Sévenier 2000; Laird 2001; Gee 2003; Champion 2003; Aldrich 2003; Fritsch and Kada 2004; Roussou 2004; Andreoli et al 2005).

24.2 What is a game?

24.2.1 Defining Games and Game-Style Interaction

In order to understand what computer game design and interaction could offer, we need to define the features and criteria of successful games and game-style interactivity. We could define game-style interaction as meaning the types of interface technology (such as joysticks, and consoles) that one finds in games. Console gamers have access to task-specific devices and interfaces not common to desktop personal computers. However, such devices and interfaces may well have improved task-efficiency or ergonomics, but for many games, one can still use a keyboard and mouse. Thus, the success of games cannot be directly related to the use of dedicated gaming interface devices.

One of the more concise reviews of game definitions is a paper by Juul (2003). He offered the following definition of games, which is really more the listing of six criteria for a game to be a game. "A game is a rule-based formal system with a variable and quantifiable outcome, where different outcomes are assigned different values, the player exerts effort in order to influence the outcome, the player feels attached to the outcome, and the consequences of the activity are optional and negotiable."

Part of the attraction of games is certainly due to their interactive and engaging nature. Aldrich (2003, p.240) even defines game in this way, a game is an "...interactive and entertaining source of play, sometimes used to learn a lesson". Why do computer games captivate? Malone (1982) attempted to answer this question by systematically removing features of games until they no longer seemed to be appealing. His conclusion was that successful games have goals, uncertain outcomes, metaphors that evoke a sense of fantasy and emotional appeal, activities that evoke curiosity through complex information and the suggestion of new knowledge that can be formulated.

Games also seem to have other features. Computer games typically have challenging tasks, social embeddedness, physical embodiment, metaphorical rewards, and player feedback. For example, combat and racing games tend to emphasize *physical embodiment*. An avatar represents the player, there are dynamic environmental elements (hostile or beneficial), and metaphorical mortality or health points. Collision typically results in acoustic feedback and surface erosion or deformation. Feedback tends to be by loss of points, or the signaling of end of game or game level. The games tend to increase hand-eye co-ordination.

Social embeddedness requires a sense of other players or scripted agents. Common tasks include being set roles, procedures, or levels of ability to complete tasks.

Games that have this feature also includes racing games, strategy games, Civilization-type world building games, interrogation or text-guessing games, riddles. In fact, the competitive or collaborative sense of others pervades almost all genres.

In these games the *player feedback* is generally via changes in points. In status or power or equipment levels inside a game; or, (rarely), impostors are uncovered. Success is often via comparison to other players. This genre can help develop the player's memory (spatial, procedural, and navigational).

It is difficult to separate game genres in terms of whether they involve the participant being socially embedded or physically embodied (for other taxonomies, refer Crawford 1982; Malone 1982; Salen and Zimmerman 2003). One thing common to all game genres is that they are *challenging* (hard fun). All games tend to feature increasing complexity, number of puzzles, or situations to overcome. They have tasks, affordances, and constraints. The mixture of affordances and constraints and different levels is designed to be challenging in the sense of 'hard fun'. It has to be difficult enough to be intriguing, but not too difficult to make the user give up in frustration, and hopefully can be solved by different strategies. There may be random events or options between players to coax people to vary these strategies.

Sometimes winning guesses or strategies increase equipment or status, sometimes more of the environment is uncovered. As an easy way of increasing the challenge, games are also often time-based. As challenges, games can develop pattern matching and puzzle solving skills, predictive thinking and bluffing.

Rewards are also a universal feature of games- they may be internal (known as Game Feedback), or external (awards and status conferred by other members of the gaming community). In addition, as one progresses through the game there are many rewards, new weapons, changes in levels, and revealed secrets. So in games knowledge is unfolded, and directly related to increasing success of the player.

In their large tome on game design, Salen and Zimmerman wrote the following often-quoted definition of a game (2003, p.572): "A game is a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome". While Salen and Zimmerman talk of a magic circle that separates (but not always clearly) the boundaries of a game from the real world, they seem to focus rather quickly on conflict (rather than the more generic terms of challenge and competition), discount games that may never have a final outcome, and do not mention the importance of strategy.

Games are considered by many writers to be rules-based systems, but so too are interactive virtual environments. Unlike play, games have parameters that can be communicated to others, that are valid for some meaningful duration of time. Rather than stating one must do this or that, they attempt to limit certain types of activities that may overly advantage one player or make the game unduly complicated.

So to define games as being rules based does not acknowledge that the more successful games afford the developing of various and inventive strategies, tactics or combinations. Games typically indicate boundaries of conduct, and goals that are worth attempting, but they do not directly tell us the best strategy of realizing those goals. What games also typically have that virtual environments do not, is an engaging and challenging relation to a cultural genre (Wolf 2001; Fabricatore et al 2002). However, by saying games tend to belong to or identify with cultural genres, does not mean that games are purely representative systems.

Here is the author's working definition of a computer game (different to the definition by Salen and Zimmerman); *a game is a challenge with codifiable and identifiable parameters that offers up the possibility of being satisfactorily resolved via various innovative strategies without harmful outcomes to the real world situation of the participant.*

24.3. Cultural Geography Place and Games

Virtual environments have been reviewed by architects and town planners, but also by cultural geographers. Cultural geographers are often concerned with the human creation or communication of place, and their ideas as to how 'place' can be fostered in virtual environments may also be of help in designing games that use create or geographical data, elements, or conventions.

Following the work of cultural geographers, Champion (2004) attempted to classify virtual environments by the type of place interaction they engendered, in order to choose an appropriate technology and interaction metaphor. The aim was to determine the extent of place making features necessary to convey the required information, be it for visualization, activity-based, or for interpretive understanding. The first type of environment surrounds and orientates us (spatial presence), the second affords activity (allows and encourages us to do things), and the third identifies and embodies us via meaningfully interacting with the environment, and communicates this transferred sense of agency to ourselves and to others (is hermeneutic).

We may extend this classification to interactive digital environments designed for geovisualization, for geographical learning (to entertain or educate about geographical processes or facts through interaction), or for cultural geography (learning about the perceptions, values and beliefs of societies through their interaction with their surrounding environment, and how they communicate this to each other).

24.4. Games Involving Geography

While game engines have been successfully used for geovisualization, (Fritsch and Kada 2004; Stock et al 2005), computer games are seldom inherently hermeneutic. That is, game spaces do not emphasize the usefulness of interpreting past inhabitation, past usages, or how to symbolically communicate the player's intentions, cultural values and identity to others via the creation or modification of artifacts. Online game communities trade player levels and equipment or secrets via the Internet, but not in the game itself. Some gamers learn how to build 'mods' or 'levels', which are extensions or new versions of the overall game environment. However, they are generally static models that don't change the rules or ways in which the game can be played.

Games are also often competitive and destructive, focused on doing and changing rather than understanding, recovering and preserving. One might well wonder if game-style interaction would be of use in understanding geographical knowledge, controversies, processes or historical or cultural fact.

24.4.1 Strategy-based Games

There are strategic types of games that allocate resources, and may have data relating to certain places, locations, and cultures. One famous game with a geographical component would be *Civilizatio*n. The strategist type games, where one tries to develop empires through selecting resources (and sometimes throwing dice), may be a blend of procedural learning (via calculated risk taking), and prescriptive learning (by the game providing historical facts about the resources that may help player decisions). This type of game may expose the workings of previous civilizations and how they manipulated environmental resources or reacted to geophysical events, and it may incorporate historical events in the way it works out permutations of player decisions, but as a learning platform, it encounters the problem of how to separate fact from fiction for the player (Kensek et al 2002; Aldrich 2003: 14).

24.4.2 Fact-based Memory Games

Some early games tested players' knowledge of place names or regions or other place related data. One famous example is *Where in the World is Carmen Sandiego?* (Cartwright 2004). While such games may impart accurate knowledge, there has been little research on how entertaining they are for various age groups and different types of gaming audiences.

24.4.3 Explorative Games

There are games based around exploration of an environment, where interaction is little more than travel and visualization of the environment, for example, *Weekend at Capri*. Although it requires solving puzzles and calculating successful combinations, the *Myst* series can be called an exploration/visualization game. One may argue that games without clear goals are more like play environments (Malone 1982). Where they do not allow the visitor to create destroy or modify, to learn by trial and error, perhaps they are not even play environments but spectacle environments. However, there have been explorative games where players are required to guess according to visual and textual geographical information, one such example is *ArcDig* (Warden 2001), a free and downloadable game, designed for archaeology students, but with possible uses for teaching geography.

24.4.4 Affordance and Constraint-based Games

Many first person shooters use the changing and complex elements of place to confuse people's spatial memory, or create varied elements of place that either hide or make visible players, lines of sight, obstacles or dangers. By using dynamic place elements (lava, water, avalanches) they may help develop certain 'place wariness' where the player learns to run for or away from certain types or sized places.

24.4.5 Place-Fed games

Some games use real-time place data to increase their sense of realism, to update or augment content, or to personalize the gaming experience for participants. *Black & White* can be fed weather data from the Internet so that the environment simulates the weather outside the window of the player. Some virtual heritage environments have also used data mining to create dynamic real-time phenomena as a backdrop or as secondary information (Refsland Ojika and Berry 2000).

24.4.6 World Building games

Some games, especially the online massive multiplayer games, allow participants to design their own buildings, and in some cases, landscapes or place elements. What would make a digital environment seem like a ‘world’ is not yet clear, but it is interesting to note that Federoff (2002: 32) suggests one heuristic for game design is to “Build as though the world is going on whether your character is there or not.”

24.5. Game Issues

24.5.1 Games and Learning

The clues, goals, and methods of gameplay are often learnt developed or found via conversation, observation, by trial and error, or even a blend of some or all of these ways of learning. Therefore, games offer different ways of interacting to learn. However, since computer games are generally goal-based, they tend to emphasise procedural rather than prescriptive knowledge. That is, they provide clues and methods for learning how to solve a task rather than teaching right from wrong, or true from false. Computer games are thus orientated towards trial and error interaction (Roussou 2004).

Many writers have written of the learning advantages of games (Laird 2001; Prensky 2001; Gee 2003; Aldrich 2003) but few have specifically explained how to create optimal learning outcomes from games. Part of this reticence may be from the type of learning that games generate, they tend to favour the perfection of procedures and strategies rather than the acquisition of facts. There exists a degree of separation between games that develop procedural knowledge, and virtual environments’ tendency to follow traditional pedagogy by presenting prescriptive knowledge.

So how do we blend game-styled interaction with, say, geovisualization environments? Despite literature conflating narrative with environmental storytelling (Jenkins 2004), knowledge derived from observation of place features in games is typically procedural rather than prescriptive. Gamers do not typically learn what happened from observing features of place (shadows, openings, strange devices), they learn what to expect and where to move in case of trouble. Their knowledge is typically counterfactual and conjectural. If games are engaging through a reliance on procedural learning, one is left with the issue of how to create effective and engaging learning environments, that for geovisualization at least, have traditionally had a prescriptive learning component (such as voiceovers, guided talks, or popup text information).

24.5.2 Navigation Issues in Games and Digital Environments

A sense of place relates to how we individually believe we would, should or have navigated through a space. Navigation may be defined as locomotion and wayfinding; however, exactly how we find our way through environments, and virtual environments in particular, is still debated (Beynon 1998; Soini 2001) while how the brain perceives and recalls spatial navigation and spatial recall appears to be highly subjective (Raubal and Egenhofer 1998) and recreated on demand (Wang et al 2001).

Game navigation is also dissimilar to navigation in the real world. Unlike the picture space of films, the three-dimensional space of games is far closer to ‘place’. We also have more cognitive overloading in a game, as we are actively wayfinding, rather than passively experiencing the cinematic display of space, but we are not necessarily moving in the same way as we would in the real world, which may severely restrict what we perceive (Oman et al 2003).

24.5.3 Evaluation Issues

Jørgensen (2004) has noted that Human Computer Interaction studies (HCI), and games design, have much to offer each other, but have generally had no mutual interaction. Following Malone (1982), he argues that games are supposed to be easy to learn but difficult to master, while conventional usability principles stress the design of software that is easy to learn *and* to master. Further, it is not always apparent how to best evaluate a game-style environment. Is it successful when it is engaging, has high levels of usability, or imparts new forms of knowledge?

If we have the answer to that question, we also need to ask ourselves how the results are to be evaluated, through the player’s performance in the game-style environment, through a post-experience questionnaire (Slater 2004) or test (Billinghurst and Weghorst 1995), or through capturing physiological data of the players (Meehan et al 2002).

24.6 Conclusion

Anyone who designs interactive spatial environments may learn from game-style interaction. Games are challenging, rewarding, and sometimes 'personalisable'. They also offer cues on how to help people navigate through virtual environments. Although digital game environments do have issues: authenticity, relevant meaningfulness, and how one evaluates their success or failure when used for educational purposes.

However, games do offer some form of social context, embodiment, and challenge. They are also simulations. When designing learning environments, we all too often forget the point of the simulation is to challenge and reward the learning process rather than to depict a product. To stimulate that process we need to further investigate what the user experience is for, and how the interaction methods and metaphors can best present content, engage, and coax the learner to develop either transferable skills or factual knowledge.

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25 Virtual Queenscliff: A Computer Game Approach for Depicting Geography

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25.1 Introduction

The marriage of computer games technology and theory with cartographic representations is rapidly changing the scenery of cartography, both in underlying theory and the presentation. Throughout its existence, video/computer games have been closely tied to Virtual Reality (VR) systems through a close association with computer graphics production. Indeed, much of games hardware and software techniques involved in graphical display have been utilised from their more expensive counterparts. Whilst VR systems have been in existence for decades, their use by cartographers has been minimal due to the expense of these installations and subsequent inaccessibility. Wide dissemination of any cartographic representation/visualization is not feasible with these VR systems, thus restricting innovative displays of information. However, computer games now offer a more desirable platform (amongst other attributes) for designers and their audience to experience the full value of Geospatial Virtual Environments (GeoVEs). This has been possible due to the large advances in the industry over the last decade (Laird 2001).

Virtual Queenscliff is an early example of a Geospatial Virtual Environment built using computer games technology as part of the author's doctoral candidature. It is a product built with the intention of conveying real-time 3D spatial information in an easily accessible (using a PC), understandable (through a natural real-life perspective) and usable means (through simple and intuitive controls) for the average "non-expert" map and/or computer user. It consists of a virtual world, which replicates the real-world town of Queenscliff, Australia, an area covering 1.5 square kilometres. In this environment, the user explores the town through a human surrogate, or avatar, for which they can walk, fly, or drive land or sea vehicles around to understand this highly interactive, vivid space. The environment features high resolution GPS gathered elevation data, fully-textured world objects, physics, Artificial Intelligence, real-time lighting and shadowing, spatialised sound, uninhibited movement, atmospheric and particle effects and highly realistic water volumes all coupled together in an online multi-user environment with up to 128 human surrogates.

This chapter provides a brief background to the emergence and interest of computer games for cartographers, what their appropriate adoption for mapping products is and describes examples of the production process of the *Virtual Queenscliff* prototype. *Virtual Queenscliff* is chosen to illustrate the process and factors to consider when developing street-level built GeoVEs using the facilities of a highly advanced contemporary, 3D real-time, desktop game engine.

25.2 Background to the Emergence of a Game Approach

The field of cartography deals with the discipline of producing maps, which in effect are predominately abstract “aerial view” diagrams that accurately portray a geographic region. To understand maps, one must comprehend the numerous symbolisations, generalisations and map conventions. Beyond this, users need to translate this abstraction and use it to visualise a part of the real world, understanding its meaning in a three-dimensional real-world context (Fairall 2002).

Despite this generally spartan overview, cartography has always been about visualization – making aspects of the world ‘visible’. Today cartography is an active participant in fostering fundamental changes to the nature of information representation and how it is used by science, education and society. These changes draw upon and contribute to developments in the relatively new field of geovisualization (or geographic visualization). This is directed toward the integration of dynamic, three-dimensional representations within sciences where geo-referenced representations are critical (geography, urban and regional planning, geology, ecology, hydrology, meteorology and others) for better understanding of how geography ‘works’. Part of the field of geovisualization is Geospatial Virtual Environments interactive three-dimensional computer-generated environments that model or represent geospatial information. Methods and tools for the design of GeoVEs have the potential to fundamentally change the role of maps in science and society (MacEachren et al 1999).

Until recently, the geospatial community provided few examples of applying computer game tools and technologies to represent geographic data. However, recent advances in computer games have created a new platform for academic research (Champion 2003; Nack 2001; Johnston and Cartwright 2000). (Champion provides coverage of the emergence of computer games software as a tool for visualising geography in preceding chapter in this book.) The attractiveness of computer game technology lies in its ability to facilitate simple, super-fast navigation through very large and complex three-dimensional worlds. Moreover, within the past few years, this technology has matured in ways that make it more capable of handling the types of spatial data that were once the exclusive preserve of digital mapping and GIS software (Shepherd 2002). The rationale behind their use is that games offer an intuitive organisation of spatial objects that replicates or reflects the real world. This in turn utilises the user's natural perception and memory of space and spatial relationships (Boyd Davis et al 1996), therefore assisting 'travel' in desktop GeoVEs.

25.3 The Prototype – *Virtual Queenscliff*

The goal of bringing photo-realistic, real-time technology to desktop computers has challenged geovisualization and VR communities (DeLeon et al 2000). The question of the choice of a suitable modelling environment is a trade-off between fulfilling needs, accessibility and cost to the researcher and more importantly, the user.

With respect to a real environment, the game engine must be able to:

- Model a true 3D environment;
- Model landscape as well as architecture;
- Be accessible over a desktop PC;
- Allow the user real-time movement around the virtual environment;
- Allow the user to interact with the model;
- Provide animation and spatialised sound; and,
- Offer powerful graphics quality without diminishing system performance to an unsatisfactory level.

The general solution was to use the most recent 3D rendering engines from an industry that has been dealing with heavy polygon processing on low-end equipment over forty years – the videogame industry (DeLeon et al 1998). It was important to lower the development cost without sacrificing the rendering capabilities, so a gaming-based 3D engine was chosen for developing the application.

25.3.1 Site Location

The prototype models the town of Queenscliff, Victoria, Australia (see Figure 25.1). This historical township covers approximately 1.5 square kilometres and it is located on the eastern tip of the Bellarine Peninsula. It is a coastal town boasting historic buildings, situated on top of a slightly undulating landscape. This location was chosen due to its urban extent, its scenic backdrop and it covers an area that is a reasonable size to model using a gaming engine. Queenscliff contains an historic past that the town has preserved. This eliminates issues associated with temporal mapping such as constantly updating maps due to rapid built environment changes.

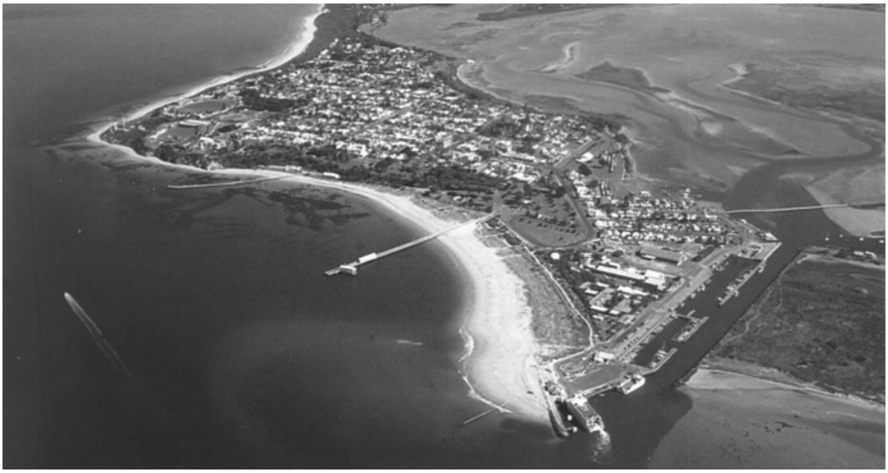

Fig. 1. Oblique aerial photograph of Queenscliff - Port Phillip Bay towards the west.

25.3.2 Choice of game engine

Careful deliberation over the choice of an appropriate 3D gaming engine/editing application was paramount. A comparison was made between several high-end rendering game engines in order to select the visualization tool. The factors used in selecting the gaming engine primarily focussed on how best to overcome the issues related to user discontent with current GeoVEs - ease of use, wayfinding and navigational functionality, graphical and interactive attributes and ability to run on an average PC (Pentium 4, 2.4 GHz processor with a 128 MB graphics card at 30-50 frames per second). Certain attributes additional to user needs were also required, principally software that allowed for customisation of the package for creating representations of reality and actual cost of the development software, as distinct from user software costs.

The best-known subset of game engines comes from the 3D First Person Shooters (FPS) game genre. The most groundbreaking development in terms of visual quality and interaction has been seen in FPS games over recent years. Even today, despite the increasing realism of flight and driving simulators and real-time strategy games, First Person Shooters are still at the forefront of computer graphics development. Currently there are four distinct generations of 3D technology employed in FPS games (WordIQ.com 2005). These extend from first generation planar worlds demonstrated by rectangular grids (*Wolfenstein 3D*) and sector-based plane levels (*Doom*) with sprite objects, through to fourth generation games that seamlessly integrate indoor-outdoor environments, pixel shader-based textures, bump mapping, vertex shaders used for animations, lighting and shadowing. It was decided that an in-depth analysis of 3rd and 4th generation FPS games would identify the most appropriate environment.

An analysis was conducted on several different types of FPS engines - Epic's *Unreal Runtime 2*, id Software's *Quake III*, Conitec Datasystems' *3D GameStudio*, Criterion's *RenderWare* (middleware), *String Collaborative Virtual Environment (CVE)* (an altered version of Garage Games' *Torque* game engine) and Crytek's *CryEngine Sandbox*. A cost-benefit analysis was conducted which yielded an appropriate implementation feasibility for three packages – *Unreal Runtime 2*, *String CVE* and *CryEngine Sandbox*. After an initial implementation of the Queenscliff elevation model and the development of several static objects, it became apparent that the most stable, easiest to learn and most powerful engine was Crytek's *CryEngine Sandbox*. The popular game developed on this engine was *Far Cry*, one of the first fourth generation FPS games engines, launched in 2004. Considering its popularity and recent availability, it provides an excellent active support forum over the Web. Therefore, this engine was chosen to develop the prototype.

25.3.3 *CryEngine* Sandbox

CryEngine Sandbox is a real-time multiplayer environment and editing application written entirely in modular C++. This fourth generation game engine provides proprietary 'Polybump mapping', advanced environmental physics, Lua based event scripting, an autonomous AI system, dynamic lighting and shading, motion-captured animation and total surround sound. The terrain uses an advanced height-map system and polygon reduction to create massive, realistic environments. The view distance can be maximised to 2 kilometres when converted from game units (Ubisoft 2005). This greatly exceeds the feasible view distance available on all other engines to this point in time in which the next best product could barely achieve half this view distance.

Similar to many recent popular games, such as *Return to Castle Wolfenstein, Quake III Arena, Unreal Tournament* and *Half-Life 2,* game publishers have bundled their game engines/editing applications with their game, just as *CryEngine* was bundled with its game, *Far Cry.* As long the creation isn’t built for commercial purposes, independent developers are allowed to explore the many possibilities of the game, which can extend from constructing a map of another game level to an entirely different game altogether – known as a mod, or modification. Software Development Kits (SDKs) are often released for download off the Web primarily as a facility to import user-made models, but also in some cases, the entire game code is released as open source, as in the famous examples of *Doom* and *Quake* (Geitgey 2004). The *CryEngine* world building environment features a simple to use, point-and-click graphical user interface that allows building and previewing of worlds in real-time.

25.3.4 Workflow

Geometry, surface, and sound are authored in external applications and accessible via *CryEngine* to compose a map by working with a range of software. A typical workflow is outlined in Figure 25.2.

The typical workflow begins with the collection of the base data, which is used to formulate the modelling environments. The base data consists of a Digital Elevation Model (DEM), imagery of textures, sounds, buildings and three-dimensional objects, avatars and animated objects. All of the base data needs to go through a process to transform it into an appropriate form that the game environment understands. Textures need to be the correct size (base 2 up to 1024 by 1024 pixels) and tile seamlessly before being packaged into a Microsoft *DirectDraw* (.dds) file.

Sound may further be manipulated in a package such as *Audacity*. *ArcGIS* allows the DEM of the town of Queenscliff to be visualised in three dimensions and an image map generated in preparation for entry into *CryEngine Sandbox*. Buildings, trees, characters, animated objects and other 3D entities were modelled using Discreet’s *3ds Studio Max*. The production of street-level object detail is a painstaking process. Developers of a 3D world should identify important elements to model for high resolution and to simplify and/or duplicate other less important objects.

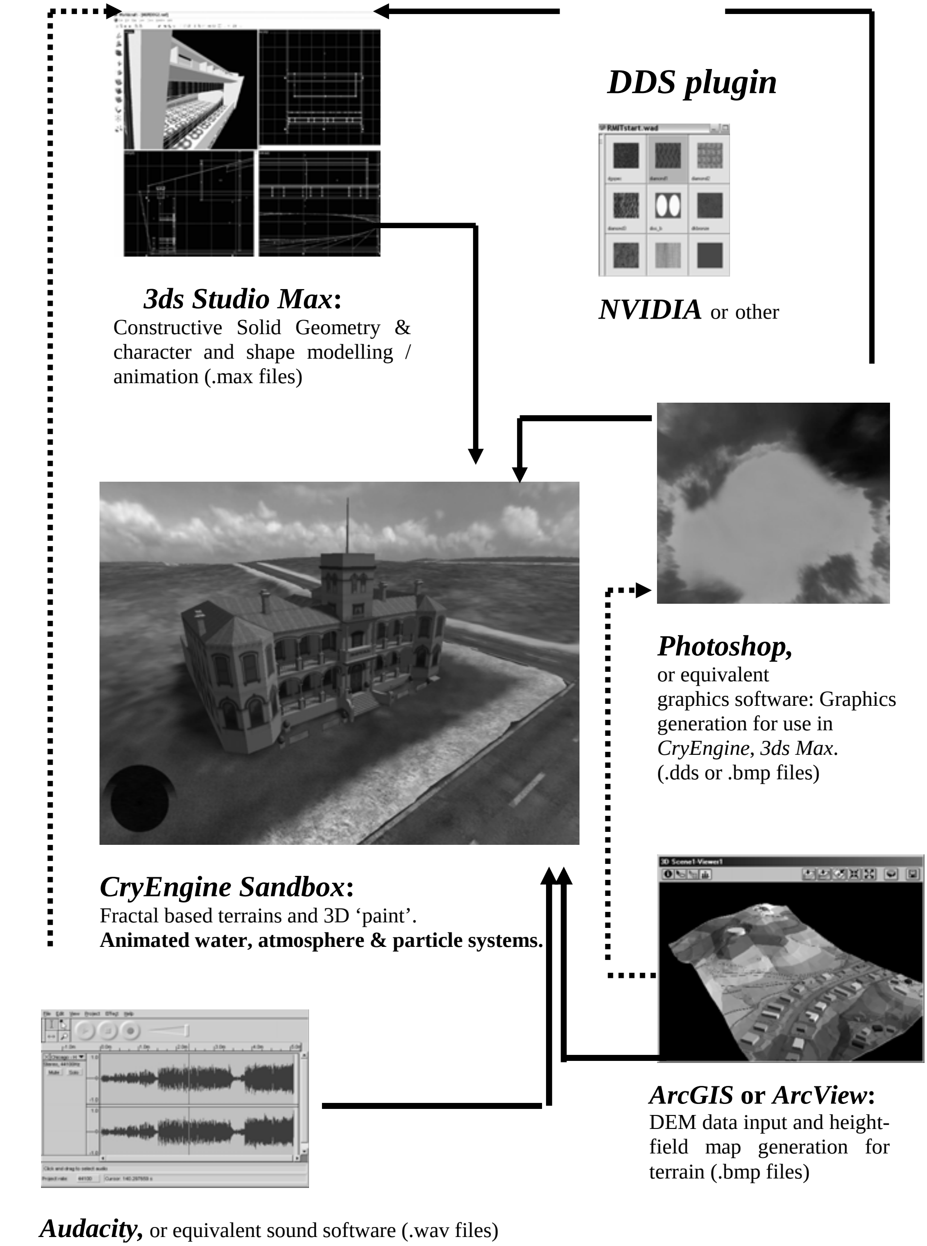

Fig. 2. CryEngine Sandbox workflow (modified from Germanchis *et al* 2005)

25.3.5 The Visualization Environment

After the base data had been processed, it was be imported into the *Far Cry* visualization environment, then recompiled. It is here that the user ultimately visits and explores *Virtual Queenscliff*. The user may view it via CD-ROM or possibly access it via an online multi-person environment (of up to 128 active participants). The appearance of *Virtual Queenscliff* in the *Far Cry* environment is shown in Figures 25.3 and 25.4. It represents a photo-realistic, true, three-dimensional environment, allowing the user to control their navigation within the space. This space may include perspectives not achievable by reality, such as subterranean areas or inaccessible aerial views. Given that this environment allows for real-time movement and interaction, the *CryEngine Sandbox* engine offers a power and ease-of-use that geospatial technologists and cartographers are beginning to widely accept (Moloney 2003).

Fig. 3. Fort Queenscliff

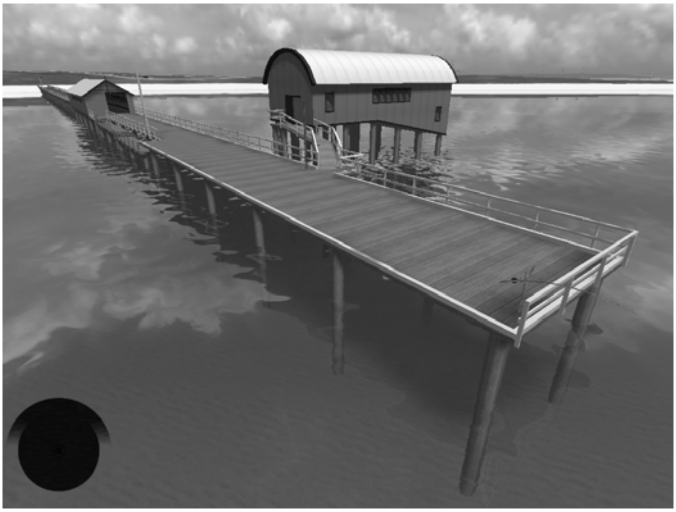

Fig. 4. The main pier of Queenscliff

25.4. Conclusion

Looking towards the future of (multimedia) cartography, it can be said that cartographers have always been quick to adopt new technologies and means of presenting geographic information. With the ever-increasing development of computing technology, especially over the previous decade, the use of multimedia cartographic products that utilise the third dimension are becoming more common. The first generation of games-based multimedia cartographic products presents developers with many challenging issues for producing effective displays and refining methodologies for advancing ‘just’ static maps.

The development of the *Virtual Queenscliff* prototype is still continuing. At this stage, *Virtual Queenscliff* can be considered to be a spatial data store, as it presents most of the town’s spatial data, but lacks the game-style interaction that affords much of the user’s knowledge formation of a core value of computer games. Nevertheless, at this point in development, the game medium offers virtual tourists of Queenscliff with a familiar, alluring environment.

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26 Maps and LBS – Supporting wayfinding by cartographic means

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26.1 Introduction

Within the scope of the project *NAVIO* (Pedestrian Navigation for Combined Indoor-/Outdoor Environments), which is carried out at the Technical University of Vienna, communication methods for pedestrian navigation systems are investigated and tested in order to efficiently support guiding along unfamiliar environments. Before analyzing various multimedia presentation forms, tests are described that approach the subject the other way around by exploring how users actually gain knowledge about their surroundings and how they represent the obtained information to other people. For this purpose route descriptions and sketches of directions by students of the Technical University were collected and analyzed. Additionally a wayfinding test, where people should follow a certain route with the help of different map types, is currently carried out in the area of the university. It is expected that the results of this field test will give information about the most efficient map types for pedestrian navigation systems. In the meantime only preliminary results can be inspected and are represented in this contribution. Furthermore insights from an extensive literature review about multimedia presentation forms are collected and analyzed. Based on these findings theories about multimedia presentation forms, which could be found during an extensive literature review, have been collected and are represented in a subsequent chapter. Here the outcomes and theories of the empiric tests could be mostly verified, confirmed and expanded. Furthermore the topic “landmarks” was treated in more detail.

In this chapter general considerations about wayfinding tasks in urban environments are discussed and diverse communication methods are investigated regarding their potential as route finding aids. Then it describes current efforts at the Technical University of Vienna to prove the effectiveness of certain levels of map abstraction for route communication in pedestrian navigation systems. Different levels of map abstraction are investigated regarding their potential in specific user situations. No detailed results can be presented yet, because the test phase is not finished, but ideas and concepts are introduced and provisional trend results and characteristics are described.

The integration of active and passive landmarks into a navigation system was analysed and possibilities on how to realize their application are discussed. In a final section the major achievements are summarized and discussed.

26.2 Analysis of route descriptions and sketches

In order to obtain information about how people observe and revisualize their environment an experiment that analyzes properties of route descriptions and sketches was carried out. 23 undergraduate students were invited to join an informal test at the Department of Geoinformation and Cartography, where they should take their time and write down 2 different route descriptions and additionally draw sketches of the described paths. The 14 male and 9 female students were therefore asked to describe how they would get from the city centre at ‘Stephansplatz’ to 2 different auditoriums at the Technical University.

The objective of this test was to get an idea about how mental maps are structured and how people describe these depictions to someone who is not familiar with the area in question (The actual efficiency of these depictions was not tested here and should be explored in a different test). Nevertheless the results of this test can provide information about how people project reality in their minds and can therefore help to find an efficient way to describe routes to people:

The north-orientation of mental maps seems to be rather important to many people, probably because it facilitates the comparison to street maps. Indoor maps, on the other hand, are not necessarily heading northwards. Presumably some people seem to save them separately in their minds and recall them from the perspective they would have when entering the building. But, as this test shows, indoor maps do not have a very important status anyway. Most people tend to rely on the logical structure of buildings and on efficient signage and hence neglect to explain indoor paths in detail. None the less this does not necessarily mean that indoor navigation systems should be ignored completely. Many people do not read signs because it is easier for them to ask for directions (Muhlhausen 2002), and even if they do rely on signs, we do not know, if they are distributed by logistic means. Faulty sign design can cause navigation problems in unfamiliar environments. Therefore it is practical to offer another navigation aid than solely signs.

Another interesting outcome of this test concerns the individual view of different people on the same thing. Even though all participants of the test were first-year students of the same faculty and therefore could be defined as one particular user group concerning way-finding abilities in the area of the Technical University, they still have an individual mental map of that area. About 40 % of the students decided to go to the Auditorium Maximum via the main university building even though it is a lot longer than the direct way, but the other 60 % used very individual paths to get to that target. Presumably humans tend to rather use chunks of well-known routes than experimenting with shortcuts, but their familiarity with an area is based on personal experiences and not the same for people of the same user group.

The same holds for the use of landmarks. Apparently a lot of landmarks used in the descriptions derive from personal preferences. A little café or an Italian restaurant is probably just noticeable to someone who has been in there before, and shoe shops might only be of interest to people who enjoy shopping. However, there are some landmarks that are evidently outstanding to most people, like churches, the Opera House, theatres or market places, thus they should be included in every way description. Moreover places, where a change in direction is required, should be handled as landmarks. This conclusion can be drawn from the students who participated in the test, because they instinctively described decision points in more detail than any other location along the way.

Finally it should be remarked, that the test did not give any evidence about gender differences. The number of participants would be too small to draw any conclusions in this respect anyway, but not even insignificant differences could be observed here.

26.3 Wayfinding test: How much detail is necessary to support wayfinding

All candidates who participated in the test had to follow the same route, merely the map source, which was their only guide during the trip, was chosen coincidentally. That way a quantitative analysis could be achieved by measuring the time needed to orientate at decision points and counting the amount of errors during the task. By asking subjects to draw sketch maps of the visited area and by comparing the results of participants who followed different map sources, conclusions about their effectiveness when generating cognitive maps can be drawn qualitatively.

21 people participated in the test, 10 of them evaluated a schematic map, 10 were guided with the help of a simplified street graph and 1 person had to find her way with the help of a typical city map. Recapitulating we can say that even though some tricky paths had to be crossed most people got on quite well with the used map. The required time for the walk was somewhere between 20 and 30 minutes, only one person, who nearly got completely lost was on his way for about 45 minutes. Each candidate was accompanied by the test instructor, who was not allowed to help the person in any way, but followed him/her, stopped the time needed and took notes of unusual and surprising behaviour:

- At the meeting point in front of the Opera House in Vienna, the map was handed out to the participants and their current location and orientation was explained to them.
- About half of the candidates accidentally left the route at different spots, but all except one realised the mistake within 2 minutes and could get back on track no matter which map type their test was based on.
- Surprisingly 14 out of 21 people used underpasses and subways in order to overcome traffic or bad weather conditions even though the used maps did not give any information about them. Some of them did know these subways beforehand and others have never seen them before in their lives. It was remarkable to find out, that none of them had orientation problems the moment they left the underground system.
- 19 participants turned and rotated the map in their hands in order to adjust the map alignment to their current walking direction. Only 2 men, one of them a local and the other a foreigner, left it northbound.
- People who are familiar with the area in question did not have any major difficulties with the schematic map as a presentation form once they got used to the unusual depiction. Only one tourist, who has never been in that area before, had major difficulties to follow the route. 2 other foreigners, who tested the street graph and the topographic map, stayed on the right track without any problems.

Subsequent to the way-finding task, subjects had to draw a sketch of the visited path. As expected the sketches of the local people were quite precise even though most of them navigated along the route with the help of the schematic map, and were all pointing northwards. The outlines of the foreigners, on the other hand, were all pointing southwards, which was the starting direction, and as expected lacked a lot of information. When looking at the sketches of the tourists, who did not know the area at all, we noticed that even though a lot of information and essential turns in direction were missing, most of the corners were rounded and many different angles were used to visualise intersections, just like in the original map. Similar observations could be made when analysing the sketch of the tourist who used the simplified street graph as a navigation aid. The most interesting sketch though was drawn by a foreigner who used the schematic map. Here we could clearly see the influence of the depiction, which only uses perpendicular or 45° intersections. Even a large distortion of distance between two intersections was adapted to the sketch. These results indicate, that the presentation form used when navigating along an unknown route, could highly influence the generation of the user's mental map of the environment. Further investigation on this subject will be carried out and analysed in the near future.

26.4 General design goals of route descriptions

If possible, different routes with different characteristics should be available, so that the user is able to pick the quickest, most scenic or shortest route. That way the system does not need to differentiate between user groups, but the user can pick the most appropriate path himself. Nevertheless not too many options should be offered because that might lead to confusion.

When looking at the route description for the first time, the user should be able to get an overview of the whole route at a quick glance (Radoczky 2003, Hohenschuh 2004). This could be realized by displaying a survey map, where the entire route is visualized at small scale. Only when the user actually starts moving, the scale could be adapted to the current situation. Additionally information about the length of the route and the expected travel time could help the user to decide, whether to move along the suggested path or not. Furthermore the start and the end point of the route should be clearly marked, so that the current and the future location can be easily identified (Agrawala et al. 2000). When moving along the way, decision points, where a change in direction is needed or could happen accidentally, should be clearly indicated, especially if there are no signs available in the area. In case no landmarks exist at critical points, distances between nodes could be mentioned. However, usually the individual length of segments is not required, because humans are generally quite bad in estimating distances. Only in indoor environments this information could be of value, because distances are usually short and assessable.

26.5 Presentation forms

Rating the efficiency of presentation forms for pedestrian navigation system and comparing them in order to find the optimal communication medium is a rather difficult task that can never lead to a simple conclusion. Many aspects influence the result of such an investigation: the user himself, his experiences and personal preferences, the complexity of the respective area, the available technical resources, the availability and quality of datasets, and so forth. Therefore no universally valid propositions can be made - only rough guidelines can be defined. Moreover it is important to mention, that redundancy reveals to be one of the most important properties a navigation system should consist of and therefore various presentation forms should be used simultaneously (Belke et al 2000, Michon et al 2001). Yet exaggerations should be avoided, because even though singular information could cause irritation, too much information can also slow down decision making (Klippel 2003).

26.5.1 Maps

The basic visualisation element when communicating routes should always be a map (Reichl 2003, Thorndyke et al 1982, Kray et al 2003, Reichenbacher et al 2003, Dransch 1997). Even though nowadays new techniques like virtual and augmented reality, animation and many other multimedia tools are imaginable, cartographic representations are still the best form of giving an overview of an area. This acknowledgement applies to all sorts of user situations, like day and night time, fog, rain or snow, quiet and noisy environments, as well as to different user groups, like tourists, natives or business travellers (Reichl 2003). This result implies that even though maps can differ dramatically from the perceived structure of a spatial environment, they can help the user to get a good overview of the area. Precision does not seem to play an important role in the navigation process, as long as essential topological information can be extracted and distortion is not disproportionately high (Denett 1969, Evans 1980, Carstensen 1991).

Instinctively people typically consult maps when they have to find their way through an unfamiliar environment, and when using conventional paper maps as navigation aids, humans tend to twist and turn the map in order to facilitate way-finding and avoid mental rotation (Zipf et al 2004, Radoczky 2003). In that way, a previously northbound map can be adapted to personal requirements, and turning points can be viewed as simple left and right turns. Some tests showed that even with the help of digital maps in navigation systems, the efficiency of way-finding tasks is generally higher when an egocentric map view is used.

Many different types of maps are available today. They are designed in different styles and contain different levels of detail. Usually a lot of information is displayed on a comparably small sheet of paper, which could hinder information extraction when reading the map. But how much detail is actually needed to guarantee wayfinding success? In some situations schematic maps, like the famous London Underground map, contain enough information to easily find a certain destination, but when moving through a city as a pedestrian, these depictions might not contain enough detail to stay on the right track. On the other hand, topographic maps might include a lot of detail that is not needed by the user. Since neither topographic maps nor schematic maps seem to be ideal for communicating route information, because of their overload and respectively their lack of information, a medium of both seems to be the obvious solution. For that reason we suggest switching to a highly simplified graph which is derived from a topographic map and add certain features (like street names, parks, landmarks, zebra crossings, monuments etc.) that are essential for the wayfinding task in question.

26.5.2 Verbal Information

In general, the visual is superior to the textual human memory. Nevertheless different contents can only be described verbally and not with the help of pictures and spatial layouts of environments can be transmitted remarkably well solely by language. Especially for navigation systems verbal aids can be a major mode of communication when describing routes, as long as simple and clear language is used (Fontaine et al 1999). A major difference can be found when analyzing audio and textual information:

Oral route directions should be more concise and tight, because too much detail may pose a problem for the receiver (Lovelace et al 1999). The main advantage of oral information though is the independence of the display that could be hidden in a pocket. The user can walk around without being distracted by looking at the device, which could be a major advantage in the dark or when weather conditions are bad.

With written route directions, on the other hand, the potential of overload on the receiver is less a problem and so longer route directions may be given which can be reread at any time. The advantages of written text are also quite clear: even when the user walks along a busy street or moves in some other noisy environment, he/she will be able to read the text

(Reichl 2003). On the other hand, darkness and weather conditions can make it impossible to read written text on a small screen.

Recapitulating we can say that both, written and audio instructions do not demand a lot of technical resources and are therefore easy to implement (Kray et al 2003). The main disadvantage of verbal instructions though is the fact, that they purely concentrate on the communication of the route and do not convey an overview of the whole area to the user like a visual presentation.

26.5.3 Images

An image can be a very important representation form in a navigation system, even though it is not really valuable as a navigation aid (Radoczky 2003). Users need a lot of time to compare reality with the image, before they walk in the viewed direction. This could be very annoying when being in a hurry, which is why photographs are not used for giving directions. The usage of photorealistic images is only advisable when describing landmarks, and even here we should make sure, that this information can actually help the user to stay on the right track. Therefore photography could be an optional choice that people, who are not familiar with the environment, can choose to gain additional information about a certain object. Beside conventional images panorama views are imaginable as additional information. They provide a better overview of the environment and contain more information than traditional photographs.

26.5.4 Videos

Videos have similar properties as pictures: objects and streets can be directly compared and identified with reality. The main disadvantage though seems to be the speed of the movement in the film, which does not give a lot of time to watch everything in detail (Radoczky 2003).

Altogether the overall potential of videos as route information aids can be rated as very low (Reichl 2003). However, videos can be used as optional information about landmarks and sights.

26.5.5 3D Presentation Forms

Nowadays new techniques allow different types of three-dimensional presentation forms. Still most of them are not particularly relevant until now because they are not fully functional, require too many resources or are too complicated to imply on a large scale. Nevertheless a few possibilities should be mentioned:

Until today the most common way to include 3D models in computer visualisation is the VRML mode. The Virtual Reality Modelling Language (VRML) is a standardised language that can be viewed with the help of a plug-in and enables the depiction of three dimensional scenes. When used in pedestrian navigation systems the user could view the environment on screen from his/her current point of view. Still the efficiency of this depiction can be rated as rather low, because users are not used to this presentation form and are therefore irritated by it (Kray et al 2003, Rakkolainen et al 2000).

A more reasonable alternative for pedestrian navigation systems is augmented reality, where subjects need to wear special glasses that display additional information to the user whenever needed. As soon as this method functions well enough to be commercialised, it could replace conventional systems that work with the help of a mobile device.

Overall we can say that map mode is more familiar to most people and therefore the use of 3D models, which are also very time-consuming in the production process, is not likely to be adapted in pedestrian navigation systems in the near future.

26.5.6 Landmarks

A landmark is understood to be an orientation point in space that helps humans to find their way in an environment (Michon et al 2001, Klippel 2003). Typically it bears a visual characteristic that is unique in the immediate environment or it holds a distinguishing function or purpose or the landmark is located at a central and salient location (Raubal et al 2002, Elias 2002, Sorrows et al 1999). The more distinctive an object is the more relevant it is as a landmark. In route directions landmarks seem to be even more essential than the mentioning of street names.

There are several classifications of landmarks:

A visual landmark shows special visual characteristics, a cognitive landmark is an object with outstanding meaning and a structural landmark is important because of its function or location within an environment (Sorrows et al 1999). Furthermore we can differentiate between local landmarks, which are only visible from a small distance, and global landmarks which are distant landmarks such as mountain peaks, towers or even the sun (Steck et al 2000, Lynch 1960). The most interesting distinction though concerns the function as a positioning tool for the navigation system: An active landmark (as opposed to ordinary passive landmark) realizes when the user moves within its reach and builds up a spontaneous radio contact to the user via an air-interface. That way the system does not need to locate itself all the time, but receives position information from outside. Another main advantage of this concept is the fact that active landmarks do not need to fulfill classical landmark criteria. Even if the object is entirely insignificant, it can be equipped with a sender and support the navigation system (Brunner 2003). For that reason active landmarks can be located at decision points, in narrow streets where GPS systems fail to deliver accurate position information or in areas, where surrounding objects look very alike and lead to confusion. When thinking about where to place active landmarks, it is important to consider, that they should not be too close to each other, especially if positioned indoors. Signal overlap could cause problems in the intersection area. The actual range of the signal depends on the used air-interface: Bluetooth (10-100m), WLAN (100-300m), IrDA (1-3m) or a proprietary radio interface are possible solutions. The connection itself could be implemented in two ways: either the active landmark constantly transmits signals or the handheld device of the user searches for the nearest active landmark.

Six different methods of landmark derivation have been analyzed and tested:

- The first method is based on the concept that landmarks are outstanding because of their content (for example public buildings). All objects that have special names in the database are picked as landmarks, which is quite easy to fulfill. The main disadvantage though is that buildings with special functions are not necessarily visually outstanding and might not be recognised by users as such (Elias 2002).
- Method 2 is based on the assumption that structural distinctiveness often equals visual distinctiveness. For this purpose node, edge and region degrees are automatically calculated in the street graph. If a place degree is higher than the average degree, it is then chosen as a landmark. That way places where more than 4 streets meet and areas which serve as obstacles are chosen as landmarks. Unfortunately most crossing features have a similar node degree which means that there are hardly any landmarks available (Raubal et al 2002).
- In method 3 objects are chosen as landmarks because of their visual, semantic and structural attraction. Each building along the way has to be examined, which is why this method is quite close to reality but also very time consuming and therefore hard to realize (Raubal et al 2002).
- Method 4 is quite similar to method 3. Here landmarks are also chosen by walking through an area and inspecting buildings in more detail, but unlike in the last method, there is no objective basis to the procedure.

Landmarks are solely chosen in a subjective way by the examiner (Brunner 2003).

- In method 5 the visibility of outstanding points is analyzed with the help of a 3D model. This works very well for global landmarks, but could be difficult for local landmarks in case texture is not attached to building blocks. Another disadvantage is the necessity of a detailed 3D model and the time-consuming work on it (Achleitner 2003).
- Method 6 is adapted to the user's needs. In a first step route descriptions by pedestrians are analyzed and landmark types (e.g.: traffic lights) are extracted. Afterwards methods are derived on how to extract these types out of the database. Unfortunately some categories are usually not included in the database which makes results of this method incomplete (Brunner 2003).

Additionally, if a high density of landmarks has been achieved, they could be divided in two classes: landmarks with high or lower importance. According to several tests (Fontaine et al 1999, Lovelace et al 1999), route descriptions usually include most landmarks and decision points near the start and near the end of the route. Therefore objects in these areas could be classified as highly important landmarks, and objects somewhere along the route could be of lower importance and could therefore be left out to avoid information overload (Brunner 2003).

After the specification which landmarks are to be used in the route description, their visualisation in the map should be decided. Again different methods are imaginable (Elias 2002):

- The object is marked with an arrow
- The object is coloured, emphasised and highlighted
- All other objects are simplified in their geometry apart from the target object
- Less important objects are merged
- The object is presented with a self-explanatory symbol

26.6 Conclusion

The search for an optimum way to present route information to pedestrians is a never-ending task that depends on many different aspects. Different users have different preferences, and even the same users could vary their priorities depending on the respective situation. Nevertheless the project *NAVIO* demonstrates, that some principles are valid for the majority of people:

1) It is advisable to offer different (but not too many) routes with different characteristics (shortest, most scenic, …), so that the user can adapt the route to his current situation himself. Sometimes it is helpful to include chunks of well-known routes to guarantee wayfinding success.

2) Landmarks are indispensable when describing routes. They have to be included in every navigation system, unfortunately there is no derivation automatism available yet, that is neither incomplete nor too time-consuming to implement. For that reason Active Landmarks, that do not need to fulfill classical landmark criteria, should be implemented. As soon as the user moves within their reach, the Active Landmark builds up a connection and sends information to the user.

3) When deciding which presentation form to use, it is advisable to consider, that the medium could possibly influence the generation of the user's mental map which could again influence wayfinding success. Besides a map, which should always be the basic visualization element, it is advisable to implement one or (at the most) two additional communication methods. Verbal information is the most obvious communication method and could therefore be used orally or in a written format. Technical resources for text are rather low and therefore easy to implement. Images and videos are impractical as navigation aids, but are useful as additional information about landmarks, and 3D formats are negligible for the time being, because users are generally unfamiliar with these complex formats and because they are very time-consuming to produce. Augmented reality, on the other hand, could soon displace conventional systems.

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27 Adaptation in mobile and ubiquitous cartography

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27.1 Introduction

With new technologies such as mobile computing and mobile communication networks, cartography faces many changes as well as challenges. This chapter looks on the possibilities of adaptation for mobile maps. First it analyses the different types of mobile map usage and general requirements of mobile maps. The concept of Web services is discussed followed by an inspection of Web mapping services and their functionality. Next, important context dimensions in mobile map usage, their interrelationships, and their influence on map visualisation are discussed. Finally, the general facets of geographic information adaptation are presented before the actual adaptation within a map based mobile service is demonstrated through the example of two adaptation methods.

27.2 Challenges of mobile and ubiquitous cartography

27.2.1 A comparison of stationary, mobile, and ubiquitous map usage

Over the last few years numerous new technologies have been adapted by cartography. The first edition of this book had its focus on discrete Multimedia and Internet Cartography. Since hardware has become much more mobile (*mobile computing*) and the Internet has also moved on to a mobile stage (*mobile Internet*) geographic information technology and Web mapping made great advances as the dissemination of digital geospatial data was no longer bound to the desktop platform. New technologies offer the possibility to build powerful supporting tools for the use of geographic information that is attached to almost any everyday activity.

Stationary map usage refers to viewing and manipulating maps on computers that generally do not change the place of delivery. This offers the most powerful computing power, sufficient memory, big displays, stable broadband Internet connections and rich client map applications. Furthermore, the maps are used in a more or less quiet and static environment. However, the access points to map information are limited to a few locations, e.g. home, office, library, where a computer is permanently installed.

Mobile map usage is the use of maps on portable devices that are in most cases owned by the user and are constantly carried around whilst moving. This kind of mobility is sometimes called *terminal* mobility. If the user is moving and uses a service at certain places (e.g. access points like office or home) the mobility is said to be *personal*. The two types are often hard to separate precisely and rather blend into one another. Personal mobility can be seen as ubiquitous map usage where the device could be embedded everywhere in infrastructure facilities. The mobile map usage is affected by changing modes of movement, different and changing activities beside the usage, a potential of distractions, different and fast changing contexts, and harder usage conditions, e.g. a limited time budget. This also implies that there is less time available to watch the display and that the viewing time for mobile maps is much shorter than for classic Internet maps on desktop computers. Limitations in many respects are inherent to mobility. Hence, the map usage on mobile devices faces a very small display size and a low resolution, reduced processing power and memory, short battery lifetime, and smaller Internet connection bandwidth.

Ubiquitous map usage is the use of maps provided and displayed by distributed and embedded computing units. For an introduction to ubiquitous mapping c.f. (Morita 2005). Some of the usage limitations of mobile maps also apply for ubiquitous computing, for example the usage within a highly dynamic environment with its potential of distractions.

The remainder of this chapter will focus on the mobile map usage and ways to improve maps for this delivery mode.

27.2.2 Application scenarios of mobile map usage

In mobile cartography there are two general use cases are technically imaginable. The first use case is a combination of stationary and mobile usage, where the device is first used in a fixed place (e.g. at home) to plan a trip or select relevant information to save on the device beforehand. Later the device is used on the move and extensional information can be downloaded to the device over a wireless network connection (e.g. on a trip). In the second use case the user is mobile and information relevant to the current usage situation is downloaded over a mobile network and adapted due to changes in the environment or due to spontaneous decisions.

Typical scenarios of mobile map usage are car navigation systems, pedestrian navigation systems, electronic tourist guides, and navigation-enabled leisure maps. The typical questions in all scenarios are almost the same: “What does the area look like?” The expectation is to get a geographical overview of the area. “Where am I?” or “Where is an object?” The map is used for orientation and locating objects and people. “What is there?” The map helps identifying objects and their meaning. “What is the state of an object?” The map offers information about the state of objects and events. “How do I get there?” The map offers navigation support by route guiding and presenting information about the route, route conditions and relevant information objects along the route. Depending on the area of use (e.g. urban or rural), the means of transport (e.g. on foot, on skis, by bicycle, by car) and personal preferences users would expect different points of interest (POI) and services to be shown on the map, e.g. sightseeing spots, shops, catering, public toilets, accommodation, public transport network, timetable etc. For further examples of mobile map services, use cases, and mobile maps c.f. (Meng et al. 2005)

27.2.3 General requirements for mobile maps

Mobile maps must be able to effectively visualise and structure information needed in a mobile usage. Among others this includes locations (own or POI) and routes, activity regions and other areas of interest (AOI), landmarks and other anchor points of the real world, objects and persons with qualitative and quantitative differentiation, the state of objects, search results (objects, distances, relationships, relevance, importance, availability, time criticality etc.), events, multimedia information (images, text, sound etc.), relevance, availability or importance as a visual ranking, spatial relationships, and spatial patterns and distributions. The spatial reference information should reflect the characteristic spatial structure in the sense of Lynch (1960), i.e. paths, edges, districts, nodes, and landmarks. Due to the very small display area of mobile devices mobile maps need to be extremely generalised. Moreover their design should be as simple, concise, and self-evident (use of self-explaining, pictogram-like symbols) as possible and should be instantly usable. This means to lower the information density following the primacy of relevance over completeness.

The map elements must not be too detailed and fine and drastically enlarged minimal dimensions have to be applied. Text should only be used where needed and only be displayed with sans-serif fonts.

Mobile maps need to employ emphasising and focussing techniques in order to produce salient map features. At the same time the map rendering must be fast and efficient and allow for dynamic and flexible changes by applying an information layer structure. However, mobile maps not only need to be fast, they also should be affective and emotionally pleasing to produce a positive user experience.

Finally mobile maps must be able to adapt the information content and its visualisation to the user activity and knowledge, the environment, and the system, i.e. mobile maps must be personalised.

27.3 Mobile Internet and mobile map services

27.3.1 Web services

Another important technological step for cartography is the paradigm of Web services that has matured in IT over the last few years and should replace, in part, the paradigm of rather static map products. The basic concept of Web services is a distributed set of software with limited functionality and standard interfaces allowing the inter-communication of different Web services (Cerami 2002). More precisely Cerami (2002) defines a Web service as "… any service that is available over the Internet, uses a standardized XML messaging system and isn't tied to any one operating system or programming language". The concept includes a service provider who describes the capabilities of the service and its interface with the *Web Service Description Language* (WSDL). To register and later to discover services *Universal Description, Discovery, and Integration* (UDDI) is used. *Simple Object Access Protocol* (SOAP) is utilised to encode messages for communication between the services that are usually transported over HTTP. Web services can be differentiated according to their level of functionality. Basic or low-level services offer simple functions whereas complex or high-level services combine several functions within one service. One possibility to achieve more complex and enhanced functionality is the bundling of basic services. For this purpose the Web service architecture provides a mechanism called service chaining where the response of one service acts as an input for another or other services.

27.3.2 OGC Web services: Web Map Server and Web Feature Server

Geoservices or geospatial Web services are an instance of Web services that provide, manipulate, analyse, communicate, and visualise any kind of geographic information (Meng and Reichenbacher 2003). The ISO/TC211 provides under the ISO 19101 standard a classification of geographic services with the Extended Open Systems Environment (EOSE) model for geographic information. The services called *portrayal* (ISO 19117) are of particular interest. The Open Geospatial Consortium (OGC) names the same service type *presentation service*. The OGC has proposed a framework for geoservices, named Open Web Services (OWS) that aims at standardising the different kinds of geoservices. Likewise OGC defined the Open Location Services (OpenLS) specification that involves a set of Core Services. For Web mapping purposes the OGC has defined several specifications such as Web Map Servers (WMS), Web Feature Server (WFS), Web Map Context (WMC), Styled Layer Descriptors (SLD), and Geography Markup Language (GML).

27.3.3 Functionality of mobile map services

Both the WMS and the WFS services implement a *GetCapabilities* request that responds with a description of the service and the kind of data it offers. WMS is aimed at serving maps based on user requirements encoded in the parameters of a *GetMap* request. The most important parameters are the image format of the map, the layers to be shown in the map, the size of the map, and the geographic extent of the map. In most cases the map will be sent back as a raster image, but the specification also allows for maps encodes as Scalable Vector Graphics (SVG). If the WMS supports SLD (definitions of how layers should be symbolised) additional requests such as *DescribeLayer*, *GetLegendGraphic*, *GetStyles*, and *PutStyles* are possible.

The task of WFS is to deliver the actual geospatial features instead of a symbolised map. The *DescribeFeatureType* describes the type and attributes for a selected feature. The desired features are accessed by a *GetFeature* request that can incorporate a Filter expression based on the Filter Encoding Implementation Specification (OGC 2001). The features returned by the WFS are encoded in GML and can be further processed, for example transformed with Extensible Stylesheet Language Transformation (XSLT).

27.4 Mobile geographic information usage context

27.4.1 Dimensions of mobile map usage context

The significance of context-awareness for Location Based Services (LBS), mobile cartography, and mobile Web services has recently been underlined by many researchers (see for example Dey and Abowd 1999; Nivala and Sarjakoski 2003; Reichenbacher 2004; Schmidt et al. 1998). Context-awareness in a map context sets the foundation for possible adaptations of the maps to the context at hand. Apart from the obvious spatial context there are other dimensions in mobile usage situations that shape the usage context and can be partly derived from location. These dimensions are situation (location and time), the user, the user activities, the physical environment (e.g. weather conditions), information and system (network bandwidth, device characteristics).

Certainly, the most important context dimension concerned with mobility is *location*. Location information is related to a position and denotes different kinds or levels of granularity (e.g. point coordinates, addresses, place names, regions) with distinct ranges of values. The granularity required for specific activities or information demands varies substantially. LBS apply the location context to filter information to the user's current location.

Time is almost as important as location. For time information the same granularity differences as for location can be identified. Time could for instance represent the exact system time, the day time, or the season. This temporal granularity affects the way the system or service can react to a user request. Location and time together constitute the situation.

Although some authors see the modelling of the *user* as a matter of its own, here the user is regarded as one of the context dimensions. As for the other dimensions, for the user in particular the question arises which characteristics need to be modelled or, in other words, which attributes are important and relevant for the mobile geographic information usage and the adaptation to it. Such information includes identity, preferences, knowledge and skill.

Activities are always embedded in a specific context and thus belong to the context. For a given context it is important to know which activities are possible, allowed, or appropriate, i.e. to model rules and constraints in specific contexts. Some activities form typical patterns regarding space and time (e.g. locations, sequence, and frequency) and can be associated with particular geospatial objects. McCullough (2001) proposes a preliminary typology of everyday ‘situations’ relevant for mobile services in a rather qualitative manner. He argues that design which is considering these activities will be more usable. The four main ‘situations’ are at work, at home, in the town, and on the road, each associated with activities such as collaborating, watching, cruising, eating, shopping, sporting, touring, driving, walking, etc. (see also Fig. 1).

Information as a context dimension in mobile cartography describes the context of objects inside the spatial context scope and co-located geospatial objects. Discrete geospatial objects can be modelled with the collocation approach, i.e. the presence of a geospatial object could be deferred with a certain probability from the observation of another geospatial object. Clearly the attributes and states of these co-located geospatial objects are of utmost interest, since they considerably characterise the context.

The characteristics of the *system* in use constitute another important context dimension that must not be underestimated. Information about the device and network in use, their characteristics and functionality and the available infrastructure have a substantial influence on the way information should best be transmitted and visualised.

27.4.2 Relationships between context dimensions

Of course the individual context dimensions cannot be considered independently. It is important to analyse the different relationships and interdependencies among them (see also Fig. 1). Certainly most relationships exist between the user and the other context dimensions. The user wears the mobile device, i.e. the determined device location is assumed to be the user’s location. Furthermore the user has access to the device and its functionality. Many system conditions (e.g. access to high speed network, lower or higher bandwidth, GPS signals shadowing) depend on the device location. The location also defines the current temperature, which has a great influence on the battery life. Activities are always situated in space and time and differ for distinct user roles. Location and time restrict certain activities, influence the possibility or meaningfulness of activities, or change their quality. Depending on the time locations can have a different meaning, importance or accessibility.

27.4.3 Influence of context factors on mobile map services

In mobile map usage not all contextual factors have any or a significant influence on the visualisation of geospatial information. Figure 1 outlines the relationship of the most important factors and their possible values.

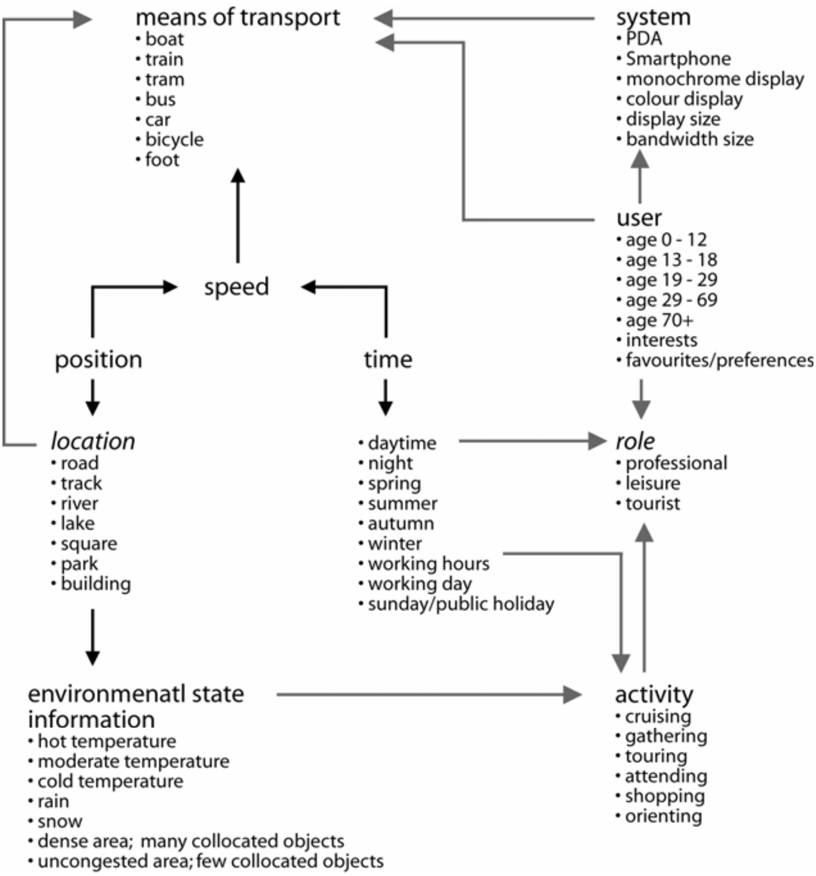

Fig. 1. Possible values of context factors and their relationships

Several context dimensions can have a significant impact on mobile maps. The season could for example influence the features shown in the map and their symbolisation. The age can influence the style of symbols and their size. The current activity and the user role influence the map content, the map style, and the map graphics. (For further details and examples see Meng et al. 2005; Nivala and Sarjakoski 2003; Reichenbacher 2004).

27.5 Adaptation of geographic information

27.5.1 Adaptation principle and adaptation process

Adaptation in the context of information systems refers to ability of flexible systems to be changed by the user or the system in order to meet specific requirements. The prerequisite is that the system is adaptable at all, i.e. that it can be changed in some way and that adaptation is in principle possible. An adaptive system is capable of changing its own characteristics automatically according to the user's needs (Oppermann 1994). An adaptable system can be changed by the user in an interactive way, i.e. by explicit interference, whereas for adaptive systems the interference is implicit. The basic structure of any adaptive system is based on an adaptive object that is adapted to an adaptation target through an adaptation method (Fig. 2). The adaptation method will need information about the adaptation target to work successfully.

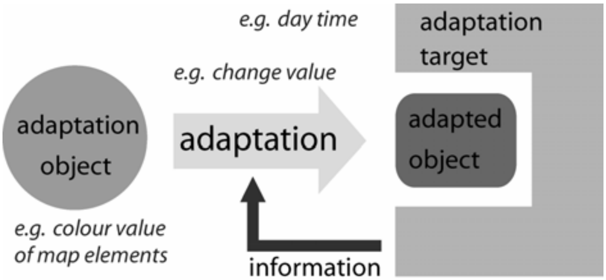

Fig. 2. Basic adaptation principle

The transfer of the general adaptation concept to the field of mobile cartography has been investigated by Reichenbacher (2004). Figure 3 depicts the general framework of mobile cartography. In the mobile usage process geospatial information is demanded by the user and visualised through the mediation of a user interface. These three items constitute the objects that are adaptable to the adaptation target, i.e. the mobile usage context, by applying different adaptation methods. The adaptation objects will be analysed in more detail below and the adaptation methods will be discussed in the next section.

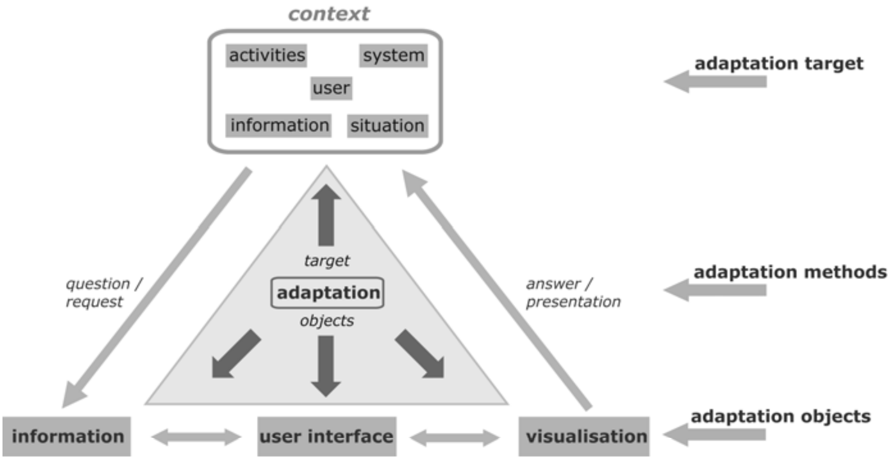

Fig. 3. The general mobile cartography framework with an adaptation component

27.5.2 Adaptable objects in mobile map services

In mobile cartography the set of objects that can be adapted is quite vast. Fig. 4 shows these adaptable objects with possible values, further divided in more global (e.g. map style) and local (e.g. symbol size) aspects.

The user interface is basically determined and constrained by the device in use. For instance, a PDA with a touch-sensitive screen allows for other interactions than a Smartphone with a keypad, thus the interaction style probably needs some adaptation. The interactive map functions' availability or granularity could also be adapted. Certain functions need to be hidden or aggregated to more coarse functions. Furthermore the interaction mode can be adapted, i.e. depending on the current function the interaction mode is changing (e.g. from pointer to text entry). The geographic information can be adapted in different ways. Selecting, adjusting the amount and level of detail (LoD), classifying, and grouping information are all forms of information adaptation. Another form is the adaptation of information encoding due to capabilities of devices or constraints of the mobile network (e.g. bandwidth). However, most important to mobile cartography is the adaptation of the visualisation. Map section and map scale are global objects adaptable in the visualisation. The visualisation method used, i.e. graphics or photo, 2D or 3D, photo-realism or abstraction can also be an object of adaptation. A landmark could for instance be displayed as an abstract symbol or a small photograph depicting the object. Dimension is another adaptable object in the visualisation process. As in generalisation, it refers to the fact in which dimension a feature is represented, e.g. a city as an area or a point element. Last but not least symbolisation parameters (graphical variables) and text attributes are adaptable. It is obvious that certain objects are constrained by or dependent on others. Not all of these potentially adaptable features are equally adequate for adaptation.

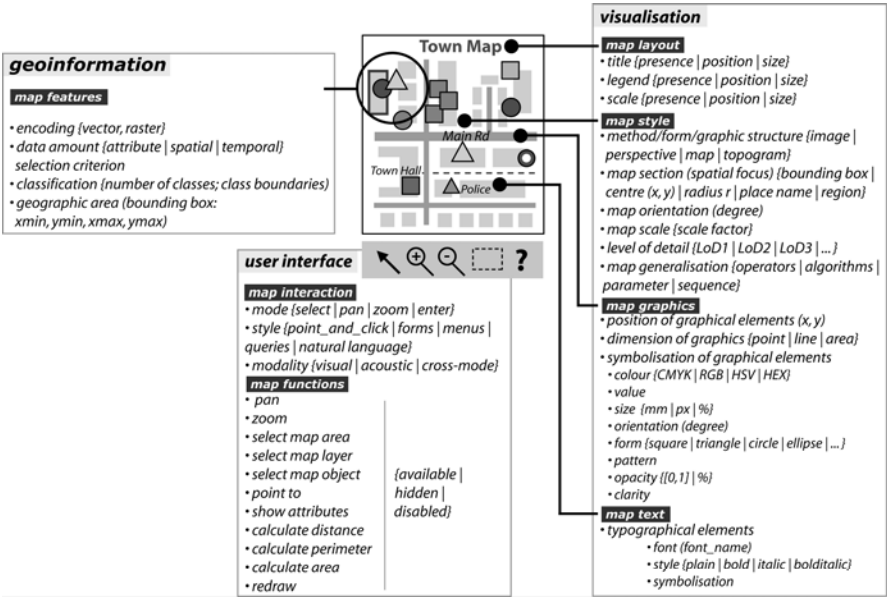

Fig. 4. Adaptable objects in maps

27.5.3 Adaptation methodology and implementation concepts

Methodologically the adaptation in mobile cartography occurs on different levels: content, presentation, user interface, and technology. Either all or parts of content, user interface, presentation form or encoding of a map can be adapted to the context factors identified above. Technically the adaptation can be implemented within a mobile map service as described by (Reichenbacher 2004). The client sends context information along with a request to the service. The service evaluates the context parameters and again sends a suitable request to a WFS, which in turn delivers features encoded in GML that can be transformed to SVG encoded maps through XSLT. This approach offers various possibilities of adaptation into the service. First, filter operations can be included in the WFS request and second the XSL transformation allows for adaptation of the map graphics by changing the values of the graphical variables which are mostly easily codable as SVG elements.

27.6 Adaptation of geographic information in mobile map services

27.6.1 Adaptation methods in mobile map services

The challenge for modern cartography lies in supporting as many people as possible with mobile usage of geographic information, meeting their specific information needs and personal preferences, and in offering them tools and solutions to overcome or at least compensate for some of the technical limitations of mobile devices. Small display devices especially pose an immense generalisation pressure. However, generalisation methods alone are not sufficient to assure the fitness for use required in mobile geographic information usage situations. In addition to a rough generalisation specific adaptation methods need to be applied in order to provide users more relevant, detailed, and accurate and thus adequate information meeting their needs better.

Based on the context dimensions described in section 3 Reichenbacher (2004) proposes a first attempt to incorporate context parameters in the process of *ad-hoc* map design and generation. The parameters are used in controlling the adaptation of the geovisualisation, i.e. the fitting of the adaptation objects identified above to the adaptation target, i.e. the context dimensions. Thereby some of the following methods of mobile map adaptation are applicable:

- select map features (filters, e.g. based on user profiles) to reduce the map content and the information density (only few feature classes; limitation to selected, important objects and information);
- prioritise information based on relevance;
- substitute equivalent presentation forms (e.g. symbol through picture);
- switch between predefined design alternatives (e.g. map symbol styles);
- change presentation; (re)change symbolisation (e.g. different opacities for relevance) colour depth reduction; colour to greyscale; change dimensionality (e.g. area to point);
- (re)configure map components (e.g. different base maps or scales for different purposes or movement speeds); dynamic composition of layers for the base map (e.g. with or without public transport network);

- adapt the user interface (reducing degrees of freedom for interactivity); and
- change encoding (e.g. vector to raster)

In the remainder of this chapter two adaptation methods for mobile maps are discussed in further detail: the configuration of map components and the change of the map symbolisation.

27.6.2 Configuration of map components

An intelligent structuring of geospatial data allows for decomposing a mobile map into several single map components. In the simplest way geospatial information is separated into two groups: the core layer is constituted by the base map including the geometric reference, (e.g. buildings, major roads, rivers and so on), maybe enriched by public transport network and major landmarks. The second group are the superimposed thematic layers of information that will be changed more often and maybe dynamically (e.g. POI, routes, point symbols, additional map labels, dynamic landmarks, geolinks, routes, directions, events, weather, traffic information etc). The base map and the dynamic map content could be stored in separate SVG (Scalabale Vector Graphics) documents. These additional layers can be referenced from the main map, generally the base map, as SVG fragments using XML (eXtensible Mark-up language) referencing mechanisms.

27.6.3 Emphasising highly relevant POI symbols

Probably the most powerful adaptation method for mobile maps is the changing of symbolisation. This is for example applied to highlight important features in order to emphasise their importance or relevance. The cartographic toolbox is rich in techniques for putting visual emphasis or focus on important features. Some examples are listed below and also illustrated in Figure 5:

- highlighting the object using a different (maybe more luscious) colour (*colour, hue*);
- emphasising the object using brighter colours (*value*);
- focussing the object while blurring the other objects (*clarity*, *focus*, *crispness*);
- decreasing the opacity of the object against the other objects (*opacity*, *transparency*);

- emphasising the symbol size or the size of the outline (*size*);
- enhancing the contrast between the object and the background (*colour*, *value*);
- enhancing the LoD of the object against that of the other objects; and
- animating the object (blinking, rotating, increasing/ decreasing size)

Fig. 5. Examples of feature emphasising techniques

Moreover dynamic variables such as *duration*, *frequency*, or *order* can be applied to animations of the classic graphical variables to attract the user's attention. For these kinds of examples like colour transformations, symbol rotation or blinking symbols, or increasing and shrinking, as well as further examples of application of different graphical variables visualisation of POI and events see (Reichenbacher 2006).

27.7 Conclusion and outlook

This chapter analysed the different kinds of mobile map usage and explained the adaptation concept in the field of mobile cartography. It has been demonstrated that the combination of different context dimensions has several advantages over a more one-sided approach as for instance in the case of LBS. The sole use of location as context parameter does not always lead to value-added solutions. A more comprehensive approach that includes time, personality, user activity, co-located information, etc. has a better chance to enhance the overall relevance of a map based mobile service and thus the user satisfaction. A precondition for a successful implementation of more comprehensive, adaptive mobile map based services is the formalisation of context, cartographic knowledge, as well as rules and constraints governing them.

Hence, further research should focus on modelling and formalising context for mobile cartography, the design and refinement of adaptation methods along with establishing rules and constraints for governing the adaptation process. Whilst this chapter concentrated on the adaptation of presentation objects there is also a strong need for investigating the adaptation of the user interface of mobile map services. And finally, a careful testing of the usability of different adaptation solutions in practice is indispensable.

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28 A Real-World implementation of Multimedia Cartography in LBS: The Whereis® Mobile Application Suite

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28.1 Introduction

Working with the world's leading wireless carriers and service providers, Webraska Mobile Technologies developed a unique location-based services environment called the *SmartZone Application Platform* that is able to link a range of discreet applications together in order to deliver an optimal user experience and drive both carriage and usage based revenues. In 2003, Webraska licensed the *SmartZone Application Platform* to Sensis, Australia's leading local advertising and search company, who has subsequently developed a range of location-based applications based upon the key elements of the platform. This chapter details the Sensis applications and highlights key learnings from their commercial deployment. Particular reference is made to the first Australian 3G location-based application and the improvements 3G technology has brought to the offering.

28.2 Location

Location is the most fundamental element of all human movement. It is required to know where one is, and where one can travel to. Location-Based Services (LBS) coupled with multimedia (i.e. combining textual and graphical information (including maps) and interactivity), various delivery platforms and wireless devices aims to provide solutions to these challenges as well as a host of other location oriented services. The success of ubiquitous online mapping and location relevant products and their inherent ability to provide real-world and relevant spatial solutions to everyday users, has resulted in much wider distribution and usage of maps; perhaps the greatest increase in map usage since Gutenberg's printing press in the mid-1400s. However, the wireless Internet market has yet to experience the usage and growth that its bulky connected counterpart has. This is due in part to deficient supporting technologies (platforms, devices, networks, speed, etc.) and their limitations. The much-hyped platform of its time, WAP (Wireless Application Protocol), developed in the mid to late 1990s failed to deliver in early 2G environments. It failed at both an application level and in growth and acceptance, largely due to primitive display formats and devices, extremely lengthy download times and prohibitive costs. Over time, technology marginally improved, but later 2G devices and then 2.5G (enhanced 2G) devices still suffered similar shortcomings, remaining inherent of the issues that plagued earlier environments. However, these devices benefited from much improved display characteristics, such as colour displays and slightly improved screen sizes and resolution capacities. Recently, 3rd Generation (3G) devices, the natural evolution from 2G, have been thrust upon the marketplace, and at last may provide the foundation by which the original goals of the WAP platform can be achieved. Cartographers, designers and developers have a wonderful opportunity to adopt and exploit the 3G technology to aid in the provision of mapping solutions by the most efficient means. In Australia, mobile mapping applications are still in a relative state of infancy, however the promise of and enthusiasm behind applications such as those in the *Whereis*® Mobile suite of applications have the potential to shape the future of mobile mapping in this country and throughout the world.

28.3 Webraska Mobile Technologies

Webraska Mobile Technologies (Webraska) was incorporated with the sole intention to develop and deploy location-based applications on a worldwide basis (http://www.webraska.com). Webraska's position as industry leader began with the pioneering vision that integrating mobile telephony, the Internet and emerging technologies for the automatic location of mobile devices would open new markets and revenue streams for large wireless service providers, and provide tremendous productivity gains for enterprise customers. At that time, 1996, the Internet was still in its infancy; its usage was set to increase dramatically. But it was tied to a fixed location. Mobile telephony was also booming. But network operators were aware that voice-generated revenues would soon have to be complemented by income from data services. Building on this innovative vision, Webraska established itself as an international leader, filing several patents and launching the world's first real-time mapping service on mobile phones in 1998 with the French operator SFR (Société Française du Radiotéléphone). Webraska subsequently cemented its leadership position by:

Developing the most comprehensive product portfolio in the industry, spanning geospatial middleware, application development environments for location-based and telematic services, wireless navigation applications, professional services and hosting. In 2005 it had a rich set of more than 20 ready-to-deploy LBS applications such as maps and directions, traffic alerts, yellow pages, and community-based finders; and

Deploying more location-based services in more continents than any other LBS solution provider. In 2005 Webraska middleware and applications powered the location-based services of over 20 wireless carriers across 4 continents.

In September 2001, Webraska's market position was further strengthened by a merger with California-based AirFlash, a leading provider of location-based technologies and services for network operators and wireless service providers, with viral LBS applications successfully at the time launched using WAP and SMS with leading carriers such as Viag and E-Plus in Germany and Orange in the UK. It was through this merger that Webraska unlocked one of the key secrets when deploying consumer location-based applications; that being that no one LBS application will render success and that applications must be linked through what is known as context sensitivity in order to promote strong repeat usage.

28.4 *SmartZone Application* Concept

When observing any consumer LBS deployment, it is important to note that location will underpin a raft of services across any wireless portal. Of course, operators will conveniently refer to and promote an individual application, but to only deploy and market an individual application without either linking location amongst services provided or in relation to geographical context, will forgo much of the power of location and the wireless Internet. A good analogy is that LBS will be like the Internet; not so much an application as a 'killer enabler'. Webraska's 'killer enabler' is the *SmartZone Application Platform* that governs everything related to bringing discreet LBS applications together into a tightly integrated, highly individual continuous user experience. It helps application components to work together, building user knowledge to assist the applications in maximising that knowledge and quickly serving the user. Increasing user loyalty becomes more prevalent as the platform augments the user's service activity history with additional relevant services.

The *SmartZone Application* Platform enables continuous navigation by making it extremely easy to wire applications together, and via the prebuilt 'Actions' menu, it allows users to perform additional queries relevant to the results they received in the application they were using. Through the Platform, *SmartZone Applications* users also have access to a variety of common capabilities to enable a compelling user experience. Applications can access available information through to making decisions about content applicability, and in what order, for display to the user. Figure 1 demonstrates how discreet LBS applications can be linked through context sensitivity so as to bring maximum value within the total LBS session.

Fig. 1. Webraska's discreet Location-Based Services concept

Working with the world's leading wireless carriers and service providers to deploy the first generation of Location-Based Services (LBS), Webraska quickly understood that it would be many years before location was adopted and it became ubiquitous. Many of Webraska's early LBS applications had to be deployed on 2G (circuit based) networks with black and white devices and SMS (Short Message Service) delivery. The resulting user experience tested the patience of even the most techno savvy early adopter and carriers were acutely aware that, until both devices and networks improved, the majority of subscribers would continue to use their mobile phone for voice communication only. In the early years, location was a niche application that needed to generate significant ARPU (Average Revenue Per User) across a relatively small number of potential users in order to be viable and for services to remain active. It is with this knowledge that Webraska developed the *SmartZone Application Platform*, such that, until both devices and networks improved the length of any LBS session and the value gained from that session would be enhanced from linking a number of contextually relevant LBS applications together in a seamless chain. Indeed, until the advent of the much publicised 3G networks and devices, the *SmartZone Application Platform* was Webraska's solution for providing a viable suite of LBS applications.

28.5 *SmartZone Applications* in Australia

Up until the end of 2005, the first and only implementation of the *SmartZone Applications* paradigm in Australia is owned and operated by Sensis Pty Ltd, the wholly owned subsidiary of Telstra Corporation Limited and Australia's leading local advertising and search company. Sensis' location and navigation brand, *Whereis*®, offers various spatial products including the hugely popular and successful online mapping and directions Web site Whereis.com, provided an ideal foundation for the provision of location-based services over a wireless network. In 2003, Sensis licensed Webraska's *SmartZone Application Platform* to deploy a range of LBS applications that leverage their extensive local information source incorporating: the *White Pages*® and *Yellow Pages*® directories; the *CitySearch*® lifestyle site and the *Whereis*® location and navigation database. The resultant platform is known as the *Sensis Wireless Platform* (*SWP*) and is today powering the *Whereis*® Mobile suite of products for wireless devices; a highly interactive service providing location-based functionality Australia-wide. The implementation of SmartZone via the *SWP* identity utilised the knowledge and experience gained from the delivery of similar products across Europe and throughout the rest of the world. The applications that comprise *SWP* include *Whereis*® Maps (map finder), *Whereis*® Directions (directions finder), *Whereis*® Nearby (nearby finder) and *CitySearch*® Nightlife (event finder) – discussed in further detail in the following section. *SWP* was initially implemented in WAP format and experienced ongoing usage since October 2004. Since that time, *SWP* has undergone various guises and the inclusion of added network support for formats such as, *i-mode* (deployed November 2004) and 3G (deployed October 2005).

28.6 *Sensis Wireless Platform* (*SWP*)

As previously noted, the *Sensis Wireless Platform* provides location-based applications to mobile devices based upon the similar functionality made available via the Whereis.com Web site. Here, users can obtain maps of any location or find directions to and from any given locations within Australia (see Fig. 2 below). Similarly, the *Sensis Wireless Platform* enables the exact same functionality, albeit on a much smaller screen size than its desktop counterpart, but with the added freedom of access whilst being actively mobile. In *SWP*, the *Whereis*® Maps application allows users to enter an address (street, intersection or suburb location) and then display a map of that location, whereby maps can then be manipulated by pan or zoom. One key feature of the *Whereis*® Maps application is the auto-location positioning functionality, whereby the street location of a mobile device can be returned upon request. The 'auto-location' is calculated using a complex algorithm based on the mobile's cell location at the time of the request, returning the nearest major road intersection as the location. Similarly to its desktop counterpart, the *Whereis*® Directions application provides route calculation (or directions) functionality between address locations. Once the departure and arrival locations have been provided (a route with a stop-off is also possible), a route can be calculated using either car (with the use of toll roads if desired) or walking modes of transportation. The platform also supports the ability to calculate a route based on traffic flow, calculating the fastest route to the destination by diverting users around congested areas (although this data is not currently available in Australia). Once calculated, a route overview map is displayed to complement the list of turn instructions, with each instruction detailing the road name travelled on and how far (distance) before the next maneuver. Maps of individual turn instructions may also be displayed.

Fig. 2. Appearance of the Whereis.com mapping (pictured) and directions service (http://www.whereis.com)

Where the *Sensis Wireless Platform* differs from the Whereis.com Web site in providing location and direction finding applications, is in the provision and integration of other complimentary services. These other location relevant services contributing to the *SWP* suite of applications include a nearby finder and an event finder. The nearby finder, *Whereis*® Nearby, provides access to various Places of Interest (POI) or "landmark" information (e.g. ATMs, restaurants, petrol stations, etc.), including *White Pages*® and *Yellow Pages*® directory content, which can be found nearby to your current or another location. Returned results can then be selected to display further information about the POI (e.g. address, telephone number, etc.), from which directions to that location can be obtained, POI details can be sent as an SMS to a friend, or a phone call to the POI can be initiated. Similarly, the event finder, branded *CitySearch*® Nightlife, provides access to event (e.g. concerts) and venue (e.g. nightclubs) information around any given location for today, tomorrow or at some other time in the future. *CitySearch*® Nightlife is unique in that was the first event finder application developed and deployed by *SmartZone Applications* technology anywhere in the world. Events can be searched by date or category, or selected from a "What's Hot" listing of the hottest events in your capital city. As with the nearby application, individual results can be viewed for further information and an action applied (i.e. find venue, get directions or send as SMS).

Whilst all four applications alone provide wonderfully useful functionality for users, it is in the highly dynamic, interactive, and fused nature of the *SWP* service that sets it apart from competing applications or services. *SWP* enables users to switch between and use information from other applications within the suite, carrying across relevant information on-the-fly (dynamically). For example, a user may have found a map of an address, but may now want to get directions to or from that location. Similarly, a user may have found a restaurant but may wish to find a nearby bar or ATM. These dynamic functionalities, referred to as ‘Actions’, fully exploit the concept of an application suite, providing a broad range of functionality without having to subscribe to a multitude of applications for related information. The full gamut of options supported across the entire application suite include finding a map, finding directions, finding nearby POI (Point Of Interest), as well as the ability to send results as an SMS or save the result. Furthermore, it is not only the intermingled nature of the technology that provides a beneficial experience to the user, but also personalisation attributes. Users can enter and save predefined locations called “My Places” which may be frequently used in the future, such as Home, Work or the Local Pub, allowing for quick searches by saving time entering address information repeatedly. Additionally, the last ten addresses entered whilst using the application are stored in a ‘Location Log’ which may contribute to speedy movement throughout the application. It is in the added features of the platform which make it so powerful and uniquely simple to access such a wide range of information and services so easily and quickly.

In regard to device support and access to the platform, all devices supported by Telstra for the WAP, *i-mode* and 3G networks are able to use *SWP* (i.e. the *Whereis*® Mobile application suite). The support of devices alludes to devices that have been manually integrated, whereby, the user interface has been optimised for display, based on specific characteristics that may be inherent to those particular devices. However, generic displays exist to suit devices that may connect to the platform in the case of any unsupported devices, in the optimised integration sense. Further to this, a major feature of the platform is in its ability to support multiple delivery mediums and device types. *SWP* applications can be displayed via the Web (desktop) as well as a host of mobile devices including PDA (Personal Digital Assistant), WAP and 3G. Although multiple delivery mediums were inherently supported by the *SmartZone Applications* Platform, *SWP* was initially only deployed in WAP format with 2G phones in mind, by Sensis on the Telstra portal in October 2004. Since that time, the WAP service has undergone a number of revisions to refine the user interface, also including a redesign of the entire application suite for provision of the service in *i-mode* format (2.5G or simulated 3G). This format, an enhanced version of HTML for wireless Internet developed by the Japanese mobile communications company NTT DoCoMo, was made available by Sensis on Telstra's *i-mode* portal since its launch in November 2004. The *SWP* user interface underwent a subsequent revision and redesign in preparation for the delivery of Telstra's 3G network in October 2005, discussed in further detail shortly. It is in this natural progression of technological growth in devices and delivery platforms that has given rise to increased mobile usage, mirrored by improved user interface design and usability due to these advancements. The graph in Fig. 3 illustrates this concept.

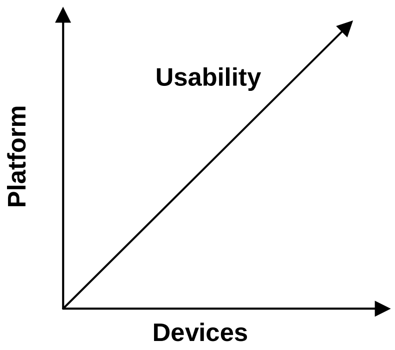

Fig. 3. Increased usability of applications and interfaces as devices and platforms

28.7 *SWP* for 3G

The implementation of *SWP* for 3rd Generation (3G) devices borrows heavily upon the *SWP* implementation deployed for earlier devices, which were built under the WAP (Wireless Access Protocol) premise (Note: the 3G *SWP* version does not include the *CitySearch*® Nightlife application). The term '3G' refers to the next generation of mobile devices following on from 2G (digital) and 1G (analogue) predecessors. The implementation for 3G facilitates access to and display of feature rich content and complex applications, all at a much faster speed than previously existing networks. Although content (data) and speed of delivery are absolutely paramount to the delivery of a useful and up-to-date application, it is the way in which that information is communicated and the key functionality it provides that often determines the success of the both the application, and the comprehension and usefulness of the information to the user. Cartwright *et al.* (2004) reiterates this point, explaining that simply producing visualizations is not enough and that what is displayed must be based on the appropriateness of information as to meet user's needs and ensure efficient usage. The 3G delivery platform, which supports XHTML (eXtensible HyperText Markup Language) for display of information, enables much greater control of page layout and elements, consequently providing the means for effectively designed interfaces. It is in this capability to flaunt the features of XHTML (specifically layout elements), whereby, the contemporary 3G version of the *SWP* suite of applications differs from its similarly dynamic yet more primitive WAP version, whilst not exploring any overly new functionality.

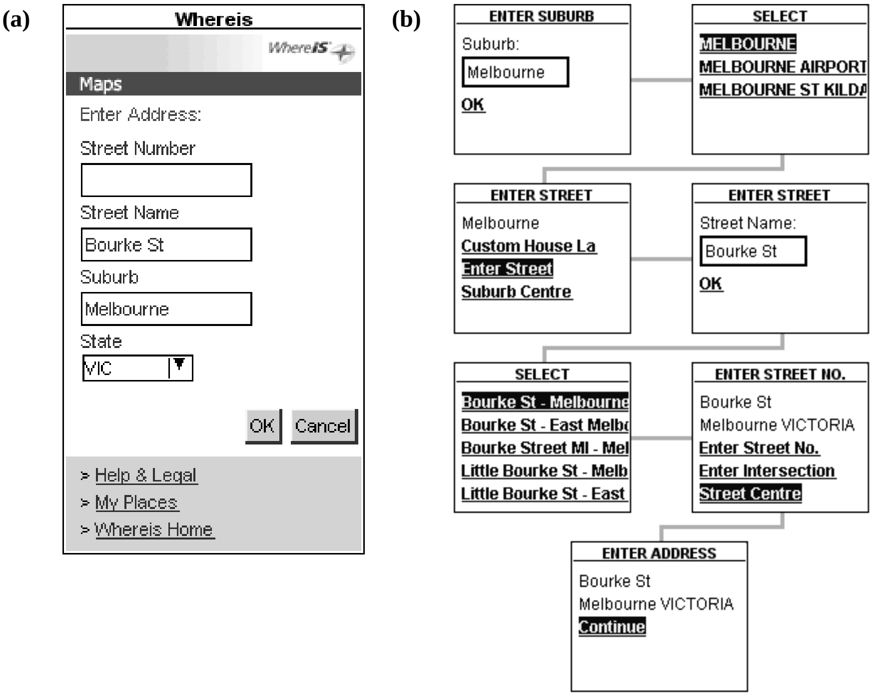

Fig. 4. **(a)** Simplicity of the address entry process in the 3G version of *SWP*, and **(b)** the elongated process of address entry in the WAP version

In the case of the *SWP* suite of applications, the XHTML delivery format enabled much improved presentation of information and consequently better application flow from that previously seen. The design process for the 3G implementation focused on improving upon all aspects of design and usability, building on lessons learnt from previous implementations (WAP and *i-mode*) with the ultimate aim of allowing the user to access required and relevant information as quickly and as efficiently as possible. Device, platform and network limitations that once inhibited effective user-centred design in the past were essentially no longer a factor. One major case in point relates to the entry of address information. In the previous 2G (WAP) format, the process of what should be a relatively fast and simple task, was spread over numerous pages and immensely cumbersome, having to enter various address related information (i.e. suburb, street, etc.) on different pages (see Fig. 4).

The support for XHTML in 3G however, allows for all these address entry elements to be displayed on a single page (see Fig. 5); dramatically reducing the user's time spent entering information and subsequently obtaining a result.

Despite not being subjected to as quite a dramatic revision in comparison to the enhancements implemented for key user interface issues such as the process of address entry, or perhaps the POI selection process for the nearby service; the tweaking of various cartographic representation elements attempted to improve geographic communication. The first and most obvious improvement, in regard to cartographic communication, was facilitated by the physical nature of 3G devices in their ability to display larger and more colourful maps. Unlike the smaller and often colourless displays of older devices, the high resolution and colour packed 3G devices provide some useful purpose for the display of maps (most 2.5G devices excluded) other than near-trivial graphical filling.

In contrast to their graphically flawed counterparts, maps displayed on an array of 3G devices enable the user to pinpoint locations at smaller scales without having to zoom in to the largest available scale. Additionally, whilst Mitchell and Smith (2000) contend that one of the most significant features of the paper map is that it is 'truly mobile' and assists the user 'in the field' where it is of most value, the provision of maps on mobile devices such as those on the SWP platform, goes some way to achieving one of the most historically significant benefits of paper maps; its mobility. Furthermore, the paper map may both now and in the future have fundamentally better resolution and usability advantages, but it cannot match the digital map in terms of data currency and the potential of up-to-the-minute knowledge support. Figure 7 illustrates the progression in map display across generational devices from (a) early monochrome to (d) contemporary full colour displays.

(a) (b)

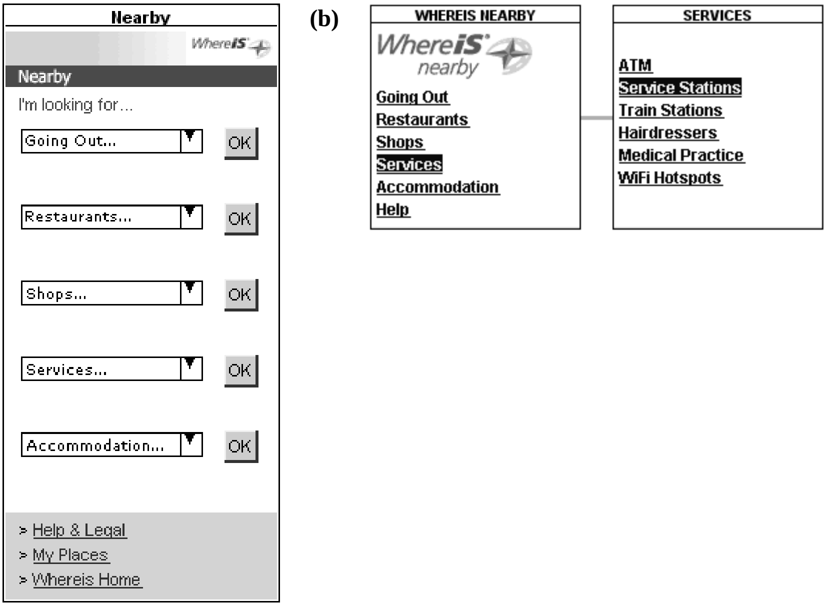

Fig. 5. **(a)** Simplicity of the *Whereis*® Nearby POI category selection process in the 3G version of *SWP*, and **(b)** the WAP version

Similarly, the POI category selection page (*Whereis*® Nearby home page) for 3G, provides a far simpler interface to operate than its WAP equivalent. The grouping of categories on a single page, rather than the elongated process of group and category selection spread across numerous pages, reduces the number of clicks to get a result. Figure 6 illustrates the appearance of the *Whereis*® Nearby home page in 3G and WAP formats.

Simple design techniques, such as adding colour, can contribute enormously to the usability of products, particularly in determining and distinguishing between various screen elements. The simple addition of alternating background colour for direction instructions aides the clarity of a user's visual perception in deciphering turn instructions, particularly for long routes. Figure 6b illustrates the use of alternating colour to enhance the users' interpretation of screen components within the directions finder application (route overview map page also displayed). Such was the impact on the application's visual cues and usability, the alternating of background colours was implemented in other areas of the application suite (i.e. for search result listings).

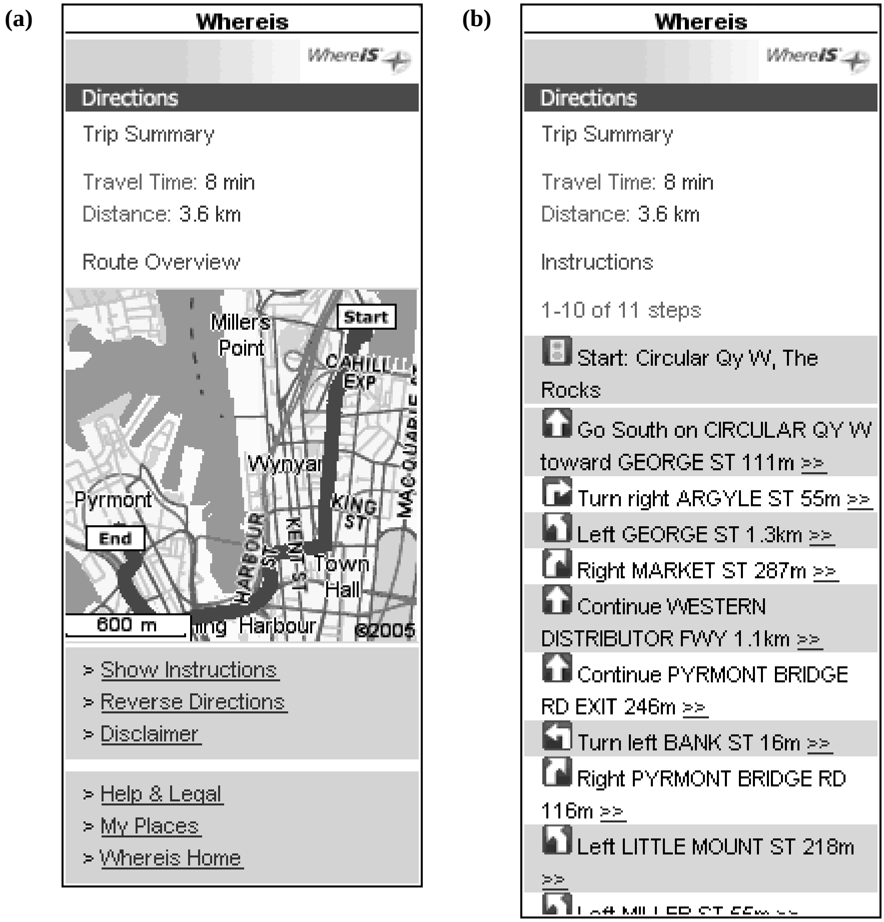

Fig. 6. The 3G *Whereis*® Directions application displaying a **(a)** route overview map and **(b)** the list of turn instructions with alternating background colours

Cartographic representations are not restricted to relate or rely solely upon the graphical depictions of reality; accompanying text can contribute greatly to a better understanding of the physical environment that is represented. Urquhart et al. (2004, p.78) supports this notion in stating, "…maps are only one form of cartographic representation that should be considered when improving usability of geospatial information – particularly in the context of LBS with its limited visual display qualities." The *Whereis*® Nearby service for 3G makes use of these multiple forms of communication (i.e. multimedia), not only providing the user with excellent understanding of nearby places of interest, but also the names of those POI and related distance (see Fig. 8). Additionally, the maps implemented resulting from a search (map displaying POI surrounding the search location) provides a great tool in assisting the user in environmental reconstruction and understanding.

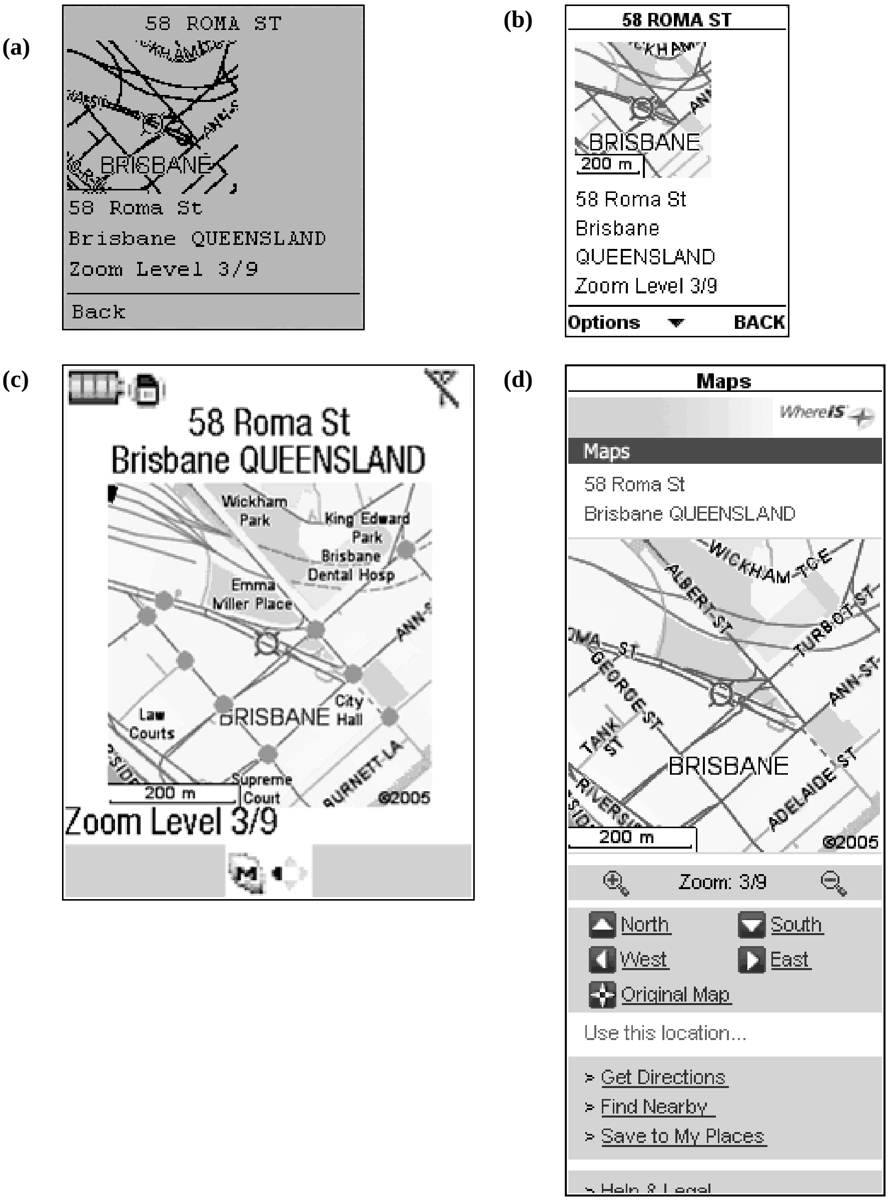

Fig. 7. Maps displayed on an array of devices – **(a)** Early 2G, **(b)** Later 2G, **(c)** 2.5G/*i-mode*, and **(d)** 3G

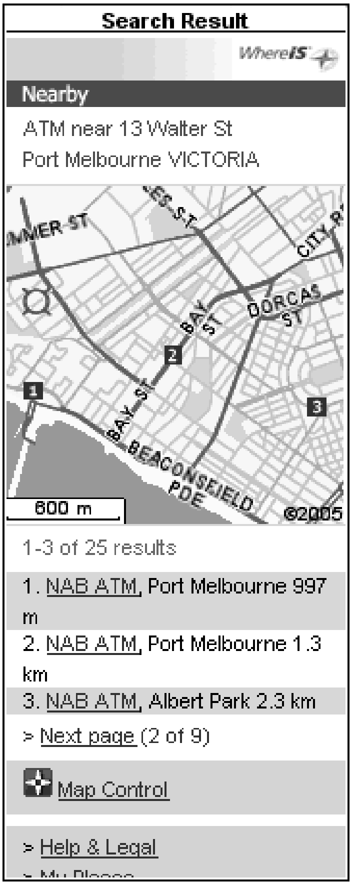

Fig. 8. *Whereis®* Nearby service displaying a map of surrounding ATMs to a supplied location in the 3G version of *SWP*

Essentially, what the 3G implementation of *SWP* amounts to is, resultant fewer clicks by the user to access information quicker and more efficiently than previous versions (e.g. 2G), throughout the entire application suite. Consequently, it goes some way to achieving the aim of reducing the time spent by users to acquire relevant and useful information, ultimately contributing to an enhanced user experience. The fulfilment of these endeavours was made possible by the commitment from both Sensis and Webraska to deliver a product that was designed with the user in mind (i.e. user-centred design). Furthermore, the 3G platform provides the ability to display more visually appealing user interface layout and designs, ultimately enabling better communication of information and encouraging user return.

28.8 Conclusion

Like so many new technologies, when the concept of WAP was initially conceived, the supporting technology of the time was far too primitive to facilitate adequate achievement of its aspirations. Instead, it floundered; yet the work in those early days allowed for the refinement of ideas in the belief that technology would one day provide the means to achieve its aims. Recently, continued rapid growth in mobile usage and particularly important advances in mobile technologies (particularly 3G) are enabling a realisation of the ideals and aims that WAP set out to achieve. Consequently, this translates to higher distribution and wider use of location-based services, placing further importance upon the delivery of timely, relevant, usable and above all useful information to users. Third Generation technology is by no means the end point of the technology with many aspects still to be improved, but if embraced, the supply of new and worthwhile content and applications that support multimedia will shape the future and success of 3G, mobile technologies, and mobile mapping applications as a whole.

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29 Standards and Open Source for Cartographic Multimedia Applications

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29.1 Introduction

The development of digital environments over the past decades has resulted in a diverse number of tools available for cartographic multimedia applications. This ongoing process has led to new methods, formats and applications for playing, reading or accessing content. One reason for this development may be motivated by adapting the latest technology available, which concerns processing and displaying resources using hardware or new software creations. In this sense the impact on cartographic multimedia applications is characterised by new technical possibilities, like interactivity, dynamic animation techniques or immersive information transfer.

Generally technical development provides the means for more effective cartographic information transfer. But developers and users may observe incompatibilities with formats and applications. Older multimedia maps may not be accessible due to missing plug-ins, geospatial datasets may not be readable or interaction models may need to be rebuilt using newly introduced scripting methods. The map-creation process needs to consider both the power of distribution and sustainability and accessibility of latest multimedia technologies. This balance between the latest features and the almost timeless access to content may be broken by accepting standards, norms and the concept of Open Source for digital data and the computer based communication processes and implementations of cartographic applications.

Standards, norms and activities in Open Source affect the sustainability of digital content as well as the compatibility of data, software and hardware. Therefore various initiatives work on specific tasks like data exchange (encoding for media transport, signaling, protocols or media encoding), computer to computer interfaces (input/output connectivity) and data structure creation and documentation. In the unique case of cartographic information acquisition, manipulation, analysis and communication, this demands regulated standardisation so that the large amounts of data are comparable between each other and can be useful for knowledge generation and transmission.

This chapter gives a brief overview of standards and norms and relate to open file documentation. It covers the initiatives for work in multimedia cartography and lists important geospatial and multimedia formats in use. It describes possible developments for an open cartographic environment, and provides a close examination of cross-media communication techniques.

29.2 Intention and benefits of standards in multimedia map creation

The process of creating multimedia maps mainly relies on access to spatially related information, multimedia supplements, authoring tools and the definition of an objective. These components define the content, functionality and the distribution method, thus affecting the efficiency of spatial communication (Kirschenbauer 2003). Questions that need to be addressed are: Is the user able to build a mental model and understand reality? And will the application be available and usable by a wide user community and operate on future systems (Borghoff et al 2003)? The following sections elaborate on these components from the viewpoint of a developer in context with the difficulties and efforts of incorporating today's standards.

29.2.1 Data, information and multimedia

The need to combine data from various sources in a consistent and high quality way assumes readability of data and further knowledge of data origin, quality, compatibility and structure. Sources for multimedia maps cover geospatial data, additional database-related information and various multimedia components, including text, images, animations, film sequences or 3D. All of these offer different data descriptions and usability methods which have to be considered within the production process.

A reasonable implementation of geospatial data requires a minimal knowledge of geographic projection, frame of reference, data scale, origin, production date and primary purpose of use (Nebert 2004). This knowledge enables a combination of different geographic references, meaning that the description of locations on the Earth are known and may be transformed to another. For example, the use of geographic data in national references often requires the transformations to geographical coordinates to allow combination with other global resources. In addition the frame of reference may add a general description of geographic height values, which removes inconsistencies of the different height systems used (WGS84, national height references, etc.). A given data scale provides some information of geographic data ‘granularity’, which expresses the outcome of generalization processes on the dataset. Combined with an origin and primary purpose of use information the detailed ‘amount of truth’ (Neudeck 2001) of the data will be assessable to a degree. The production date directly provides the relevance of the dataset, which may explain inconsistencies with a given dataset. Further parameters of metadata may be surveying and recording methods, precision, the primary cartographic model information (status before simplifications are made and a transformation to the secondary cartographic model begun), or temporal relations, which support time based animations and visualizations of spatio-temporal analysis. The most important aspect with geospatial metadata is that the structure of this information should be standardised in order to make further automatic processing possible, like some descriptions that can be combined in GDAL, OGR or GML (http://www.opengeospatial.org).

Much geospatial data is stored in database formats for more efficient accessing methods, e.g. *PostGIS* (the spatial extension of the *PostgreSQL* database) or spatial extensions in *MySQL* (http://postgis.refractions.net/ index.php). With these extensions the query for spatial characteristics is enabled. Traditionally, any type of information may be stored in this database format, demographic data or similar spatially related facts. One characteristic of this format type, which structures and links data in tables with almost no redundancies is the possibility for analysis in the form of queries. These are special kinds of instructions, SQL queries that extract specific values according to the query. As well, based upon no redundancies, changes and updates can be easily made. The problem with this format is again accessibility of data. Depending on the format and data structure provided, queries have to be established, assuming that the query itself is understood by the database. This communication aspect of databases and the ability to query them externally (from another program) is supported by the Open DataBase Communication (ODBC) standard (http://www.sqlsummit.com/ ODBCPORT.HTM).

The combination of multimedia components is the basis for an effective multimedia presentation (Kroeber-Riehl 2000). The 'playability' for most of these multimedia components directly depends on the end-user device and its ability to support and understand format codes and output needs. There exist problems related to codecs, the internal coding mechanism, which makes the file format more effective (reading and writing), minimising storage space required and minimising the processing power required.

For example the use of text calls for known font coding. Discrepancies become visible when the characteristics of different languages overlap, like the German use of codes for vowels and the English allocation of these letter codes. For the same reason discrepancies for Arabic, Asian or Cyrillic styles occur. Some solution may be found using the UNICODE standardisation or OTD (Open Type Definition) and by using special typesets that combine languages in one font (http://www.unicode.org). Images may be characterised by their use of different coding mechanisms too. Depending upon whether a lossless or lossy compression is used, the simplification of colors or some kind of combination of picture pixels to reduce the file size, distinctions may be made as to which compression algorithm works best. These techniques of picture coding are continued in film formats. Thus the same compression methods are used in picture sequences and videos.

In general each multimedia component has its own development, and the application of a particular standard often depends on a wide distribution and implementation in end-user devices. For example MP3 is an accepted standard for home entertainment. This was due to an open policy for the format and usage.

Independent from the type of data, geospatial, database or multimedia, a description of the file format is essential for its combination into a multimedia application. For reasonable use the metadata for most formats are helpful to classify quality, scalability, granularity and range of use. Recent developments and initiatives try to create libraries for documentation and implementation of data formats and their metadata. These libraries can also be called gazetteers (http://www.w3.org). They are lookup tables to support readability and usability of the data. Some examples are GDAL, OGR, etc. Of course these libraries, like file formats, have to be supported by developer authoring systems.

29.2.2 Standardisation in authoring environment

An authoring environment provides a tool which is used for the creation of multimedia applications. This environment/programming method may be HTML coding, a scripting language or specific programs created for multimedia applications. All types of authoring environments employ data sources (the spectrum of format depends on the support of file formats and data file standards) and result in various application formats, which either follow an open standard or a proprietary application format. For example the result of an interactive 3D application may be in the form of the open Virtual Reality Modeling Language (VRML) file that is readable and manipulatable in text editors. Alternatively, it may be coded in a proprietary format of a game engine, which is a binary file using different program libraries that are editable and playable. In the end the decision for the multimedia application format will greatly depend on the objective of the project, its distribution method and the demands on sustainability.

A very simple but powerful authoring environment is HTML (Hyper Text Markup Language). It offers the possibility to structure content by using text based documents with headings, paragraphs, lists, tables or graphics, in combination with forms, layers and interactivity (depending on the release/standard of HTML used). The software independent text format of HTML follows a standard rule-set for its technical implementation, recommended by the W3C (WWW Consortium). This consortium is an independent, self supervising board for technical standards for the Web (http://www.w3.org). It also produces standard recommendations for CSS (Cascading Style Sheets), XML (eXtensible mark-up Language), SVG (Scalable Vector Graphics), etc.

The extension of HTML with scripting methods provide another authoring environment, which uses the compatibility of HTML and empowers the application with more flexibility for interaction and animation. The scripting is not an expansion of HTML, but a self-standing programming language. Some of the most common scripting languages are JavaScript, PHP and Perl. JavaScript uses a code interpretation included within the Web browser and PHP or Perl need an interpreting machine for the code at the server side. This means that the developer needs access to a working server environment on the development PC to test applications with PHP or Perl. The programming itself takes place in text editors because the scripts, being ASCII format, need no compilation. Additionally these three scripting methods follow an Open Source directive (more later in the section on organisations) which enables expandability and open documentation to the scripting methods and the resulting application. Newer developments for server-side mapping, map-servers, employ these scripting methods after some adaptation. The adapted script, called MapScript (http://mapserver.gis.umn.edu/), is used for database access and interactivity expansion.

Often proprietary programming environments are used for the development of multimedia maps. These generally offer extensive support with predefined scripts, the management of multimedia components, composition and interactivity development. But the format of the resulting application is encapsulated into a binary format, which prevents extraction of content and multimedia elements from within the file. Playability is reduced to a proprietary interpreter (player) for the file, which may be embedded as an object into HTML and thus distributed via the Web. This happens providing the plug-in is installed user-side. The main characteristic of this proprietary work-flow is that developments within the programming environment and the output format strictly follow proprietary policies without any consideration of standard recommendations or user (developer) needs. For some special fields, like gaming, Open Source authoring environments are also available. For example, the game engine *Blender 3D* (http://www.blender3d.org) uses binary formats for distribution, but the authoring environment and the compilation format is open and documented for open access.

The decision to open formats, where the file format becomes documented, usable and expandable by anyone, often supports distribution and implementation to a wider community. For example the distribution, standardisation and acceptance of the Portable Document Format (PDF) standard was made possible by changing the license model to Open Source. Thus it became possible for anyone to implement this format in other applications.

Independent from supporting and standardising file formats within the authoring environment, another element concerns demands of the operating system by the authoring tool. Proprietary environments especially demand specific versions of operating systems for using the authoring environment as well as for executing the resulting application. Some initiatives within the Open Source community (e.g *GRASS GIS*, *JGRASS*, *QGIS*, *Blender3D*, *OpenOffice*, etc.) try to spread their applications on different operating systems, which is easily done with Open Source applications. Then this free accessible source code may be modified and compiled using a user-specific operating system (http://www.opensource.org).

From a developers point of view the authoring environment and standards used should be chosen to follow the overall objective, which defines the intended user group, the distribution method (Web, CD-ROM, DVD, broadcast, etc.) or presentation techniques used (specific user interfaces, interactivity and specific animated content).

29.2.3 The definition of an objective and its influence on using standards

In general, the selection of an authoring (programming) environment will depend on the needs and objectives of the multimedia project. It is a commitment for capabilities of distribution, interactivity and sustainability, which concerns media for distribution (the media applicable for the aimed user group), available user interfaces/interaction/presentation models and archiving methods based on the media used.

When focusing on the distribution of a multimedia application a strong connection to availability of the media, which forms the carrier of information, may be observable. The higher the availability and distribution of a media the more accessibility for the content might be possible. If no computers with an Internet connection are available, then the Internet is not a good carrier for content (Buziek 2000).

The standards for distribution concern communication techniques which basically enable a transfer of bits and bytes and the correct translation of compression coding, which is used for a faster transmission of data via the carrier. The most important standard for the internet is TCP/IP, the Transfer Communication Protocol. Similar standards may be found for wireless communication, telecommunication, *Bluetooth* or infrared (Lindbergh 1996). A detailed focus on these standards would go beyond the scope of this contribution.

The design of a presentation model, and associated interactivity, mostly depends on the capability of the end-user's computer (Abel et al. 2000).

The notion of sustainability offers a wide range of aspects. Sustainable information transfer, where the recipient remembers information for a long time, may also be part of this notion as well as a method to archiving aspects of multimedia applications. This role ensures accessibility and 'playability' on future operating systems. The production of long-term knowledge at the user-side of spatial related information is one main focus and task of cartography (Dransch 1997).

Alternatively the aspect of archiving often becomes replaced by the provision of information, which is most important for navigation tasks. Losing accessibility to older information means a loss of documentation and makes a recall of a situation impossible. Thus the archiving of cartographic multimedia applications becomes important. Existing archiving methods use copying storage techniques, indexing of metadata and content description for search algorithms and emulation of older operating systems for playability, which for instance makes old applications run on the latest operating systems (Franz 1993). The consideration of applying all methods will mostly depend on the importance of the multimedia project and its objectives.

Wide distribution on standardised accessible media and interfaces and the use of open file standards may support long-term usage of multimedia applications and its sustainability.

29.3 Organisations and standardisation

In this section the main organisations, initiatives and formats are described. However, it must be noted that the list is not exhaustive.

ISO. The International Organisation for Standardisation is a non-governmental organization comprising a network of national standards institutes from 153 countries, on the basis of one member per country. It has a Central Secretariat in Geneva, Switzerland, that coordinates the system (http://www.iso.org/iso/en/ISOOnline.frontpage). Although this organisation defines itself as non-governmental, most of its standard definitions become law through treaties and national standards. Generally final documents of ISO are copyrighted and charges for copies have to be paid. Draft versions are freely accessible, but may underlay severe changes before finally released. Additionally some ISO standards, most of them dealing with information technology, are made freely accessible (http://isotc.iso.org/livelink /livelink/fetch/2000/2489/Ittf_Home/ PubliclyAvailableStandards.htm). The main focus of ISO is the support of facilitation of global trade, improvement of quality, safety and security as well as the rational use of natural resources and global dissemination of technologies and good practices (http://www.iso.org/iso /en/aboutiso/strategies/ isostrategies_2004-en.pdf).

OGC. The Open Geospatial Consortium is an international voluntary non-profit organisation that focuses on developing standards for geospatial and Location Based Services (LBS). The member-driven consensus program supports the work with government, private industry and academia to create open and extensible software applications for Geographic Information Systems (GIS) and other mainstream technologies. Its mission is "...to lead the global development, promotion and harmonization of open standards and architectures that enable the integration of geospatial data and services into user applications and advance the formation of related market opportunities..." (http://www.ogc.org). The main specifications of OGC are Web Map Service (WMS), Web Feature Service (WFS), Web Coverage Service (WCS), Catalog Service-Web (CS-W), Simple Features SQL (SFS) and Geography Markup Language (GML).

The OGC Web Map Service (WMS) dynamically produces maps as digital image file from geographic information, which might be incorporated in Web pages. It does not deliver any feature information of the data. Thus the extension of WMS with Web Coverage Service (WCS) might be useful. WCS allows access to values and properties of geographical locations, which can be subsumed in geospatial coverage. In contrast, the Web Feature Service (WFS) delivers the actual data. It enables direct manipulation with the dataset by creating, deleting and updating a feature instance (http://www.ogc.org - Web Feature Service Implementation Specification).

W3C. The World Wide Web Consortium is an international consortium where member organisations, full-time staff and the public work together to develop Web standards. The main mission is "...to lead the World Wide Web to its full potential by developing protocols and guidelines that ensure long-term growth for the Web..." (http://www.w3.org/ Consortium/Overview). The Web should be accessible for everyone and on everything. This is the reason why the implementation of existing accessibility guidelines need to be promoted relating to authoring tools, media players, browsers and personalised accessibility profiles. The increasing need for ubiquitous Web access with various kinds of devices, which include mobile phones, airport kiosk systems, kitchen appliances or automobiles, demands for adapted design technologies like Cascading Style Sheets (CSS), Scalable Vector Graphics (SVG) or Synchronised Multimedia Integration Language (SMIL).

OSI. The Open Source Initiative is a non-profit corporation dedicated to managing and promoting the Open Source definition. The idea behind Open Source is the evolving process of software development where programmers can read, redistribute and modify the source code. The public improvises and adapt the software as well as further developing the software. Here, software development is a rapid evolutionary process that may produce better software than via the traditional closed development model (http://www.opensource.org/). Open Source does not only mean free access to source code, but it is based on a free redistribution policy, adaptability of source codes, technical neutrality and distributable license model. For this reason a variety of OSI approved licenses is available. The most common is the General Public License (GPL) accompanied with the GNU Free Documentation License and Open Software License (OSL). The GPL permits everyone to copy and distribute verbatim copies of the software. Changing for software is not allowed. The OSL grants a worldwide, non-exclusive and sub-licensable license that allows reproduction of the original code as well as being able to translate, adapt, transform or extract parts of the original code.

29.4 Selection of standardised formats

GDAL. Geospatial Data Abstraction Library is a translator library for geospatial raster data formats. It provides a single abstract data model to the calling application for all supported data formats. The GDAL dataset assembles related raster bands and information common to them all. Generally the dataset uses a concept of raster size (raster and lines) that applies to all bands (http://www.gdal.org/ gdal_datamodel.html).

OGR. Simple Feature Library is a C++ Open Source library, similar to GDAL, providing access to a variety of vector file formats. Most important supported formats are ESRI Shapefiles, SDTS, PostGIS, MapInfo mid/mif and TAB formats (http://www.gdal.org/ogr/index.html).

SVG. Scalable Vector Graphics is a special form of the XML for describing two-dimensional vector graphics. The coding can either be declarative or scripted, which results in static or animated graphics (http://www.w3.org/Graphics/SVG/).

GML. Geography Markup Language is another special form of the XML with the aim to express geographical features. It serves mainly as a modeling language for geographic systems. GML does not assume a specific coordinate system for geographic information exchange, but a clear specification for the coordinate reference system (http:// www.opengeospatial.org/groups/?iid=31).

JPEG. Joint Photographic Experts Group format is one of the most commonly used methods for (lossy) compression for raster data files/digital images. The compression works with extensive downsampling (or 'chroma subsampling') and discrete cosine transformation, which may result in visible compression flaws, depending on the compression ratio required (http://www.jpeg.org/).

GIF. Graphics Interchange Format employs lossless data compression for the bitmap image format. But it is restricted to 256 colors. The file size of an image will be reduced without degrading the visual quality, if the image fits into 256 colors. Thus it is a good choice for graphics, but not for photographs requiring detailed transitions (http://www.w3.org/Graphics/ GIF/spec-gif89a.txt).

MPEG video. Moving Picture Experts Group is a working group of the ISO/IEC focusing on the development of video and audio encoding standards. One main focus is the coding of moving pictures and associated audio for digital storage media. In practice a first step developed a standard for efficient storage and retrieval of video and audio on compact discs. Latest standards of MPEG (MPEG-4) enable the coding of individual objects and thus support rich 3D environments (http://www.chiariglione.org/ mpeg/who_we_are.htm).

MP3. MPEG Audio Layer 3 was invented and standardised by a team of engineers directed by the Fraunhofer Institute in Germany. It has become of the most important audio formats over recent years, mainly based on the easy dissemination of audio files over the Internet (http:// www.iis.fraunhofer.de/amm/techinf/layer3/). In simple terms, the compression format works by discarding portions of an audio file that are considered less important to human hearing and thus produces smaller file sizes than is possible by Pulse-Code Modulation encoding (PCM).

UTF. The Unicode Transformation Format is an industry standard with the goal of providing the means by which text of all forms and languages can be encoded for the use in computers (http://www.unicode.org/). Unicode provides a unique representation number for every character independent from the platform, software or language used.

ODBC. The Open Database Connectivity interface is a C programming language interface that enables applications to access data from a variety of Database Management Systems (DBMSs). The application can access data of diverse DBMSs through this single interface (http://msdn.microsoft.com/library/default.asp?url=/library/en-us/odbc/htm/dasdkodbcoverview.asp).

VRML/X3D. The development of standards for 3D contents has been mainly influenced by hardware requirements. Applications were programmed to fit specific hardware specifications (http://www.web3d.org/). Virtual Reality Modeling Language (VRML) is an important standard file format for representing 3D interactive vector graphics using mainly the Internet as distribution media. It is a text file format, where the vertices, edges and polygons along with the lighting situation and interaction can be specified. Interpreters for VRML understand the textual specification and convert this to a graphical output. X3D is the successor format to VRML. It is based on XML syntax and aims at real-time communication of 3D data across all applications that are in use for engineering, scientific visualization, architecture, multimedia, etc.

29.5 Conclusion and vision

Standards are useful for almost all kinds 'exchange' applications and have enormous impact when transferring/using digital data. For cartographic applications the influence of standards on technical implementations are becoming standard in telecommunications and spatial description, where these formats result in executable software. Thus the use of standards may affect interoperability in each step of the cartographic communication process.

A vision for the unification of data used and communication types may for instance support real X-media cartography. This means that if the presentation form and the media format changes the content will stay the same. Of course the high quality needs of cartographic applications, its semantics, perception, knowledge communication and immersive multimedia usage have to be further investigated. But the ability to compose sustainable multimedia maps with the help of standards, norms and Open Source is a formidable *modus operandi*.

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30 Scalable Vector Graphics and Web Map Publishing

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30.1 Introduction

When compared to other areas of cartography Web mapping is relatively new. However, since the cartographic community has embraced the Web as a means of making our products available a new genre of mapping product has evolved. This has caused cartographers to assess how they need to design, produce and deliver these new, innovative products, resulting in a new 'mindset' about what we do and how we approach how we conduct our activities. A new *modus operandi* (for mapping) has been established, one that facilitates the provision of new and exciting Web-delivered products.

Initially Web-delivered mapping products used text-heavy interfaces to list the available mapping inventory. Later collections of scanned maps were provided as 'one-stop' repositories for images about geography. However, the true potential for the Web as a provisioner of map products was compromised somewhat with raster-only image repositories. It wasn't until vector-based mapping became possible on the Web that maps that could be zoomed into, without image degradation, could be delivered.

This chapter provides a brief overview of SVG, a vector-based standard for publishing graphics on the Internet, focusing on its use for Web mapping. It then describes how mapping products can be produced by 'travelling' through the development of a prototype SVG Atlas for school children in Brazil. It links to the previous chapter that outlined the potential that Open Standards offer and illustrates how useful, and usable, this method of Web publishing can be for publishing on-line, rather than on paper.

30.2 Open Standards

Standards can be understood as a "*Document, established by consensus and approved by a recognised body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context*" (CEN 2004). Standards are necessary in any kind of activity and they are most valuable in computing. However, Neumann and Winter (2000) stressed that "*within the Internet we are only able to speak of a 'Standard', if a majority of companies accepts (applies) a technology, which is actually used by viewers and editors of Web sites*". Neumann and Winter argued that there are basically two types of standards: *de facto* and *de jure* (Neumann and Winter 2003). *De facto* standards are considered to be those developed and implemented by sectors of the industry, which became widely used. *De jure* standards are those developed and validated by a cross-industry organization or consortium.

Open standards can be defined as standards established by a public body (comprised by members of industry and/or public sectors) with the purpose of providing guidelines for their field of activity. By definition open standards are not proprietary, in other words, they do not belong to any individual or company (CEN 2004).

The issue of open standards is not new for those who are engaged in digital cartography. The 'Open Source' movement rose as a collective response to the technological companies, software's owners, which dominated the market for years.

Open Standards and Open Source technologies are important for cartography because they not only allow free communication between different systems and data sharing, but they also provide tools for developing and distributing cartographic applications at relatively low cost.

Several organizations develop different standards that are related to cartography. The Open GIS Consortium (http://opensourcegis.org), for instance, lists a series of spatially-based applications developed under the umbrella of open standards philosophy. Some examples available in the

Web site are *Spring*, a GIS and remote sensing application developed by the Brazilian Institute of Spatial Research (INPE); and GeoVRML, a technology for publishing three-dimensional geographic information.

The World Wide Web Consortium (W3C) develops and regulates standards for publishing on the Internet. XML (an acronym for eXtensible Markup Language) is a remarkable example of non-proprietary technology validated by the World Wide Web Consortium (W3C). This language is based on the Standard Generalized Markup Language (SGML), a standard developed by the International Standards Organization (ISO). XML aims to provide guidelines for exchanging data via the Internet. XML is the basis of a series of other standards with different purposes; one of them is the Scalable Vector Graphics (SVG) a vector-based technology for publishing 2-D graphics on the Web.

For being open standard and vector-based SVG is a powerful and flexible way of publishing interactive cartography on the Web. However, there are many solutions for Internet map publishing, involving both open standards, open source and proprietary technologies. This chapter analyses the use of SVG for interactive Web map publishing.

30.3 Using Scalable Vector Graphics to publish Web Maps

The use of open standards, particularly the XML-based SVG, to publish maps on the Internet is a recent trend. Although this chapter does not intend to explore details of both languages, short samples of XML and SVG code are provided in order to illustrate the basic structure of derived documents.

XML was introduced in 1998 by the World Wide Web Consortium aiming to overcome problems with data handling in HTML. In fact XML and HTML were created to achieve different goals: XML is a standard for describing data and HTML is a standard for displaying data.

XML was created as an open-ended technology, in other words, it can be adapted to different applications and be used in different areas. Generally, XML can be used for two purposes:

- Data structure: XML can be used to create the structure of data documents, including descriptions and attributes; and
- Data exchange: XML is a cross-platform technology, which means that it can be used to exchange data between different formats. It can also be used to send data over the Internet.

A XML document follows a series of rules. Sample Code 1 illustrates a simple XML document. The structure of an XML document is reasonably simple as can be seen in Sample Code 1. The first line of the code contains the XML declaration - in the example shown line 1 says that the code following is an XML document version 1.0. There are no pre-defined tags in XML, therefore the user can define their own tags according to the nature of the data. The example provided in Sample Code 1 comprises geometry data about different blocks in a particular suburb. In the XML file the table suburb is created with the tag <suburb> the property id="a" identifies the suburb; each <block> tag comprises a line of the table. The table embraces the fields <id> and <geom>.

Sample Code 1. Fragment of XML code.

```
1. <?xml version="1.0"?>
2. <suburb id="a">
3. <block>
4.    <id>1028</id>
5.    <geom>M226.5,295.4   L225.8,295.4   L225.5,298.3   L227.7,296.9
L226.5,295.4
6.    </geom>
7. </block>
8. <block>
9.    <id>1029</id>
10.    <geom>M227.9,297.1   L226.7,297.8   L228.7,300.2   L229.6,299.7
L227.9,297.1
11.    </geom>
12.   </block>
13.</suburb>
```

As an XML-based standard, SVG documents follow a structure very similar to the structure presented in Sample Code 4. However, there are some specific tags and properties reserved for particular SVG objects.

As vector files, SVG documents follow a coordinate system. However, it is completely the opposite to the Cartesian system, in which the vertical axis (y) is positive above the horizontal axis (x). In SVG the vertical axis has positive values below the intersection point with the horizontal axis (0, 0 coordinates). Figure 1 shows the difference between the Cartesian coordinate system and the SVG coordinate system.

In the example illustrated in Figure 1, a point will have coordinates (1,1) in SVG. These coordinates are rendered by the SVG plug-in as one unit to the right (x) and one unit downwards.

Another important concept in SVG is that different measurement units can be used. The most common units are pixels, millimetres, centimetres and inches. However percentages of the screen size can also be used, in this way all the dimensions within the SVG file will be calculated according to the size of the screen window.

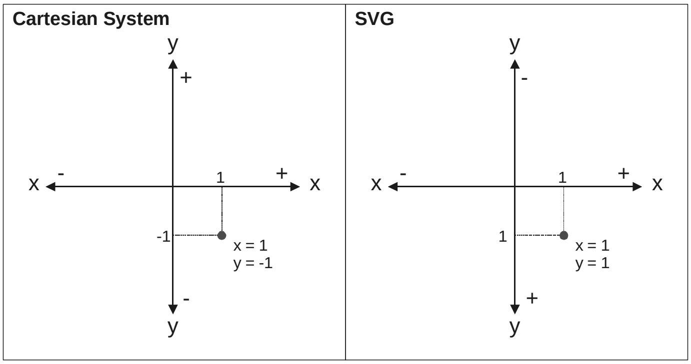

Fig. 1. The Cartesian and the SVG coordinate system.

Sample Code 2 shows a sample piece of SVG code. The first line in Sample Code 2 specifies that the following code is an XML document. The second states the type of the document (SVG in this case) and the DTD (Document Type Definition) used. DTD is a document that defines rules for using tags and attributes to describe contents within the document. The third line, initiated with the <svg> tag, defines the size of the SVG file and the coordinate system. Every SVG document must contain this tag.

The example below comprises one rectangle and three different text components. Note that two text elements are grouped into a 'g' element.

Sample Code 2. A simple SVG code.

```
1. <?xml version="1.0" encoding="iso-8859-1"?>
2. <!DOCTYPE svg PUBLIC "-//W3C//DTD SVG 20001102//EN" "http://www.w3.org/tr/2000/
   CR-SVG-20001102/DTD/svg-20001102.dtd">
3. <svg width="220" height="50" viewBox="0 0 220 50">
4.   <rect x="0" y="0" width="216" height="42" fill="#3333CC"/>
5.   <text font-family="Arial Black" font-size="55" fill="#6699FF" x="179" y="40"> ?</text>
6.   <g font-family="Tahoma" fill="white" font-size="13">
7.         <text x="6" y="15">text 1</text>
8.         <text x="6" y="33">text 2</text>
9.   </g>
10. </svg>
```

The SVG file outlined in Sample Code 2, when rendered in a Web browser, with an appropriate plug-in, should appear on the screen as shown in Figure 2.

The property viewbox in the <svg> tag establishes the coordinates within the SVG file, in the example provided in Sample Code 5, the SVG file is divided into 220 columns and 50 lines (the first two numbers identify the coordinates x and y of the top left corner and the final two number indicate the coordinates on the bottom right corner). The viewbox property does not necessarily contain the same number of columns and lines as the width and height of the file.

In the example illustrated in Figure 2, the tag <rect> defines that one rectangle will be rendered. The properties x and y define the starting coordinate for rendering the rectangle (top left corner) width and height define the dimensions of the geometric figure. The border of the rectangle is not defined in Sample Code 5. However, borders can be defined by using the "stroke" and "stroke-width" properties. The property "colour" defines a filling colour for the rectangle. In the example the hexadecimal code 3333CC was used. Colours can also be referred to by English names such as red, yellow and blue and by the RGB palette code (such as 255,255,255 for white, 255,0,0 for red, etc). In the case shown in Sample Code 5 a colour from the Web Safe Palette was used.

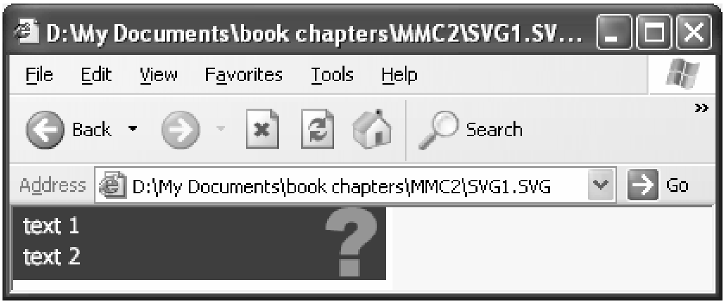

Fig. 2. Rendering of the code presented in Sample Code 5.

A Web Safe Colour Palette was developed to provide guidelines for using colours in Web sites. The purpose was to establish a number of colours that would be rendered in the same way in different Web browsers or different hardware, as a result the Web developer can design pages knowing exactly how users of different platforms would view the resultant imagery.

Although the file used as an example here is static, animation can be implemented into SVG files. SMIL (Synchronized Multimedia Integration Language) statements can be used within SVG documents to allow users to create animations involving transformations of objects' attributes, including movement.

SMIL is also a markup language based on XML, validated by the W3C. It divides multimedia files into different streams (for audio, video, text and images) and defines rules for their presentation. Frame animations can be implemented by creating chained animations, controlled by time. It is also possible to implement interactivity within SVG. For complex interactivity it is recommended using a combination of SVG and JavaScript. There are several Web sites dedicated to SVG and SVG tutorials available on the Internet, for more detail in the SVG syntax refer to Neumann and Winter (2003) and Campesato (2004)

30.4 Case Study: Developing school SVG-Based school atlases

For this example SVG was the graphical format chosen for developing templates for publishing a school atlas for Brazilian school children on the Web – *the Internet School Atlas of Rio Claro*. This choice was made considering the following guiding principles:

- Brazilian developers have on budget restrictions and therefore the solution proposed should be as inexpensive as possible;
- Brazilian developers of local school atlases are usually primary school teachers, academics, undergraduate and graduate students with background in education and geography. The group probably would not include Web developers and/or computer programmers. The solution proposed needs to be self-explanatory and easy-to-use; and
- The atlas needs to be built in such a way that it can be accessed using different of computers. Therefore the solution proposed should lead to the publication of atlases delivered over the Internet (using dial-up and broadband connections) as well as stand-alone, from a CD-ROM version.

There are two different approaches that can be used to publish SVG maps on the Internet:

- **Client-side SVG -** SVG files are loaded into the client's computer and run independently (this part of the template is already implemented); and
- **Sever-side SVG** – In this case, considering budget restriction cited previously, a *MySQL* databank, which is an open source application, containing the geometry information to be inserted into SVG maps will run on a Web server. PHP, another open source application, can be used to communicate the client with the server and deliver the maps.

Here the client side approach was adopted. After the analysis of the contents of the atlas, the source of information in this research, a set of four templates was developed. These templates aimed to cover different types of information architecture that could be implemented in a local school atlas. The templates developed were:

- **Template 1:** applied to linear presentations;
- **Template 2:** to help developing clickable maps;
- **Template 3:** to be applied when the text is the main focus of attention; and
- **Template 4:** to help developing maps with interactive zoom and pan.

In order to assure that the proposed templates would be designed for viewing on most computer displays used in Brazilian public schools an 800x600 display resolution was adopted.

The topics within the atlas were summarised so as to create an optimised navigation menu. It was established so that the menu would be located at the top of each page.

After testing different interface designs, it was decided that an approach would be that Brazilian primary school students be invited to design the navigation bar for the atlas. The involvement of students in this stage was considered beneficial, because it not only engages students with the application but it also removes the need for the developing team to design the navigation bar.

30.5 Interface Design – Template 4

Template four will be used as an example to illustrate the development process. This template focuses on the implementation of a map with an interactive legend and a navigation map for interactive zoom and pan functions. Due to the high level of JavaScript coding necessary to develop this kind of interactive map it was decided that this map would be always available in a separate window (pop-up). Therefore the Web-map developer should not be concerned about any other content but the map itself.

The design for Template 4 is shown in figure 3.

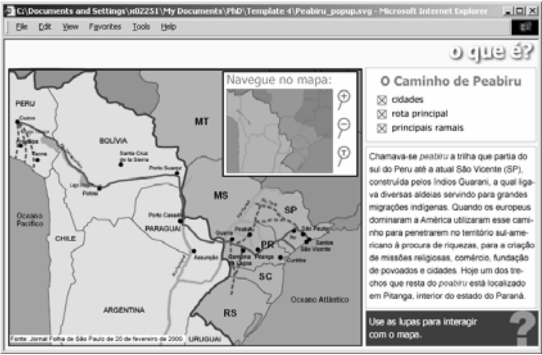

Fig 3. Interface design for Template 4.

In this template, the emphasis was placed on four elements. The first is the map itself. As the original map was provided as a vector file (*Freehand* format) it could be converted into SVG. In this way separate graphic elements within the map could be manipulated by using an interactive legend.

The interactive legend, placed on the top right corner of the main map, allowed the user to make the layers of information invisible. Another interactive legend allowed the user to control zoom and pan in the main map. This legend was located inside the main map's frame so that an additional text box could be placed to the right. This location is not essential and this navigation map could be placed out of the main map's area as required by the developer.

The final important element in the interface design is the help box, in blue, located on the bottom right corner of the window. The text was this box, also seen in other templates, changed according to the movement of the mouse pointer on the screen.

30.6 Template four – code and interaction

The JavaScript code used in this template was adapted from carto:net. The template code was extensively annotated so users would see how they could adapt the code to their needs. For example, the main map on the left side (figure 4) can be replaced with the user's map. The code is annotated throughout so as to identify the pieces of code that must be replaced. See Sample Code 3 for an example of these comments.

Sample Code 3. Example of comments provided into the SVG Templates.

```
<!-- ***********************************************************************

************************  M A I N  M A P  **************************
********************************************************************
* This part of the code should be replaced with your map, the id   *
* "main_map" must be kept and all graphic elements must be grouped *
* into the g tag named "complete_map". References to CSS have to   *
* be updated into the CSS section earlier in this code             *
**************************************************************** -->

<svg id="main_map" x="5" y="35" width="396" height="356" viewBox="0 0
2200 1980">
       <g id="complete_map">
       (…)
       </g>
</svg>

<!-- ***********************************************************************

****************** E N D  O F  M A I N  M A P  *******************
**************************************************************** -->
```

After inserting their own information into the SVG template the user has to adapt the JavaScript code to be able to use interactive functions. In Template 4, a small navigation map is provided with interactive zoom controls next to it. The zoom symbols as well as the JavaScript used to handle them were adapted from cartonet <http://www.carto.net>. By manipulating the navigation map the student will be able to pan the main map and change its zoom as well. Additionally, the help area is provided on the bottom right corner. Help messages change according to mouse move events over different objects, this is believed to be a valuable feedback to the students on how to interact with the map.

Firstly, the developer is advised to insert their map into the main map section of the code. The navigation map is a reduced version of the main map. The pieces of code that should be changed in order to make the navigation map and the interactive layers work are also extensively annotated. Sample Code 4 illustrates the implementation of the navigation map within the SVG code.

Sample Code 4. Creating the navigation map.

```
<svg  id="referenceMap"  x="411"  y="203"  viewBox="0  0  2200  1980"
width="158" height="142" pointer-events="none">
      <use xlink:href="#complete_map" />
</svg>

<!-- ***************************************************************
* This is the object that will control the zoom tool, it has to be  *
* the same size as the reference map and needs to overlap it.        *
* Therefore use the same width, height, x and y as the reference     *
```

```
* map. Do not change any other part of the code.                       *
*****************************************************************-->

<rect id="dragRectForRefMap" class="dragRect" x="411" y="203"
width="158" height="142" onmousedown="myRefMapDragger.drag(evt)" on-
mousemove="myRefMapDragger.drag(evt)" onmouseup= "myRefMapDrag-
ger.drag(evt);myMainMap.newViewBox('dragRectForRefMap','referenceMap'
)"/>

<g id="navigatorElements">
      <text class="allText subTitleText" x="411" y="195">Navegue no
        mapa:</text>
      <use id="zoomIn" transform="translate(590,215)"
        xlink:href="#magnifyerZoomIn" onclick="zoomIt('in');" on-
        mouseover="magnify(evt,1.2,'in');" onmouse-
        out="magnify(evt,1,'in');" />
      <use id="zoomOut" transform="translate(590,265)" xlink:href=
        "#magnifyerZoomOut" onclick="zoomIt('out');" onmouseover=
        "magnify(evt,1.2,'out');" onmouseout= "magnify(evt,1,'out');"
        />
      <use id="zoomFull" transform="translate(590,315)"
        xlink:href="#magnifyerFull" onclick="zoomIt('full');" on-
        mouseover="magnify(evt,1.2,'full');" onmouse-
        out="magnify(evt,1,'full');" />
</g>
```

The <svg> object named ‘referenceMap’ corresponds to a reduction of the developer’s map, called ‘complete_map’. The object called ‘dragRect-ForRefMap’ controls the interactive zoom and pan. The user is advised not to change the functions called on the events mousedown, mousemove and mouseup.

The <g> object called ‘navigatorElements’ comprises the interactive icons for zoom in, out and zoom to extent. The user can change x and y coordinates at their will. Sample Code 5 shows the changes that have to be done in the JavaScript code in order to implement the interactive zoom and pan tool.

Sample Code 5. Necessary changes in the JavaScript code.

```
function init(evt) {
    svgDoc = evt.target.ownerDocument;
    myMapApp.resetFactors();

    // In this line change the values.
    // 2200 is the bottom right coordinate of the navigation map
    // (referenceMap)
    // 100 is the minimum zoom
    // 200 is the maximum zoom
    // 0.6 is how much the system will magnify the map each time
    // the user clicks on
    // the magnifying icon
```

```
      myMainMap = new map("main_map",2200,100,200,0.6);

      // to adapt this line to your map:
      // 411 is the x coordinate of the top left corner on the
      // navigation map
      // 569 is the x coordinate of the top right corner on the
      // navigation map
      // that is (x coordinate + map width)
      // 203 is the top y coordinate on the navigation map
      // 345 is the bottom y coordinate on the navigation map
      // (top y + map height)

      myRefMapDragger   =   new   dragObj("dragRectForRefMap",411,569,
203,345,"ul");

      actualzoom = 1;

      // the variable group_el stores the map object that will have
      // the scale changed
      group_el = svgDoc.getElementById("main_map");

   }
```

The only necessary changes to the code are noted in Sample Code 5. Many other functions are included into Template 4, however the user is advised not to change them, including the help messages that will be displayed according to the mouse move event.

30.7 Final Product

The interface design of the final product includes a menu bar with interactive buttons proposed by Brazilian primary school students. Figure 4 illustrates selected screen shots of the interface design adopted in the prototype of the *School Atlas of Rio Claro.*

The prototype was tested in Brazil, with a group of primary school teachers. The templates were also tested with a group of Brazilian atlas developers. Brazilian primary school teachers were in contact with the digital atlas prototype during two weeks. In this time they were given a number of questionnaires where they were asked to identify interface elements, interactive functions and difficulties they had dealing with the product.

Brazilian atlas developers, mainly graduate candidates from Brazilian universities, used the templates proposed in this research to develop a prototype atlas product. Their product was developed using the combination of HTML, SVG and JavaScript proposed in the templates. The main outcomes of both tests were:

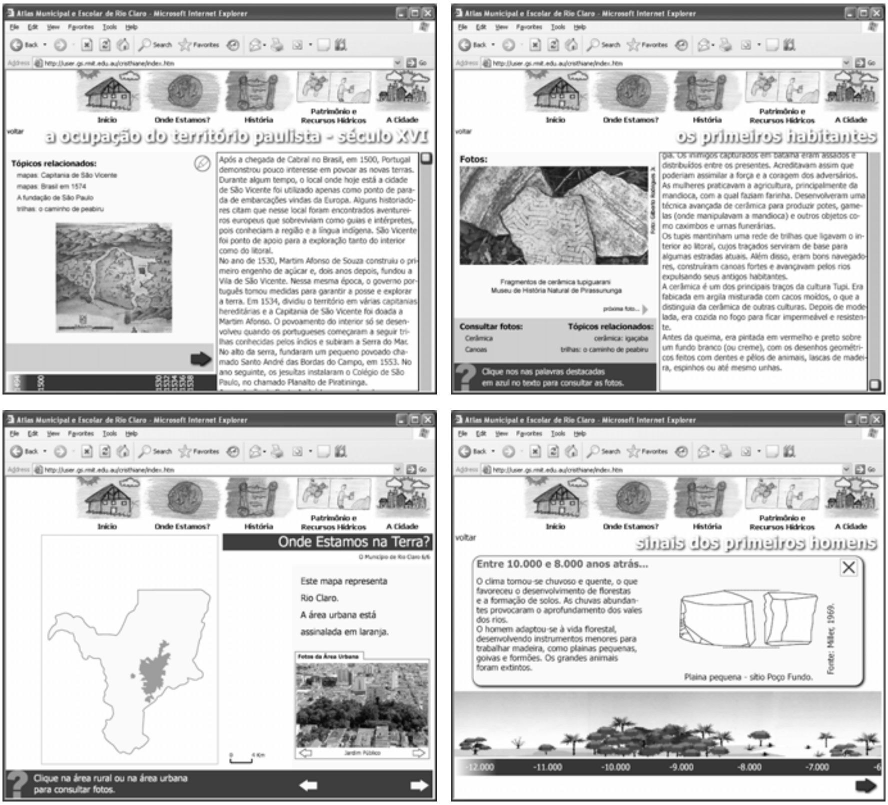

Fig 4. Selected screen shots of the School Atlas of Rio Claro.

- The methodology for publishing SVG-based atlases can be used by Brazilian local school atlases developers. A group of Brazilian atlas developers published a small Web atlas using the templates provided;
- Primary school teachers were eager to use Brazilian Web atlas applications for educational purposes. Therefore if Brazilian developers of local school atlases start exploring the Web as a publishing medium, the atlases they produce will have a higher visibility and will thus be more likely used by teachers in their educational practice;
- The development of a hybrid atlas empowers teachers, encouraging them to improve the content of their 'own' digital atlas, proposing practical activities on paper to be incorporated within the product. In this

way the teachers are able to go a step further, they are not passive users, but rather active and critical users; and

- However, generally, teachers lack interactive cartography experience and may only reproduce paper facsimiles.

30.8 Conclusion

The product development discussed in this chapter aimed at developing a methodology for publishing Brazilian local school atlas on the Web that would be easy-to-use and inexpensive. A low cost solution for publishing atlases on the Web is considered necessary in Brazil because most local school atlases are developed by academic teams with research funds which are, most of the time, very limited. Open Standard Technologies were chosen as the main tool for developing such products because they can be used at no cost. The use of SVG and JavaScript to produce online school atlases proved to be very effective. The final product, tested in Brazil with primary school teachers, received a very positive feedback.

The experience described here illustrates that it is possible to develop a digital local atlas for education at greatly reduced costs. It is also possible that, in the future, Brazilian public universities can use their practical knowledge, developed through many years of work with paper atlases, to publish their products directly via the Internet, using the SVG Atlas Templates developed as part of this research. Nevertheless, it is believed that the main outcome of this project will be the 'digital inclusion', not only of public school children, but also of Brazilian children's atlas developers.

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31 Cartographic Approaches to Web Mapping Services

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31.1 Introduction

To understand the nature of thematic maps Dent (1999) conceptually split thematic maps into two principle parts, base-maps and measurable local characteristics (thematic data) (Figure 1). Thinking of a map as having both location information (base-map) and the spatial distribution of a phenomenon (thematic data) simultaneously is a cornerstone of contemporary geospatial science. Berry (1964) put forth the ‘Geographical Matrix’ where many spatial phenomena in an area could be maintained within a computer system. Once the geographical matrix was built, any number of thematic layers could be used in a spatial analysis model. This data structure, computer system, and spatial analysis tool are the fundamental elements of Geographic Information Science (GIS). Since Berry’s (1964) original description of the geographic matrix, many have understood that several spatial phenomena are collected based on a common geographical framework. The data collected during the US Census is aggregated based on a common geographic framework of country, regions, states, counties, … blocks. From a cartographic perspective, a geographic framework is equivalent to a base-map. For the cartographer dealing with both thematic and base-map data has been a significant challenge (Cammack 2005). For the thematic cartographer, finding good base-map and thematic data has always been difficult. For a large National Mapping Organisations (NMOs) (Hootsmans, 2001) such as United States Geological Survey (USGS), building and maintaining just the base-map data for the USA is a challenging task. Both the USGS and US Census Bureau are constantly maintaining and developing both base-map and thematic data sets.

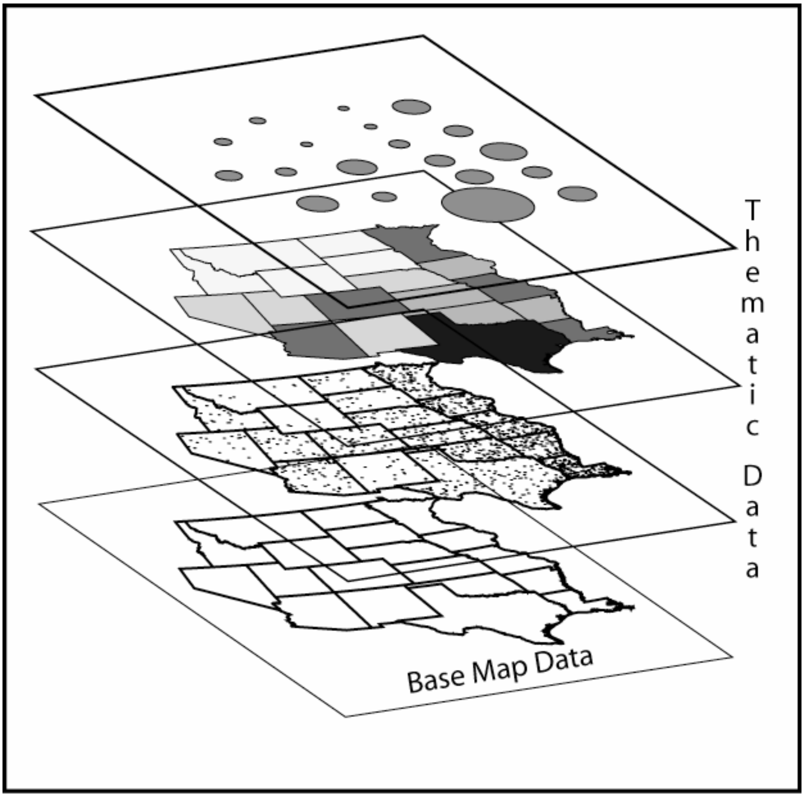

Fig. 1. Base map data is the foundation for the display of thematic data.

Because the USGS has developed a set of digital base map products, cartographers could use this base-map data with their thematic data and produce thematic maps for map-readers. Map users in the areas of humanities, social sciences and sciences could theoretically add their data to a NMO's base map data and generate maps for their topical focus. During this desktop mapping period, the number of thematic maps produced from distributed digital base maps was remarkable for its number and diversity. Changes in technology have lead to different eras based on the methods for gathering and distributing base-map data (Figure 2). As the eras progressed, the number of maps increased significantly due to increases in production efficiency and technology.

One way to understand this steady change in the method of base-map distribution is shown in Figure 2. Four eras and three transition periods have occurred in the last 60 years. At the start, base maps were drawn by hand and reproduced on paper, then sent to thematic cartographers to draw on. This paper or analog era has the longest history and lowest efficiency for thematic map production. The first major transition was the move from analog to digital. Once the digital era began cartographers were constantly looking for larger and faster means of sending digital base-map files to one another. Some of the media types include 8 mm tapes, floppy disk, CDs, DVDs, and flash drives. This method is still common today but other technologies are rapidly reducing their use by cartographers.

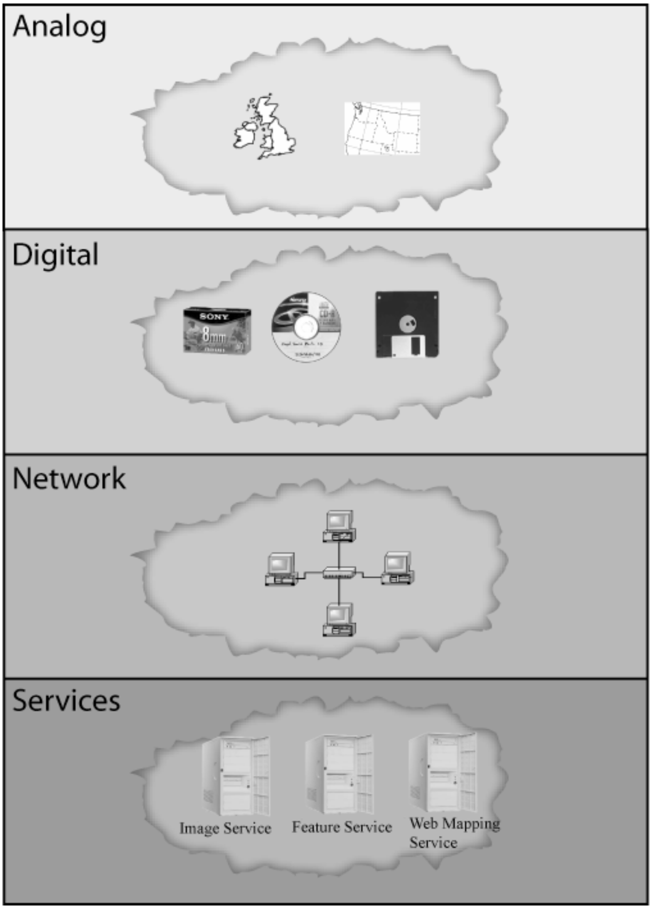

Fig. 2. Eras of base map data distribution.

The next transition period can be labeled the single to network transition. Two fundamental computer technologies made it possible for this transition. These two computer technologies were the low cost computer workstation and computer networks. By combining these two technologies, thematic cartographers could get digital base-map data across the network and have enough local computer power to create the map. Within this network era the Internet was developed. The Internet, causes individuals to see networks as either a local area or a wide area network. Base-map providers could place their data on either Entranet or Internet servers and allow both restricted and open access distribution of base-map files. The network era allowed the rapid distribution of base-map data in both the enterprise and public arena. For both the digital and network eras, individuals wanting to use base-map data would need a significant amount of knowledge, computer hardware and software to make use of the digital base-map files. Since one goal of many cartographers is to allow thematic data gatherers to work seamlessly with data from base-map providers (Cammack, 2005), the development of the Internet has made it possible to distribute information to a worldwide audience at a level never seen before. The development of the Internet and it's offshoot the World Wide Web, has given the NMOs a new set of tools that will allow them to distribute base map data to thematic context gatherers.

Yet another factor is common between the analog, digital, and network eras. This factor is the untethered (Figure 3) nature of the source base-map and the distributed base-map. In all three of these eras, once the base-map was sent to the thematic map user, the base-map provider could not control its base-map data. The significance of this untethered approach comes from the temporal nature of all information. As time passes all data will eventually move from the category of current information to historical data. Depending on the nature of the map being produced, only the current data is need. With this untethered distribution methodology of the analog, digital and network eras, base-map and thematic data products need diligence to insure temporal congruence between both data types.

The final transition period is currently underway. All reasons for this transition are not clearly understood. Many reasons may be related to pure economic factors that will quickly become obsolete. Other justifications may eventually be seen as a clear paradigm shift that has long lasting influence. The latest technology to be developed for base map distribution is the Web Service (WS). A specific WS that is related to cartography is the Web Mapping Service (WMS) (Figure 4). With WMS a new era of base-map and thematic data, interaction is possible. Currently the WMS era still requires thematic cartographers to have a significant amount of knowledge, computer hardware and software to make use of the digital base-map files. The fundamental difference between the network and WMS era is time. With the analog, digital, and network eras, updating base-map data was not automatic. Thematic cartographers would constantly have to check or wait for updates to be made and distributed by base-map providers. In the WMS era, once the base-map provider updates their WMS, the thematic cartographer can use the latest base-map data in their maps. The change will allow topics such as traffic patterns, air and water quality maps to be developed and distributed much faster and with temporal accuracy. With the base-map data and the thematic data tethered to its given creator and passed automatically across the Internet, cartographers have moved closer to the synchronize development of both base-map and thematic data into a map.

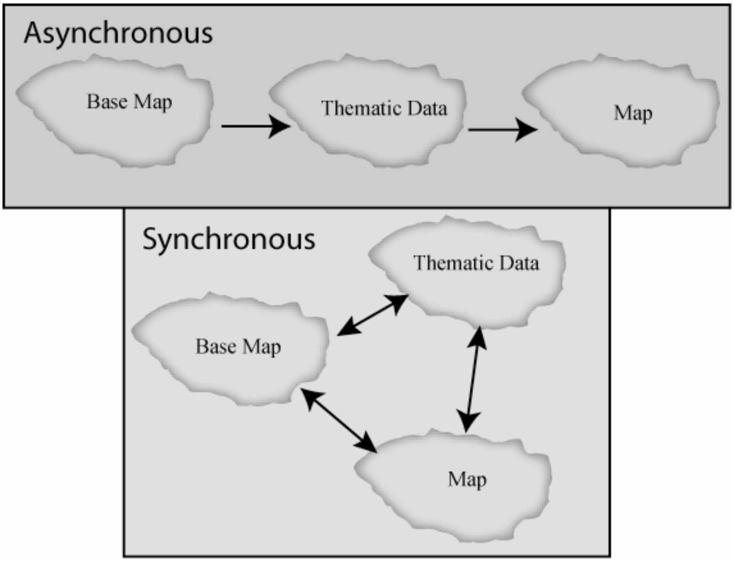

Fig. 3. The integration of thematic and base map data to develop a map in either a synchronous or asynchronous manner.

31.2 Web Map Services

WS are a rapidly growing part of the Internet. Cartography has long been a part of the Internet (Peterson, 2005) prior to the development of WMS. In this research, a definition similar to the Open Geospatial Consortium's (OGC) definition of WMS is used. This definition states that a WMS is one or more Web map services or Web feature services that distribute map data to Internet clients. The one difference between the two is the inclusion of the OpenGIS specification standard in the Open Geospatial Consortium (2004) WMS definition. By excluding the OpenGIS specification this definition can be within the entire IS community. To further explain this definition, the concepts of a Web map server and Web feature server will need to be explained.

The Web map and Web feature servers both manage and distribute map data. Websites can use data from WMSs and produce a map component for a given Web page (Figure 4). Mapping data from a Web feature server comes as feature data, i.e. vector data to a Website, while image based data sets are distributed by Web map servers. The OpenGIS standards definition for both of these WMS types can be found in the Open Geospatial Consortium (2004).

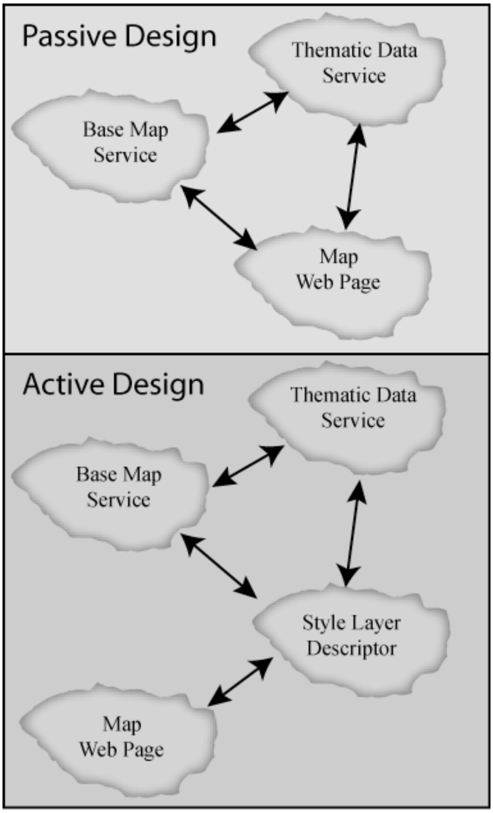

Fig. 4. Passive and active models for designing Web maps with Web mapping services.

The OGC defines several different types of Web mapping services but all of these services are just a part of the larger term WS. A Web service is a functionality that is exposed to the Web and has a standard interaction format (Zaslavsky, 2003). The service must be implemented in a platform independent standard. Zaslavsky (2003) traces the standards history from present day Simple Object Access Protocol (SOAP), Web Services Definition Language (WSDL) and Universal Description Discovery and Integration (UDDI) to its predecessors Common Object Request Broker Architecture (CORBA) or Distributed Component Object Model (DCOM). Some of the current development of WMS uses the SOAP/WSDL/UDDI standards. Microsoft's *MapPoint .NET* and ESRI's *ArcWeb* were developed with these standards (Zaslavsky, 2003).

By developing WMSs, base-map data providers are distributing their data in real time. This real time distribution allows thematic cartographers to get the most current base-map information whenever a map-reader wants to use their thematic map. Figure 3 shows some of the different methods used to distribute base-map data. The temporal disconnect between the base-map data and distribution of the thematic data could be days, months or years. For the thematic cartographer this temporal disconnect can have a devastating effect on the map-readers confidence in the accuracy of the maps being distributed. If the map-reader has little confidence in the information from a thematic map, it is likely that "geo-communication" (Bordersen, 2005) between the thematic data and the map user will not occur.

31.3 Web Map Design

Many cartographers have been concerned with the quality of maps produced by digital methods. In the early history of digital cartography maps from computer programs like SYMAP, developed as general-purpose mapping package in 1964 at the Harvard Laboratory for Computer Graphics and Spatial Analysis were viewed with great skepticism. As the digital technology has improved the skepticism has increased and decreased periodically. The latest skepticism has revolved around the use of WMS and the lack of control for symbology. The criticism of WMS is based on cartographers employing the pass design model of WMS (Figure 5). In this model the cartographer uses the standard symbology delivered by the WMS. For cartography this is the quick method of getting a map for a Web page with little effort. The passive model works well for an internal WMS project, where all the WMSs are developed and designed for a single map on the Web. But this model limits the overall intention of WMS. The WMS is designed to be a distribution service open to anybody needing the information in the service.

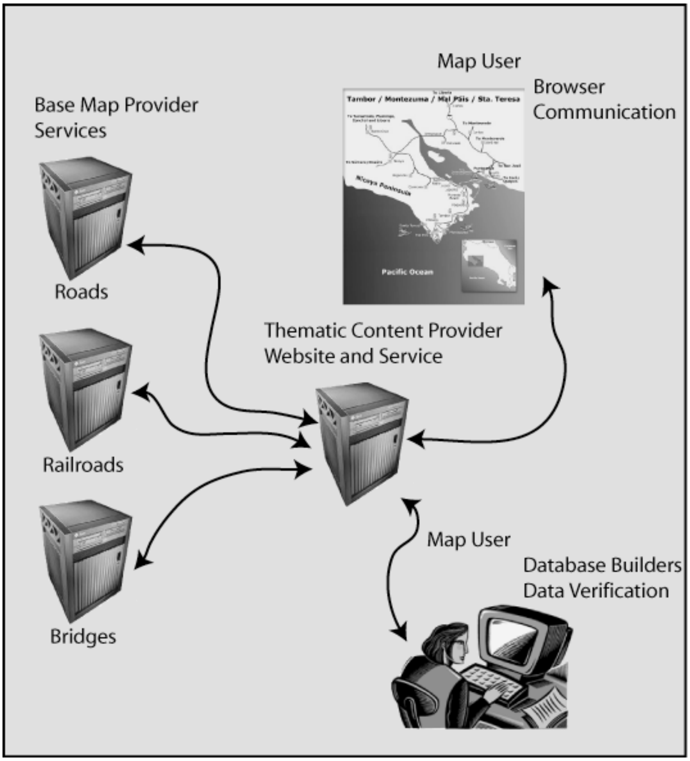

Fig. 5. Simple model for creating and distributing thematic maps on the Internet using Web mapping services.

In this open data environment, cartographers should use an active design model (Figure 5). In the active design model cartographers should employ the Style Layer Descriptor (SLD) component of the WMS model. SLDs are not well understood and implemented in only the most advanced mapping Website. Ibanez et al. (2005) show how to design a SLD through a design tool they developed. The design tool develops a SLD document that a mapping site can use to request spatial data in the graphical format needed for its map product. One implementation example of SLD is the USGS's National Map project (USGS, 2005). The National Map creates SLD settings for all of their geospatial partners supplying base map data to the project. With SLD, the USGS can create consistent map symbolization across a geographic region in the USA. SLDs are focused solely on symbolization of data. Many of the actions within cartographic abstraction

(Robinson et al. 1966) such as selection generalization are still problematic. One of the biggest problems occurs when similar data entries from different WMS are shown simultaneously. The generalization of the features will not correspond, so the same road might appear twice but not in the same spatial location. The weakness the WMS will need to address is improving the quality of cartographic displays. Callejo et al. (2005) developed a method for expanding the functionality of SLD. This type of functionality is not a part of the OGC WMS standard, but as time passes the standard will be improved and functionality like the one developed by Callejo et al. (2005) will be reviewed and included.

31.4 Thematic Information

Cartographers have always focused on map production methods. Because of this focus, aerial photography, photogrammetry, remote sensing, global positioning systems (GPS) and geographic information systems (GIS) have long been a part of the cartographic educational experience. In the case of thematic data, cartographers must learn to process this information so that it can be transformed into a map. The steps to processing this information are being able to find thematic data by:

- Identifying the data type of the thematic data;
- Converting the data into a mapping system;
- Determining an appropriate map type for the data;
- Classifying the data; and
- Symbolizing the data.

An experienced cartographer simply does the task, but for the non-cartographer all of these tasks can seem impossible. What is missing from this list of tasks is the process of gathering or creating thematic data. As previously stated, individuals from many other fields constantly gather thematic data. It's not practical to have cartographers learn how to do all of these methods, but cartographers should consider how to support thematic data gatherers.

The decennial census taken by the US Census Bureau is one of the largest data collection efforts in the world. Many of the cartographers that use US Census Bureau data make an uncountable number of maps from this data set, but most of the cartographers have little knowledge on how to create such a survey. Again, the focus of cartographers has been on the process of making maps. But for thematic data gatherers like the US Census Bureau, the method of data collection and organization is their expertise area. The US Census Bureau is an easily recognizable thematic data gatherer, but it is not a prototypical type of thematic data gatherer. Since the development of computer mapping, the US Census Bureau has used several aspects of cartography as a foundation for its data collection and distribution processes.

A prototypical example of data gathering would be a botanist who is studying the migration patterns of a species. Before a botanist goes out to the field, he or she researches any relevant migration data published for their chosen species. With this research in hand the botanist will begin their field observations. The scientist will use their preferred method of data collection. With the data set the botanist will want to create maps showing the migration patterns of the species. At this point in the scientific process base-map data is needed. Still today a significant amount of the thematic data is attached to old or out of data base-map data. The base-map data of the botanist's study area may or may not be updated. This temporal disconnect (Figure 3) from the base-map data and the thematic data could lead to some significant misconceptions regarding the meaning and value of the thematic data.

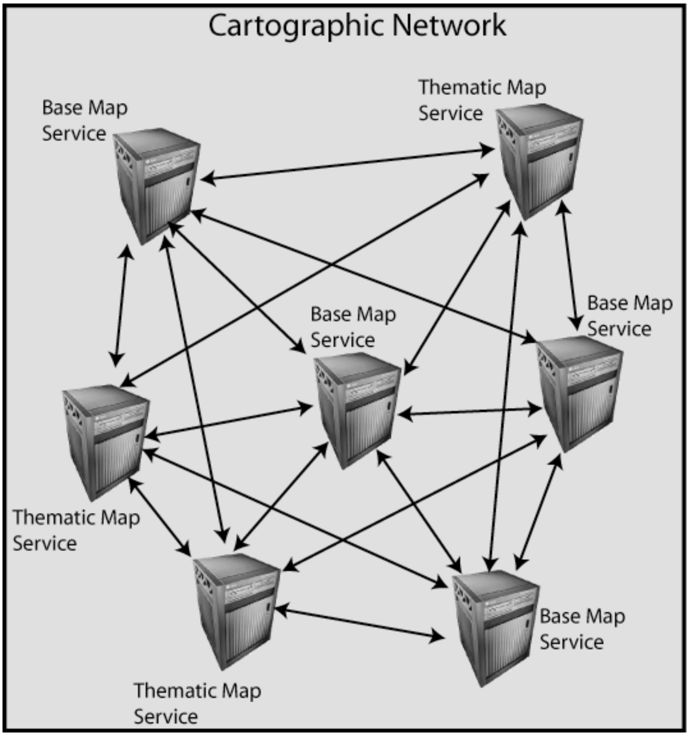

Fig. 6 This abstract model of a cartographic network shows a mixture of both base-map servers and thematic servers.

A solution to the temporal disconnects between the base-map provider and thematic data gatherer is to use WMS (Figure 6). This WMS solution shows that the thematic data gatherer can draw on the base-map data from base-map providers in real time. Cammack (2005) describes two distinct advantages to this approach.

- Use of real time base map data during thematic data collection; and
- Use of real time base map data during thematic data distribution.

Synchronized base-map data being used for both the collection and distribution of the thematic data, the thematic data gathered will have better data accuracy. WMS allows for a team of researchers to gather and share thematic data gathered during the thematic data collection process (Fig. 6).

31.5 Cartographic Network

Cammack (2005) stated "One of the earliest goals of geospatial science communities after the development of digital cartography and the Internet was to develop some sort of basis geospatial data infrastructure." Several countries or groups have developed independent approaches for building this geospatial data infrastructure:

- NSDI (National Spatial Data Infrastructure);
- GSDI (Global Spatial Data Infrastructure) ;
- INSPIRE (INfrastructure of SPatial InfoRmation in Europe);
- Geography Network (ESRI);
- MasterMap (Ordnance Survey);
- Imagi (Inter-ministerial Committee for Geoinformation); and
- Etc…

Similar sets of goals are shared by all of these groups.

- Data format standard;
- Metadata standard;
- Process standard; and
- Data transfer standard.

The data transfer standards were developed before WMSs. WMSs are a logical extension of the data transfer standard. Instead of sending the raw data file, a WMS sends a fully symbolised map layer to the client. With the continual development of WMS specifically, and Web service in general, most of the cartographic criticism for map design may be overcome. The scientific community has long benefited from the division of labor. WMS has taken steps forward by developing the infrastructure for the cartographic network (Cammack, 2005). Cartographic research will continue to refine this process to reduce the cost and complexity for thematic data provided to connect to the cartographic network.

31.6 Conclusions

The progress of the geospatial community to develop WMS has opened the door to great knowledge sharing. The creation of a cartographic network that is open to all thematic data gatherers for use before and after data collection in a synchronized method can only improve scientific understand of spatial phenomena. WMS are a pathway for the discovery, distribution and understanding of scientific knowledge. As this scientific knowledge base becomes widespread through the Internet, the process of discovery could accelerate and create new and exciting opportunities for research in cartography and all the sciences. Although the current implementation of WMS is limited and has some serious drawbacks, this initial step creates numerous advantages for the cartographic process.

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32 From Mapping Physical and Human Geographies to Mapping 'Personal Geographies': Privacy and Security Issues

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32.1 Introduction

Using the Web and Mobile devices for location information provides users with access to a plethora of geospatial resources or an immediate at-location service. We have become attuned to using the Web as a 'first-stop' virtual shop for all things geographical. And, the Mobile Internet, accessed through the use of mobile telephones or enhanced Personal Digital Assistants (PDAs), enables us to bring map artifacts, commerce and information resources to us, wherever we require the service. Our whole approach to finding and using cartographic artefacts has changed. But, it is argued, at a price – the loss of privacy.

Consider accessing 'free' geographical information using the Web. Prior to actually downloading data, services or digital products we are usually obliged to provide certain details of ourselves. This can range from general profession/country information to those of a more specific nature. With mobile telephone use the service provider knows, fairly precisely, where we are and who we are when a location-based service is requested and subsequently delivered. We have sacrificed privacy for almost instant access to digitally-delivered information.

This chapter addresses the issue of privacy related to the use of Web-delivered and mobile telephone-provided geographical information. Firstly, it looks at the general issue of privacy and how it affects the delivery of information using contemporary communications systems. Then it looks at the loss of privacy that has occurred when ‚new' communication systems are introduced. Then it considers how service providers have compromised privacy with online and wireless systems. It then covers aspects of security and privacy initiatives. Finally, it comments on problems with developing technology and some of the privacy and security issues that need to be addressed by the geospatial science industry involved in the delivery of Location Based Services (LBS).

32.2 The Internet and information access

The extent and the use of the Internet have now matured to a point that users see it as an everyday commodity or communications device. Education has embraced it for content delivery, face-to-face lecture support and as a tool for students to keep in touch with academics and peers, and to conduct day-to-day administrative and general queries. Industry uses it as a tool for facilitating more effective logistical approaches. Commerce uses it as a means for linking their services. And, business views it as a conduit for marketing, selling and delivering (digital) products.

Use of the Internet has grown tremendously, but its use is relatively new, and there are major issues of concern related to security and privacy. It is argued that with the Mobile Internet these issues are compounded when the receiver/transmitter (a cellular telephone or an Internet-enabled Personal Digital Assistant (PDA)) is included in the formula. Those provisioning users with map products and services related to the 'Location-Based Services' phenomena must be aware of the potential personal risks associated with 'someone else' knowing where users are at any given time, their movement history and their activities linked to them being at a certain location. Using the concept that LBS (Location based Services) now needs to map 'Personal Geographies' to enable this genre of geospatial information provision to ‚work', this chapter addresses the issue of privacy related to the use of the Mobile Internet and the responsibility we, as providers or facilitators of geospatial information delivery via the Web or by providing support for LBS projects, have to ensure that a user's privacy is not compromised and that adequate privacy and security standards are developed for this sector of the industry.

32.3 Mapping Personal Geographies

Maps use small-scale space to represent large-scale (geographic) space. How they are designed, developed and produced vary and the 'rules' used to guide design and the 'foundations' upon which they are built can vary. There are a number of ways for visualising / expressing the world and a number of them have been adopted by sectors of the mapping industry. The most common method is the Mathematical (or Surveyor's) view that can be seen to be near-Euclidean. This results in a map that is both positionally correct and accurate. However, this type of impression of the world is not always the most usable. But, the very basis of gathering the content for these maps is based upon building a 'picture' of either human geography or physical geography. For Location-Based Services, whether they are delivered via the Web or on mobile devices, depend upon knowing the location of the user to work. Thus a users 'Personal Geography' must be mapped.

Building a database of a personal geography demands that information is collected about the movements of an individual. This needs to be undertaken irrespective of whether the user is accepting location-defined services or not. The users personal geography is ‚built' on activities that include those that are directly related to the services they request, but perhaps the major part of the data collected has no relevance to the service being used. The user accepts, knowingly or unknowingly, wittingly of unwittingly, that their privacy is compromised if they subscribe to particular services.

The delivery of other mapping services sometimes has demanded that part of the user's personal geography be divulged, say, by providing an address or defining a study area. But, the collection of personal travel data, movements and time spent at various locations, especially when mobile devices are used, uses ubiquitous computing technologies and, in many cases, the user may be unaware of the extent of the data being collected about them, or they may have forgotten that this is always taking place. Therefore there exists the need to consider privacy when product delivery methods are determined. And, this was perhaps not the case when cartographers 'just' produced maps, removed from the actual delivery and use.

32.4 Privacy

Monmonier (2003) covered the issue of privacy and the Internet and coined the term “”locational privacy” (p. 99). He addressed the issues related to the use of the Internet and GPS-enabled mobile appliances. Related to 'tracking' users, he focussed on 'known' tracking, where law surveillance agencies and organisations could follow the movements of known criminals and automobiles, individuals could subscribe to 'child-tracking' or keeping tabs on elderly parents (Monmonier 2003). The approach of this chapter differs to that of Monmonier, insofar as it addresses the unknown (to the user) surveillance possible with LBS (Location-Based

Services) and the confidential or private information we, as users, readily offer to providers of services and goods in return for speedy delivery, online transactions or services and information delivered directly to desk-bound or mobile device.

For example, loss of privacy was a trade-off for the US Federal Communications Commission's decree that all providers of mobile telephone services needed to be able to locate a caller in an emergency to the nearest 125 metres (Monmonier, 2003, from Divis, 2000). This was in response to findings that showed that US 911 (emergency) dispatchers had reported that many callers to their facilities in emergency situations did not know where they were. However, technical problems have stalled the introduction of services that can provide the required positional accuracy.

32.5 Going on-line with the Internet

With the Internet now take for granted this global system that provides us with access to information from almost anywhere in the world. The simple use of email illustrates how digital global communication changed the way information transfer and privacy was viewed. An on-going debate has been conducted in the USA regarding the amount of control government should have over encryption and the 1994 Communications Assistance for Law Enforcement Act (CALEA) to preserve law enforcement's access to communications. The Act required that telecommunications common carriers had to ensure that their systems could satisfy law enforcement electronic surveillance requests (Berman 1997).

Also, early in the use of the Web privacy and access became issues. In 1994 many countries restricted or banned satellite dishes to reduce Western influence. And in 1996 restrictions on Internet search engines use in China, Germany, Saudi Arabia, Singapore and New Zealand were introduced. In a 2001 review of 750 commercial Web sites conducted by Consumers International, a worldwide federation of 263 consumer organisations, it was found that two-thirds of the sites examined had collected personal information about visitors to their site. 60% of the sites lacked a privacy statement. Only 9% of European sites asked for permission to sell customer-provided information, 20% asked for approval before adding users to mailing lists and 15% of the sites gathered information in ways that were invisible to the user. Some sites transferred customers' credit card information over unsecured connections (Evers 2001).

For mapping, users do need to be aware what the limitations are when they use a site and what possible consequences might result. For example, the actual location of individual Web site users is able to be tracked. Quova, Digital Envoy, NetGeo and InfoSplit, offer ‘geolocation services’ (The Economist 2003). Their databases link IP addresses to particular computers, and then the location (country, organisation and the actual location of the computer) can be ascertained.

32.6 Going wireless

The first cellular mobile telephone network was introduced in Japan in 1979. Since then the coverage and the use of mobile devices has grown tremendously. We have small, portable devices that keep us in contact, constantly and instantly. But we can be ‘overheard’ accidentally or deliberately. There exist numerous devices to eavesdrop on mobile telephone conversations. And, as Berman (1997 p. 4) points out *“Cellular eavesdroppers are invading the privacy not only of the person who is using a cellular phone, but also of anybody else who is in on the conversation using an ordinary landline telephone.”*

In the USA the Electronic Communications Privacy Act (ECPA) was introduced in 1986 and in 1994 the Communications Assistance for Law Enforcement Act (CALEA) (Berman, 1997). CALEA extended legislation to cover email and mobile telephone conversations. According to Berman (1997, p. 3) *this “…gave an important degree of credibility to those communications media when they were in their infancy, contributing to the dramatic growth that they both have undergone”.* The Act of 1986 made it a federal crime to intercept mobile telephone conversations and to manufacture, sell, assemble, possess or advertise any device that could be used to intercept conversations. However, the anti-terrorism Act of 1996 repealed the provision (Pub. L. 04 –132, section 731) (Berman 1997).

The Federal Bureau of Investigation (FBI) has pushed to be able to physically track users of mobile telephones. However, the events of 9-11 have changed what is seen as essential information to be kept private. The US has proposed the “Location Privacy Protection Act 2001 to forbid telephone providers from providing information without consent. And, the Wireless Location Industry Association provided self-regulation guidelines whereby users are able to either ‘opt-in’ or ‘opt-out’ of the release of positional information (Monmonier 2003).

Another ‘wireless’ application is the availability of Wi-Fi (Wireless Fidelity), which provides immediate wireless access to the Internet. Websites, such as *wifinder.com* and *80211hotspots.com*, are used as global directories of Wi-Fi base-stations, and sites are located by entering a postcode or a particular address (The Economist 2003). There is a perceived need to publicise WEP (Wired Equivalent Privacy) and the use of encryption tools when using these network access facilities (Wired News, 2003). Consider the problems that could be encountered if a mapping package depends upon accessing, say, *Bluetooth* via Wi-Fi if proper and integrated security systems are not in place.

Wireless is now seen as part of the Internet, and not distinct. It is increasingly being used as a ‘gateway’ to resources provided via the Internet and it demands the same degree of security and privacy infrastructure and checks as does ‘wired’ Internet nodes. Conversations are not the only communication that needs protection, it is also the very data that is being sent or received by the mobile device and the database from which it requests that information or where information from activities like banking transactions, field surveys, etc. are lodged. Even what was considered to be ‘unbreakable’ security was expounded by Berman (1997 p. 5) as an example of what could go wrong with digital transactions, and he reported: “*In one series of transactions in 1994, an international group of criminals penetrated Citicorp’s computerized electronic transfer system and moved about 12 million from legitimate customer accounts to their own accounts around rhe world*.” For the geospatial sciences, as many contemporary practices employ mobile devices to ‘upload’ the results of surveys, sometimes into official repositories like government cadastres this is an important point to consider. The very link that makes almost ‘immediate’ updates from field parties possible may also be the means of ‘breaking-in’ or corrupting these legal repositories of data. If Citibank’s security was compromised, how safe would a land data repository be?

As a final note to this section, Berman’s address to the House Committee on Commerce in 1997 (Berman 1997) concluded with a request that Congress should ensure that wireless data transfers should be brought explicitly within the Electronic Communications Privacy Act.

32.7 Wireless and location

Currently mobile telephones have reached almost saturation point in terms of everyday use. However, using these devices to access geospatial information has not yet been properly exploited. As the information delivery infrastructure is already in place, and the fact that the graphics displays on telephone devices are always being improved, they offer the potential for delivering usable geoinformation graphics and support information like sound, or a series of SMS (Short Messaging Service) textual ‘prompts’ to assist navigation.

The ‘voice’ about privacy issues was quiet when the location of a cellular telephone user could only be located to the nearest cell, and even this location might be vague during times of intense phone use, where users might be ‘switched’ to another, less crowded cell. Obviously the accuracy of the location varied between urban areas and rural areas and from country to country, where the saturation of mobile telephone transmission towers might be different. European and Japanese companies were the first to market solutions based on these imprecise location technologies, using the cell ID (jlocationservices.com, 2000). Accuracy requirements are context and application-specific – emergency services and navigation requiring the highest degree of accuracy and weather and general information the least (Gisler 2001). The US’s e911 initiative provided for mobile telephones to be shipped with GPS locators (Landgrave 2003).

32.8 Business interest in LBS

Location services, sometimes referred to as L-commerce, has seen European operators struggling to create LBS revenue models. Short Message Services (SMS) was seen as providing the most dependable revenues from location services over the next several years (Gisler 2001). E-OTD location measurement was seen as the basis of high-value services. ‘Assisted GPS location solutions looked-upon favourably by ‘location services’ company Snaptrack and telco Sprint, who have conducted a joint case study. The industry sees that the biggest potential money earner is mobile location entertainment, especially amongst teenagers (Gisler 2001). But, Swedeberg, from Ericsson Radio Systems has noted that the immediate industry needs are in the areas of technological standardisation and security and integrity in the system (Gisler 2001).

An interesting example is the Zingo cab service in London (www.zingotaxi.co.uk) that provides a direct connection to available taxis to subscribers. Users call Zingo from a pre-registered mobile telephone, then Zingo’s location technology – Cellular and GPS for the user, and GPS for the taxi – links the customer with the nearest available taxi (Zingo 2003). The system pinpoints the potential passenger’s location by locking on to the location of the mobile ‘phone. The system operates using the UKs Vodafone, O_2, Orange, Virgin and Three cellular telephone systems. It works automatically with O_2 and Vodafone. In April 2003 there were 400 cabs using this system, with ‘several thousand’ planned (Rubens

2003). There are already some concerns about privacy. Comments solicited about Ruben's story in the BBC News 'feedback' section saw correspondents concerned about Zingo's privacy statement – *"… by calling the Zingo hailing number you give your consent to the use of your information as described above"*. But an issue was raised about how the mobile service providers, the 'partners' in this service, would use this information, or how they would release or sell this information. It was noted by another respondent that recording of pick-up and drop-off points, a process that is assumed to be part of Zingo's service, would not be allowed under the UK's Data Protection Act unless a user specifically signed-up for it (Rubens 2003).

32.9 Privacy concerns

Information and access to information is now an important commodity and an every-day need. As information is now stored digitally, we have a love/hate relationship with the systems that store our information, but control us with the same information. Our very existence, and the proof that we do exist relies on the integrity of digital data repositories that store information about us. To illustrate the importance of digitally stored data to achieving our daily goals the movie *The Net* (starring Sandra Bullock) illustrated how we rely on this information to prove who we are and to determine what we are allowed to do and the things that we can access. In the movie her (digital) identity was stolen by removing her personal digital data. It proved to be impossible to establish who she was and what she owned or had access to.

There are some concerns about how 'tracking' information will be used by employers and service providers. For example, Landgrave (2003) reported that a court in Virginia, USA, have already decided that a company providing commercial services must provide notification before using GPS services. He cites the case about how one rental car firm installed devices in its cars. One renter, who saw an "excessive speeding" charge on his bill later found that the company had used the GPS device to track the hirer's driving speed – without informing the renter. As the company had failed to inform the renter of this condition (and the associated device fitted to the vehicle) they lost a related court case.

32.10 Security and privacy initiatives

It has been noted that enterprises have resisted adopting wireless LANs due to the immaturity of management standards and security. As security means confidence in a system and confidence means increased business, providers of information services via wireless LANs are keen to 'bed-down' formal security methods and practices. As building a complex LAN to provide converged media that includes voice, video and data, requires a complex approach, single vendor and third party solutions like wireless gateways are tipped to be the means by which this will happen (ZDNet Australia 2003c).

Security and privacy initiatives have taken two distinct paths: 1. Self-regulation; and 2. Legislation. Generally the self-regulation path has been followed by US companies and the Legislation path by European concerns. However, the US is developing a number of legislation papers related to privacy and data protection related to LBS, especially through the Federal Trade Commission (Gisler 2001). These classifications can also be split into private verses governmental security and controls.

Self-regulation generally is conducted and implemented by individual companies or by consortia of companies. This involves the development of and the introduction of privacy policies and procedures. For example, US firm EPL Communications Limited require providers to pre-register subscriber mobile numbers in advance, enabling subscribers to opt-out of tracking service. An 'on/off' service allows users to select their required level of assistance and to suspend individual applications from being able to locate them (EPL Communications Limited 2003).

The Cellular Telecommunications Industry Association (CTIA) of the USA has taken a position on privacy and consumers and advocates the following:

- Inform each customer about the collection and use of location information;
- Provide the customer with a meaningful opportunity to consent to the collection of locational information before it is used;
- Ensure the security and integrity of any data and give the customer reasonable access to it; and
- Provide uniform rules and privacy expectation (www.wow-com.com)

The Wireless Location Industry Association state that members should:

- Notify subscribers hoe location information may be used;
- Offer reasonable options regarding the generation, use and disclosure to third parties of location data;
- Make every reasonable effort to ensure that location data is accurate;

- Retained location data should be secured (www.wliaonline.org).

And, Privacy Times (www.privacytimes.com) see the importance of:
- Anonymity;
- Opt-in;
- Default: no tracking;
- Purpose and use specification;
- Access/correction; and
- Security/enforcement.

These examples provide what can be considered to be ‘motherhood’ statements – good on websites, but they are so non-specific to be almost impossible to be used to ensure real privacy. Self-regulation and software controls are required. However, the problem with self-regulation is that individual companies want their security standard to be adopted as the standard. For example, Cisco and Microsoft push PEAP and Funk software and some others wish to see TTLS as the standard. Funk’s TTLS has one advantage over PEAP – scalability, providing the ability to deliver secure information to many clients and this information can be restricted via time of day access used by providers like Nortel, 3Com, Checkpoint and others (ZDNet Australia 2003b). It has been predicted that PEAP will emerge as the *defacto* standard for the Institute of Electrical and Electronics Engineers (IEEE) 802.1x standard for wireless user authentication (ZDNet Australia 2003c). In the absence of the approved IEEE standard Microsoft, Cisco and the Wi-Fi alliance are promoting the introduction of Wi-Fi Protected Access (WPA) for use while the proposed standard progresses (ZDNet Australia 2003c). The standard should be ready in 2004 (ZDNet Australia, 2003d) and it is predicted that it will be integrated and deployed as part of handhelds and client services during 2004 (ZDNet Australia 2003e). This is an important standard, as there is a growing use of 802.11(b r g) or Wi-Fi technology to find the nearest internet-access point. To illustrate this popularity T-Mobile is installing such services in Starbuck’s coffee shops that provide wireless access.

The European Commission’s working group on data protection developed a proposal relating specifically to mobile location privacy issues. Elsewhere, other countries are developing/implementing legislation to protect privacy. For example, Korea’s Ministry of Information and Communication recently drafted a Bill to regulate LBS for cellular phone services (Deok-hyun 2003).

But, few solutions can prevent malicious and inadvertent attacks. And there exist few tools to detect and remove rogue wireless networks. Firewalls and encryption are still seen as the best protection still (ZDNet Australia 2003c). Even when 802.1x is introduced it will only protect by authenticating users and devices at the 'edge' of the network and information being transmitted will still need to be encrypted. This will also hold if *Bluetooth* becomes widely deployed and used (ZDNet Australia 2003e).

Threats arise from both governmental and private surveillance (Berman 1997) and methods must be employed to provide the public assurance that every possible means has been used to guard their security. Along with this is the need to ensure that consumers are adequately informed about what software is being placed on their machines (eg cookies) and how to 'turn on' their own 'privacy' button (something like that proposed by Calacanis 2000).

32.11 Problems with developing technology

We live with being always photographed by security cameras; we know and accept that credit card providers know how much we earn, where we live, how much we spend, how often, and where; and we may use smart cards (called e-tags in Australia) that record nodes of our journey on tollways, recording where we were, at what time and date we were there and the car we were driving. Digital surveillance and transaction 'machines' track our every move, and what could 'they' learn about us if this information was linked and analysed? (And, is it linked and analysed?).

Digital television has the ability to record or 'track' a users preference and thus viewing habits. Broadcasters are able to build databases and then use it for 'focussed' advertising and special programming or purchase offers. Marketing wants this type of information because, according to Wunderson of marketing data provider I-Behaviour Inc.: *"Past behaviour is the single strongest indicator of future behaviour"* (Thibodeau 2001 p. 1). It has been predicted that by the end of the decade 40% of adults and 75% of teenagers will have always-on, wearable computing and communications capabilities (Lais, 2001). But, with this 'rush' to adopt technological solutions we have accepted 'privacy invasions'.

Zimmerman, the creator of the PGP encryption product (the first widely adopted strong encryption program for protecting files and emails), sees that technologically-driven improvements on surveillance cameras pose a threat to civil liberties (ZDNet Australia, 2003a). How do we manage them when there are literally millions of CCTV cameras recording our everyday activities? Consider for example the speed at which pictures of the hijackers using an ATM pre 9-11 were made available after the event.

Digital credit card transactions and focussed search on ATMs in nearby locations led to rapid information discovery, access and dissemenation.

A technology that some have labelled as ‘spyware’ is being introduced by manufacturers, wholesalers and retailers to identify the ‘location’ of products, from manufacture, to transportation, to warehousing, to point-of-sale. This is Radio Frequency Identification (RFID), transponders that manufacturers are embedding into products from whitegoods to clothing (by weaving the transponder into the labels of clothing) (Baard 2003a). Already companies in the USA and Europe, like Wal-Mart, Tesco, Proctor and Gamble and Gillette, are using the tags. Wal-Mart have insisted that its 100 largest suppliers must tag their warehouse pallets and containers by 2005 and their other 12,000 suppliers by 2006 (Baard 2003c). The retailer is conducting tests in selected stores, sometimes with customers being unaware that they were being tracked. There is much concern that the combination of radio tag data and the information obtained from store loyalty cards could be coupled to create comprehensive customer profiles (Wired News 2003). In Australia the warning bells have began to ring. Sneddon, national coordinator of the privacy practice at law firm Clayton Utz has stated that devices like these expose “holes in existing Australian privacy legislation” (Australian Technology and Business Magazine 2003).

We now see this type of computing in the form of handheld PCs, mobile phones, wireless sensors, radio tags and Wi-Fi (Baard 2003b). Designers of ubiquitous systems envision seeding private and public places with sensors and transmitters that are embedded into objects and hidden from view, providing for the deployment of things like ‚Audio Tags’, which plays an infrared sensor-triggered message once a person is within a pre-determined proximity (Wired News, 2003). And there is ‚Assisted Cognition’, AI and pervasive systems that can support a patient’s failing cognitive skills. For example, in Milwaukie, Oregon, the Oatfield Estate operated by Elite Care use a combination of electronic badges, infared detectors and load-sensing beds to track its elderly guests (Baard 2002). But, there are also many privacy issues to address. Computers ‘hidden’ in everyday tools will collect personal information about habits, health, employment, etc. The perceived ‘convenience’ can be outweighed by loss of privacy. As Lais (2001) noted, the US federal government has already passed laws such as the Health Insurance Portability and Accountability Act, requiring health care organisations to safeguard patient information. But there is still some confusion about how this will actually operate and how privacy related to an individual’s medical records will actually be protected (Jones 2001).

32.12 Privacy issues

There are numerous privacy issues related to the use of new electronic devices for capturing storing, processing and representing information, including geospatial information. There are issues that we must address to ensure that we protect the users of what we provide. The list below is a starting point for discussion of the range of privacy concerns that we, as information providers must address. Some of the issues are:

- How do service providers and their partners use subscriber information, and locations visited?
- Do service providers provide this information to other companies/ And, do they sell this information?
- Can a service provider 'log' where individuals travel? A fairly simple process with companies like Zingo, who would have a record of pick-up and drop-off locations, linked to times of day and dates. Although, without the use of LBS taxi companies could already do this if they wish.
- The use of cookies and the difficulty 'general' users of the Web would have to know if cookies were being used at all, and how to set their browser to reject cookies is a big problem. (Even some government sites in the US, where the Clinton administration restricted the use of cookies, were found to use unsanctioned cookies in 2001 (a total of 64 sites) (CNN.com 2001)).
- The combination of GPS and the ubiquity of wireless communications provides the ability to track anyone, from anywhere to anywhere. How do we protect an individual's rights when their every movement can be tracked and recorded?
- If a user of a LBS system crosses and international border, carrying a device with pre-recorded data, and able to access extra data from another country, what are the legal ramifications of these activities? (The U.S. ‚safe harbour' laws (approved in 2000), designed to protect U.S. compaies from lawsuits over how they treat personal information in other countries may provide a starting point here. But, laws are not yet clerely defined on legal juristiction in cyberspace (Lawson 2001)).
- In some instances, contractors employed to manage the operations of a site, and where tracking systems are used, then in some instances the contractor legally owns the information gathered (CNN.com 2001). How do we deal with the problem of having to use provider companies to deliver our geospatial products, when we may have no control of their records related to customer tracking?

- The results from a U.S. Federal Trade Commission (FTC) study about how companies exchenge personal data showed how some companies share data to provide a more detailed ‚picture' of customers (Thibodeau 2001). Since many mapping products provided on-line may be a conglomerate ‚picture' painted from accessing numerous data repositories and using various links, how can we stop the providers of the components that may make up our delivered product, related to a location-based request, ‚owing' information collected during electronic ‚procedures' that form the product request, the product itself and product delivery.
- If LBS service providers can track our movement from CCTV camera to CCTV camera, a complete, and annotated (with CCTV pictures) record of activities can be assembled. How do we address this as information providers?

32.13 Conclusion

With the advent of ‚modern' communications systems we have had to sacrifice privacy to ensure access to information and to use information devices. This is no different with wireless communications and the Mobile Internet. To ensure consumer confidence and product/delivery credibility we must address privacy and security issues and make them part of our agenda for future research and development. The profession and professionals working in this sector of the geospatial sciences industry need to view privacy and security as key ingredients of future successful products and services. Consumer confidence in what we provide will be a key ‚make-or-break' factor in the provision of services via wired and wireless services and the deployment of LBS.

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33 Location and Access: Issues Enabling Accessibility of Information

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33.1 Introduction

Accessibility is defined by the AccessForAll community as the matching of people's information and service needs with their needs and preferences in terms of intellectual and sensory engagement with that information or service, and control of it (IMS Global Learning Consortium, 2006). For instance, a person who is engaged in an eyes-busy activity such as driving a vehicle is not well matched to information when they are required to read small text on a screen. A person who does not speak French is not well matched to French instructions for buying a bus ticket. A person who is dyslexic and another who is not a native speaker of a given language may find they can understand content better if it is supported by images and does not use examples that are culturally-specific.

In this chapter, the authors focus on the problems associated with accessibility of resource content that are related to location. These include problems that are caused by changes in location, both macro-changes such as are involved when a user moves from one country or language region to another and micro-changes such as when a user moves from a home computer to an office computer, or between devices within the same building. As more users of Web-delivered mapping take up Broadband access and service providers exploit the new facilities to cross language and borders, so more users are denied or disenfranchised from public services and private activities by location-related problems.

33.2 Accessibility

Accessibility has had a variety of definitions tagged to it, but this chapter will assume accessibility means accessibility to all at all times. The Italian who does not speak Greek may have access to Italian information about Greece while at home but not when they are in Greece. The traveler using a wheelchair may have no difficulty before they leave home in finding the information for, say, the location of an automatic teller machine (ATM) but may find that, when they get to their destination and try to use the ATM, they cannot reach it because of its height in the wall. If they do manage to reach it, they may find all the instructions are incomprehensible to them because they are in the local language that is foreign to them. This is a double failure: first, the information about the location of an ATM did not carry pertinent information for the client, and second, the information about the ATM itself failed to meet the needs of the client.

Sometimes, a person's lack of access is more of a temporal problem: if an activity is taking place in one part of the world but welcoming online participants, it can be a matter of where people are located that determines the accessibility of the activity. It is not possible for everyone to be participants in everything and have sufficient sleep and day-time schedules for their local area. This location-based temporal factor means, for many people, difficulties in participating in educational, research, entertainment and financial opportunities that support international equity.

Lack of accessibility does damage to a service's business in that failure to meet client needs results in the immediate loss of business (the transaction that did not occur) and the more damaging long term loss of client goodwill which can easily lead, in a competitive environment, to loss of a customer relationship. The hard business fact is that lack of accessibility does as much, if not more, damage to the business' public perception as it does to the client. In a competitive market, customer relationships become more important, and the customer is as likely to change supplier, as they are to complain, thereby keeping the service's business ignorant of the issue. A service has many opportunities to impress the customer but only needs one chance to destroy the goodwill involved in the relationship.

Some types of information present particular problems of accessibility. Mathematics has depended upon graphical representation to make it quickly accessible to mathematicians. They learn the symbolism and write and interpret the mathematics with agility if they can see it. Blind mathematicians have enormous difficulties: they have to work with both the mathematical concepts and the very difficult encoding that represents the mathematical content but is cumbersome and increases their cognitive task enormously. Traditional cartography is another representational format that simplifies complex data. In the case of spatial data, there are often a number of alternative forms in which it can be displayed and at times text-based databases from which graphical maps are produced can be used for access to the content. The major difference between mathematics and cartography is obvious: not so many people need access to complex mathematical symbolism but everyone at some time needs access to cartographic representations.

Accessibility is about treating everyone as equal, regardless of culture, language or disabilities they may have. Lack of accessibility is defined as a mismatch between a person's access needs and those available to them. Accessibility is satisfied when there is a match regardless of culture, language or disabilities. Accessibility to all at all times, is used to mean accessibility to digital resources and services in all contexts in which technical access is available. It is not concerned with the significant but out of scope issue of possession of communications technology that makes possible the access of interest here. Issues of economic disadvantage, or specificity of disability, are not dealt with in this chapter. Instead, the authors' immediate concern is for location-independent accessibility and accessibility of spatial data. Particular care has been taken to ensure that all people's needs are considered equally so no distinction is drawn between a person using an assistive technology and another person using the latest mobile device. Accessibility is worked on as a device, location, context, ability independent requirement for all content and services, across borders.

33.3 The basics of accessibility

The international community, led by the World Wide Web Consortium (http://www.w3c.org/), initiated work to develop technologies and ways of using them to ensure that it is possible, in many circumstances, to construct digital content in ways that can make it accessible to all. Such accessibility is known as *universal accessibility*.

Sometimes making resources accessible involves merely using standard technologies in a recommended way, and at other times it means creating necessary additional content or services so that those who need alternative content can use them. For instance, text that is properly encoded according to W3C recommendations will be *transformable* and, therefore, equally accessible to those who need to change the font size, the font and background colours and to those who have the text rendered by a screen reader or in Braille. In general, this is achieved by the simple technique of structuring text well and encoding the structure separately from the desired form of presentation, and using valid encoding syntax (World Wide Web Consortium, 2006a).

The range of users includes people with large screens, as in a lecture theatre, to small screens as on PDAs and phones, and on those with no screen. Some screens are simply for looking at while others contain touch buttons for activation and yet others have keyboards integrated. Some screens are used to present material equally across the area while some are used with special zooming capabilities that let the user zoom in to some sections while maintaining carefully related location information from the surrounding material. Some screens are not viewed at all: screen readers take the content that would be displayed on the screen and render it aurally or stream it to a Braille device that encodes it for presentation as tactile Braille.

Users dependent upon screen readers have many of the same problems that others have had with audio tapes: it is not possible to see where the sections start and end and sometimes it is necessary to listen to everything to find something quite small. If content is structured, screen-readers, like tape players, can fast-forward to the next appropriate spot and save a lot of trial-and-error effort.

When users cannot hear the aural content of a resource, they may want to read it, or sometimes to see someone presenting it in sign language. They will probably share this need with someone who cannot understand the language of the resource and so would prefer to read it in their own language, perhaps in closed captions. When users have problems reading, they share some of the difficulties that others have seeing, and they too might like to have a screen-reader present the material aurally. In other cases, however, they might like just to have text with a lower reading level, or more images and less density of text, or perhaps the availability of a dictionary or thesaurus to help them interpret what they are reading.

Sometimes touch is the only effective mode of presentation and interaction, for instance for pilots in night flying emergencies or training simulations and also for people who cannot see and so depend upon touch more than most, as in the case of many blind people. Haptic and olfactory representations are not widely available yet but their use is increasing in training and simulation circumstances and should be anticipated now so they too, are not inaccessible to some users.

Images present their own set of problems. Some people merely want to see images enlarged, without loss of clarity, while others want images to fit on to their PDAs or phones, and yet others cannot see well enough at the time to use images at all. They probably want descriptions of the images, but which images? They may not want images in advertisements explained to them, so will be content just to know that is what the image is while at another time they will want detailed descriptions of the contents of the image. And what do they want to know about the images? Describing images can be difficult: sometimes users want to know about the items in the image, as they are, for interpretation by the user and at other times, users want an interpretation, to know what the image stands-for, and do not really care how it is represented graphically. Finally, images can have formal diagrammatic or figurative value and so it may be that a formal interpretation of the components of the image is needed. Sometimes such images are, in fact, generated from some other representation and it is the original one that will make the most sense to the user (as happens when blind people use spatial databases that are otherwise used to generate complex images).

Symbolic material, such as mathematics, is not so easily made accessible to everyone. The positioning of numbers and characters can mean different things according to the context and the meaning is not easily conveyed to someone who cannot see the layout. In addition, Braille, for example, is created by using a long string of characters and so the 'flattening' of the structure of symbolic mathematics needs to be explicit and unambiguous and independent of layout.

Tables also need to be linearised for presentation by a screen-reader or in Braille: the column and row headings need to be readily available to someone who is accessing the content of a table-cell but cannot see the table. When tables are used to position text and other objects out across a page, strange effects can be created for the user who cannot see the layout.

Tables, used only for layout, can be 'nightmares' for users of screen readers. The following table shows what can happen when information presented as shown is elicited from the table in which it is embedded for layout purposes.

My Diet

Monday I ate:	and Tuesday,	and Wednesday,
a banana	a tomato	a mango.
a pear	a peach	
a peach		

This example, although laid out by using a table, does not contain enough information for the screen reader to make sense of the rows and columns. Read out, the user will hear: “Monday I ate: and Tuesday, and Wednesday, a banana a tomato a mango. a pear a peach a peach” whereas a sighted reader will quickly realise there are three columns and they will read down the columns.

It is not only content that can be inaccessible. People with severe motor disabilities often use devices to emulate the mouse that others use. For example, a user may have a head pointer and their pointing to the screen may be interpreted to provide the same feedback to the computer as the mouse would. In such a case, the device is said to emulate the mouse and nothing special is needed from the resource to enable this. In other cases, the user will prefer to navigate using keystrokes, and so they will expect to be able to jump in a logical way from one object to the next (from heading to heading, down through the available links, and so on).

What have been described are three ways in which accessibility can be limited: an unsuitable display mode or modification, inappropriate content and problems with control of the system or resource. Medical conditions have not been discussed because they are not relevant to the determination of a user's needs. It should, however, be pointed out that some users have very specific needs, and if they are not satisfied, the user cannot use the resource, whereas others have a range of possibilities and may merely want to state their preferences, ensuring they don't get nothing if their first preference cannot be satisfied. A third group has things they must avoid, such as those who need to avoid flashing objects for fear of seizures.

In some cases, the content of a resource can be transformed from one form to another to suit a user. In other cases, accessibility is a matter of having alternative forms of content. The significant difference between the two cases is that in the former, the content is appropriate but its presentation is being changed. In the latter case, the content itself is being replaced by or augmented with more suitable content. This would be the case, for example, when the user has changed location so that they need what, according to their new location, is relevant to the new location.

Of course, the potential for such accessibility depends upon the existence of alternative content but it does not necessarily mean that the alternative and original content must be available from the same source. If there is appropriate content available, wherever, and it can be identified, and it can be used in preference to other content to improve the match between the user's needs and preferences at the time the content or service is being offered, accessibility will be increased.

Two issues of significance with respect to the content are, therefore, how appropriately it is authored and how easily can the content of a resource be analysed and alternative content or components discovered for assembly into a suitable accessible version of the resource.

33.4 Alternative content creation

Imagine an image of some text on a map as part of the content being presented to a user who cannot see, for whatever reason. They will need an alternative version in text format to be available to their device for presentation in an appropriate mode. Providing such text is often a manual task and requires someone to transcribe the text. In some cases, this can be done automatically. When the text is in one language and is required to be in another, it is sometimes possible to have the translation generated automatically; with the chance of this being done accurately increasing according to how suitable the original text is for this process. Translating poetry can be difficult but there is the possibility that the sort of information that is most often needed will be the most easily translated, as with the instructions for a rice cooker or an ATM: such information is usually presented in the original language in the most unambiguous way and is, therefore, the easiest to translate.

On the other hand, when the alternate form is something specialised like closed captions for a film, or subtitles, they are usually developed by experts. Long descriptions of images are also a specialty as knowing what word imagery is appropriate for blind people, for example, is not common knowledge.

The production of content alternatives is, for obvious reasons, often done by other than the original author and so it may be that it is not published from the same source as the original. The other quality of interest is that as it is special content, and likely to have been developed by a specialist, it may be that the author can describe its accessibility characteristics in detail and accurately.

When the resource is more modest, such as lecture material produced for students by a university lecturer, it is unlikely that in all cases there will be alternatives to the content in all the many forms that may be required. In other words, it is unlikely that the lecturer will be able to produce *universally accessible* content. In many countries this is what is required, however.

The problem is clearly then, not that it is impossible to serve an individual user's needs and preferences, for accessibility, but how to manage this process.

33.5 Location specific information

Spatial information, now commonly available in multi-media forms, offers a special challenge to those who want everyone to be able to enjoy their information. Not only is there the standard range of problems, such as how does a blind person get access to the information in a map (an image), or how do they participate in an interactive walk-through of a building, but there is the special nature of the information to consider. For professionals, the problem is usually different from that of everyday users. Experts, who work in areas such as spatial sciences, usually can work with text and make sense of it: databases containing numbers are useful as representations of information and they can be interpreted and used with standard database techniques, so blind people, for example, can learn to use these alternative formats. But people who are not blind, but for now have their eyes-busy, do not have this training. Not everyone who can see reads a map well, as we know. Some people like to picture the information about the route to the beach by thinking of the land marks, others by using the compass and still others perhaps by remembering the names of streets or the number of them. Maps allow such people to read off what works for them, in most cases. But now that people are walking around with hand-held devices, and the maps are often very small, or they need the information without having to look, we have to find ways for the speech output devices to represent the information. We have to work on the variety of ways in which people might understand spatial information, to find new representations that will work for them. This is a recognised problem and the field of multi-media cartography in engaged with it. The next step is to find how to do this for people who do not have well-developed spatial sense, perhaps because they have had limited experience in space. People with mobility disabilities may fit into this category.

33.6 Location identification

Contexts often account for the special needs and preferences of users. If a user is in a noisy location, they will probably not be able to benefit from audio output whereas a user in a very quiet location may not be welcome to start using voice input. Content needs can also change because of device changes and these are at times associated with location changes. So sometimes context influences will be predictable according to the location and sometimes they will be temporary and personal, or independent of location.

The location changes might be small or large. When the changes are from one country to another, such as for a traveler moving from Italy to France, it is likely that the changes will involve language changes. When location changes are triggered by movement from one room in a house to another, it is quite likely the difference will be device changes and this may mean changes in means of control of the access device.

Location in one country or another is usually derived from a co-ordinate reference system (World Wide Web Consortium, 2006b). However, these co-ordinate reference systems do not work well on a smaller scale, such as within an educational institution, a shopping centre, an airport or a railway station. Global co-ordinate reference systems usually provide two-dimensional references but even where height is taken into consideration, often they offer little help to the user changing floors, such as in an office block, who does not know their height above sea-level.

We can also imagine the same person moving from their personal laptop computer to the one in their family's office expecting to find that the office one needs to change to their needs and preferences after it has accommodated other members of the family with different needs and preferences. We cannot imagine users wanting to set up their needs and preferences every time they make such location changes. In fact, there are many people who would not be capable of determining their own technical needs and preferences and for these people; the changes might make the biggest difference.

The problem here is that there is no standard way of describing the locations of interest. It is not sufficient to use the standard descriptions of absolute location because in many cases people have no way of determining exactly where they are. The problems have been recognized but finding plain language solutions is only recent work in geospatial research and standards organisations, so until it is clear what to do, location specification will remain a major problem for accessibility.

33.7 Location based accessibility

When the location is fixed in one sense, as is the case on a seat in a train, but varied in a global sense, because the train moves, relative and absolute location descriptions become necessary. So we need a way to be precise about the locations so that we can ease the burden of adapting the devices to the user. This not only means being able to specify a particular location with precision and in three dimensions; it also means being able to describe dynamic locations. These may be relative locations. It also means being able to associate the profile for that device with the user's profile of needs and preferences. There is a need then for flexible, interoperable, machine-readable descriptions of locations for those cases in which they are determinants of the suitability of resources with respect to given user profiles.

There is therefore a requirement for both location-dependent and location-independent profiling. The aim in both cases is the same, stability for the user and thus a personal sense of location-independent accessibility, but one depends upon not being affected by a change in location and the other upon being affected by it. The location-independence is thus as viewed from the user's perspective.

33.8 Location/time based accessibility

The authors confess to a special interest in this topic.) Anyone who works in a global company or community and uses the Web and Internet extensively to do this, very quickly comes to the realization that time can be a serious disabling factor. The time of concern is not just that involved in planning one's day and getting everything done, although that does become part of the problem. The time that first causes the problem is to do with the time zone in which the user and co-workers are located. If international teams involving Asians, Europeans and Americans are to work together, it is inevitable that someone gets to stay up too late or to start the day too early for regular life. While it is possible to suffer the inconvenience, it is often even more disturbing to those in the user's immediate family than to the participant, who has a reason for being engaged thus. In a world where online education is becoming more commonplace and live interactions are a part of that education, again those in the 'wrong' time zone can be significantly disadvantaged. Is this serious enough for it to be thought of as inaccessibility? Perhaps this depends on what it is that the potential participant is missing. The general point has to be that globalisation being enabled by the use of Internet is creating a new accessability problem.

33.9 Language accessibility

The number of European Union official languages has recently increased from eleven to twenty. The number of linguistic combinations will increase from one hundred and ten to two hundred and ten. Europe is probably the most diverse conglomerate on this planet and its wealth of cultures, traditions, languages and customs is the reason for this diversity.

Given Europe's inclusion of people from the Artic circle to the southern most parts of Spain and Malta, and its use of many established written languages, using four main alphabets - Latin, Greek, Cyrillic and Hebrew, and the range of Asian languages in use in Europe, many Europeans have difficulties when using the Internet. If they use a computer in a new location, they may well find that they are being fed information that is considered appropriate according to their context, but not their personal needs. Web servers are smart enough to determine from where a request is coming and this information is often used to customise the response for the user. This 'accommodation' is likely to be the introduction of inaccessibility if the user is not native to the location, and so can be inappropriate. The French speaker visiting Rumania will want their profile to override the general, location-specific one that would be chosen by the server.

We can then, imagine a traveller wanting to have a profile somewhere that identifies their language preferences and is available for them to communicate somehow to the intelligent server that is trying to give them what they want. Already browsers, the most common user agents, provide an accessibility feature that allows the user to choose to reject the content provider's style sheet and use their own. Although this only works where the content is well formed, it does show a model that could be used for the fuller profiles now being advocated.

While the traveller is possibly interested in being presented information in their chosen language, they do not want to find that, when traveling to another country, the information they seek about the nearest ATM, for example, is in the language of their location. Their location is relevant to their needs but not to their language use. To achieve this, the user needs locally based services that are modified, or constrained, by their personal profile of needs and preferences.

33.10 Common language descriptions

Given the distributed nature of content objects that are necessary to make composite resources for users that match their needs and preferences, it is important to have a standard way of describing the characteristics of resources and of describing the needs and preferences of users. It is important that this is achieved in the most interoperable way possible, including with allowances for cross-sectoral, multi-disciplinary and international languages.

Such descriptions are usually called metadata. If the metadata is in a standard form, and so interoperable, it can be used for discovery purposes so that closed captions for the film of Hamlet can be searched for in the same way as the play version. This means that matching the accessible content to the user's needs and preferences will be possible, given an appropriate service for doing this.

For interoperability purposes, the metadata needs to be in standard form and that usually means being similarly structured and presented according to a formally defined set of rules that can be used by everyone. The metadata also needs to be machine-readable and therefore encoded in standard, well-formed computer languages. The metadata values should be easy to determine and to encode and therefore not burdensome for authors (and so more likely to be generated).

33.11 User needs and preferences profiles

So far there has been reference several times to the 'user's needs and preferences' without explicit explanation of this phrase. The history of what are being referred to lies within the field of accessibility that was originally most closely allied to helping ensure that people with disabilities such as blindness could access Web content. (An example of this is the establishment of the International Cartographic Association Commission for Maps for the Blind and Vision Impaired). More recently, the definitions of accessibility have been broadened to include the requirements of users who, for whatever reason, are in a state of need. Needs have been dissociated from people's medical condition and recognised instead as functional user needs and preferences that may apply to anyone. These change according to location, time, and other contextual matters just as much as with changes in devices. People, for this reason, can be expected to have a number of profiles of needs and preferences or to want to generate or change such a profile dynamically, according to their immediate context.

Institutions such as corporations can be expected to want to have community profiles in which they can specify that certain logos appear on resources and perhaps that certain graphic styles apply. If an audience is watching a presentation, it probably wants a Web page being displayed to have large font size whereas individuals will view the same page later using a normal, small font size. Such examples suggest that users will require not only multiple profiles, but also that profiles should 'cascade' allowing those which are of essential needs and preferences to override those that are purely commercial or decorative.

The management of profiles will need to include then the switching of elements within the profile according to immediate needs, the over-riding of more essential profiles over less essential ones, and the choice of profiles according to locations or circumstances.

The range of information will need to be organised so that its interpretation can be unambiguous and easy. It should be available as a simple tree-structured set of possibilities that may need to be activated according to a person's needs. If there is a vision problem, details of that can become precise if necessary but it should be equally possible to make no comment at all about vision requirements.

33.12 Resource descriptions

The resource's content, controls and presentation must be appropriate. This means it must be matched to the user's needs and preferences profile and so the management issue arises again. As a minimum, a resource should be described appropriately for this process. The most obvious way is to describe the resource in the same terms as are used for the user's needs and preferences profile.

The difficulty with describing any resource is that it is almost always composed of a number of items and it may be only one or some of those individual items or objects that are inaccessible. This means that somehow the alternatives have to be organised in a logical fashion. They may, of course, also have to be organised and presented together, even where some of them are not collocated in terms of storage.

Most resource descriptions are done at the 'document' level, so having a distributed model for resources where they are described at the object level is an extra challenge. It makes sense to classify the original objects that comprise the total resource as primary objects, and to classify those that are needed in special circumstances to be substituted for them, or to augment them, as alternative resources.

Following the description requirements for the users' profiles makes sense but it leads to the need for a number of descriptions for a number of items. In order to manage this, automating at least part of the process and storing the results would be necessary. Determining all the characteristics of a resource or object that will be needed is a mixed activity with some being determinable automatically, such as the format of the digital file, and some being subject to human judgment, such as whether a text description of an image is really equivalent to the image or not.

As there are legal requirements that relate to the accessibility of content objects, it is not always possible to be sure that the descriptions available are reliable. For this reason, a notion of trustworthy descriptions is important. Similarly, it is important to know when the resource or object was evaluated, as it may change over time. As the content may be distributed, so may the descriptions of it, and so they should all be in a standard form and interoperable.

33.13 Inclusive servers

An inclusive service provides the right combination of content and services for the user, where and when they need it. This means there needs to be a way of bringing together all the pieces, including the user and resource profiles, the context information, and the pieces that are to be delivered to the user in the object combination they require.

For a user, or an assistant working with them, it must be possible to create the necessary profiles and to change them for the immediate circumstances. In addition, it must be possible to make the formal descriptions of the resources and link together all of these for the matching process. There are several layers of discovery involved. There is, however, more than just discovery information needed and, therefore, systems that facilitate the making of such descriptions would be beneficial.

33.14 Conclusion and overall emerging possibilities

Emerging from this is a complex set of requirements that gives hope for a solution to the user's need for location-independent, location-specific services.

Work is already being done in the relevant fields by such bodies as:

- ISO/TC 211-Geographic Information (http://www.isotc211.org/), who have a forum for developing location based service standards;
- Dublin Core Metadata Initiative (http://dublincore.org/) who have developed a simple but useful metadata architecture;
- IMS Global Learning Consortium (http://www.imsglobal.org/) who host work on an information model by a wide community to provide the necessary well-structured semantics, and
- ISO/JTC1 SC36 that is concerned with standards for IT in learning, education and training.

The user and resource profiles that are the subject of the IMS hosted information model, developed with broad input, are suitable for adoption and use by many metadata communities. The metadata for the location and other location specifications are not yet developed but there is a natural base for them in other geographic specifications and standards.

The Inclusive Learning Exchange (TILE) (http://barrierfree.ca/tile/) is context sensitive and matches resources to users' profiles stored statically as well as dynamically as they change. Currently all resources used by TILE are maintained by TILE so the range of alternatives is known. TILE does not deal with location-dependence, as described above, but there is an associated WebForAll (http://web-4-all.ca/) project that does.

There is an urgency to ensure interoperability and accessibility for work going on in location based services. This will require standards development organizations to work closely together and produce the solutions to the problems outlined in this chapter. This approach is likely to serve both the needs of users from the accessibility perspective, and the further needs of suppliers of content in fields such as eLearning, eGovernment, eBusiness and others. Only co-ordination at the right level will ensure success in this work and cross-border interoperability and accessibility for all.

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34 Use and Users of Multimedia Cartography

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34.1 Introduction

Users and aspects of use are the very reasons why an interest emerged into Multimedia Cartography as it is dealt with in this book. For a long time, cartographers dealt only with the graphic map as the most efficient means of transferring geospatial information. The outcomes of the first real "wave" of scientific cartographic research were the traditional models of cartographic communication (such as those of Robinson and Petchenik (1976) and Kolácný (1970)) in which the map user had a prominent role. Limiting map use to persons who actually use their eye-brain system to derive meaning from map displays, Robinson (1952) may be considered the one who laid the foundation for scientific map use research. Based on this foundation, several types of research involving "real" map users have emerged. These may be grouped into two broad categories: more holistic functional map use research, and perceptual and cognitive research (van Elzakker 2005).

Functional map use research is based on the clear assumption that a map is made for a particular purpose, and that it is useful and important to find out whether, and to what extent, a particular map meets that purpose – just like a vacuum cleaner may be tested to see whether it does what it is supposed to do. Furthermore, the maps investigated are generally made for a specific group of people, or even the public at large. This kind of research is holistic, in the sense that the functioning of the information processing system is considered as a whole; i.e. the map contents and symbolisation of geospatial data, along with the interpretation, cognitive processing and decision making of the map user. Another important aspect of functional map use research is the study of the needs and characteristics of the map users. The underlying idea is that the results of this kind of research can be used to improve the effectiveness of map products.

In perceptual and cognitive map use research, more often the individual user is taken as the starting-point in order to find out "how maps work" (MacEachren 1995). Perception deals with the map user's initial reaction to map symbols, whereas cognition deals not only with perception, but also with thought processes, prior experience and memory (Slocum 1999). Cognitive map use research investigates why maps and cartographic symbols work effectively. Where nowadays the emphasis is more on cognitive cartography, perceptual map use research has a tradition dating back almost 50 years, and has led to many improvements in the effectiveness of maps. In the course of the 1980s, however, the number of map use research projects gradually decreased. This was mainly a consequence of the shift in attention towards new ways of map making, brought about by technological developments. Of course, this shift could not be prevented and indeed was needed (after all, we now reap its benefits with our current cartographic visualization tools and with the rise of Multimedia Cartography). However it also meant that user research faded into the background at a moment when it was clear that a lot remained to be done in this field.

Recently, however, a resurgence of interest in user testing in the field of cartography has been observed. Here there is greater emphasis than before on cognitive processes, deriving meaning from maps as a whole, and on questions as to how maps work in knowledge construction. This is done in the context of the new map use goals as distinguished by MacEachren and Kraak (1997): explore, analyse, synthesise and present (and no longer starting from an existing map (display) only). Later, they introduced the concept of *geovisualization*, which integrates methods and procedures of scientific visualization, cartography, image processing, information visualization, exploratory data analysis and geographic information science (MacEachren and Kraak 2001). The underlying idea, as in Multimedia Cartography, is that users who want to gain insight into, or an overview of, geospatial data, may benefit from interaction with multiple forms of media, instead of maps only.

Whether this is actually the case, needs to be investigated more thoroughly than has been done so far. The purpose of this chapter, therefore, is to highlight use and user research in Multimedia Cartography. At the same time, it will be postulated that the scope of the research needs to be broadened: not only from pure map use research to the evaluation of the effectiveness of map displays in combination with other means of geospatial data dissemination (multimedia), but we should also research the characteristics and information needs of the user and the usability of the hardware and software involved (including the interfaces). And when we talk about ‘the user’, we should not only think about the end user, but also about the person or organisation that uses certain tools to disseminate or generate (cf. the traditional map maker) geospatial information. This brings us to user-centred design. In the section on the nature of the required use and user research, attention will be paid to this as well as to other potential methodologies and techniques. By way of example, a case study will be presented on a user-centred design approach for mobile tourism applications. The message is this: we should care more for the usability and users of Multimedia Cartography.

34.2 Setting the scene

34.2.1 Use and users

As demonstrated throughout this book, the variety of uses and users of Multimedia Cartography is great and their needs are great, and varied. By analogy with the (cartography)[3] map use cube as conceived by (MacEachren 1994), the use of Multimedia Cartography may be more private or intended for the public at large, more or less interactive and directed to revealing unknowns or presenting knowns. That is, Multimedia Cartography may be used for the exploration, analysis, synthesis or presentation of geospatial information by a variety of users, ranging from school children studying a multimedia electronic atlas to professional geoscientists who apply advanced techniques of geovisualization to discover trends or anomalies. It is also important to realise that the usage environment may differ greatly (from paper multimedia atlases to on-line interaction with geospatial data through the Web), although the computer, be it wired or wireless, will be involved most of the time. Whether Multimedia Cartography is optimally effective, and more demand-driven than supply-driven, depends on knowledge of these uses, users and usage environments.

34.2.2 A shift in focus

Over the last 30 years, research and development in computer-based cartography has been driven by the ever-evolving and advancing technologies involved. From traditional GIS to Web mapping, the design of digital cartographic representations has been dominated by a motivation to improve computational speed and flexibility, solve technical issues in applying new technology and capitalise on the possibilities for geospatial data interaction (Peuquet 2002; Cartwright *et al.* 2001; Dransch 2001). Whilst there will always be a place for such 'technology-centred development' in Multimedia Cartography – indeed, without it we may not have produced many of the innovations and concepts in common use today – it completes only half the picture. The problem with taking a purely technological approach is the lack of consideration for the user, who is thereby forced to accommodate representations which have not been designed to cater to their goals, requirements and expectations.

The need for attention to use and user issues in the design of information systems has been accepted in a broad industry sense for many years (Gould and Lewis 1985; Nielsen 1993; Mayhew 1999). In the realm of Multimedia Cartography, however, this need has only recently been recognised, with numerous researchers in the field now calling for a greater focus on map use tasks (Dransch 2001), user differences (MacEachren and Kraak 2001; and the chapter by Nevile and Ford elsewhere in this book), human spatial cognition (Peuquet 2002) interface usability (Slocum *et al.* 2001; Cartwright *et al.* 2001) and user reactions to / interaction with new media displays (Fairbairn *et al.* 2001).

Responding to this, increasing emphasis has been placed on the uses, users and usage environments of Multimedia Cartography products. This was evidenced, not least, by the many papers dealing with related issues which were presented at the recent International Cartographic Conference and associated seminars (for example: Carter 2005; Marsh and Dykes 2005; Nielsen 2005; van Elzakker 2005; Wealands *et al.* 2005). In addition, the scope of use and user research within the general field of cartography has broadened. Here, researchers are no longer concentrating only on map use, but are also addressing use and user issues related to data and databases, non-map output formats, software and information systems, hardware and interfaces, among other things. This broadening of scope was (and is) necessary and inevitable because of the increasing integration of the successive stages in geospatial data acquisition, processing and dissemination.

34.3 The nature of use and user research

As we shall see, there are numerous strategies available for conducting research into use and user issues within Multimedia Cartography. From a functional point of view one possible overarching methodology may be the concept of *user-centred design*. Drawing on aspects from cognitive psychology, experimental psychology and ethnography (Mayhew 1999), user-centred design is based on three principles, the importance of which are elaborated below:

- An early focus on understanding the user and the context of use;
- Empirical evaluation of design products by representative users; and
- An iterative cycle of design production, evaluation & redesign.

(Gould and Lewis 1985; ISO 13407 in Jokela *et al.* 2003)

34.3.1 Understanding and designing for the user

At their most basic level, Multimedia Cartography products are interfaces between users and sets of underlying geospatial data. We have seen that users of even single products can vary widely, which raises the issue as to whether any one interface can be developed to suit all users. The answer is of course no, with some form of adaptive interface being the ideal. Fairbairn *et al.*(2001) identify that individual users may react differently to alternative representations of the same geospatial data, depending on their preferences, experiences and abilities, as well as on the tasks at hand. Therefore, in order to design Multimedia Cartography products "in sympathy to all users" (Cartwright *et al.* 2001), it is essential to determine the range of potential user differences or, put more simply, to *know the user* (Nielsen 1992).

There are two components to this process. The first is to obtain a comprehensive *definition* of the features of the user population, including their physical attributes (e.g. demographics), relevant knowledge and experience (e.g. skills and abilities) and their psychological characteristics (e.g. attitudes, motivations, preferences) (Mayhew 1999). The second is to develop a *understanding* of the users in terms of: what they are trying to accomplish (their goals, associated tasks and geospatial information requirements); how they think about their tasks (related to their personal, social and cultural characteristics and influenced by their previous knowledge and experience); the influence of the physical environment; the interface qualities they value most; and any problems they have with current techniques (Hackos and Redish 1998; Nielsen 1992).

Early collection of this information is important for establishing a global style and approach to the design of a Multimedia Cartography product. Not only will its consideration contribute to ensuring that the ultimate design adequately supports the users, it will also provide a foundation for achieving both *utility* and *usability* in the final product. Utility implies whether the system can perform the function(s) required by the users to achieve their goals (Nielsen 1993). By understanding what it is that the users need to do, and designing the product to address this, utility may be readily accomplished. Usability, on the other hand, relates to whether users can utilise the system to achieve their goals with effectiveness (accuracy and completeness), efficiency (minimal resource expenditure) and satisfaction (freedom from discomfort; positive attitudes) in a specified context of use (ISO 9241-11 in Jokela *et al.* 2003). This is perhaps more difficult to achieve, however prior knowledge of the users' characteristics, including their abilities, experience and preferences, are of major benefit.

34.3.2 Iterative design and evaluation

It is one thing to design a Multimedia Cartography product with utility and usability in mind, but it is a different matter to ensure, and confirm, that these factors (particularly usability) are optimised in the final product. Herein lies the reason for conducting ongoing empirical evaluation throughout the design process, as shown in Fig 1.

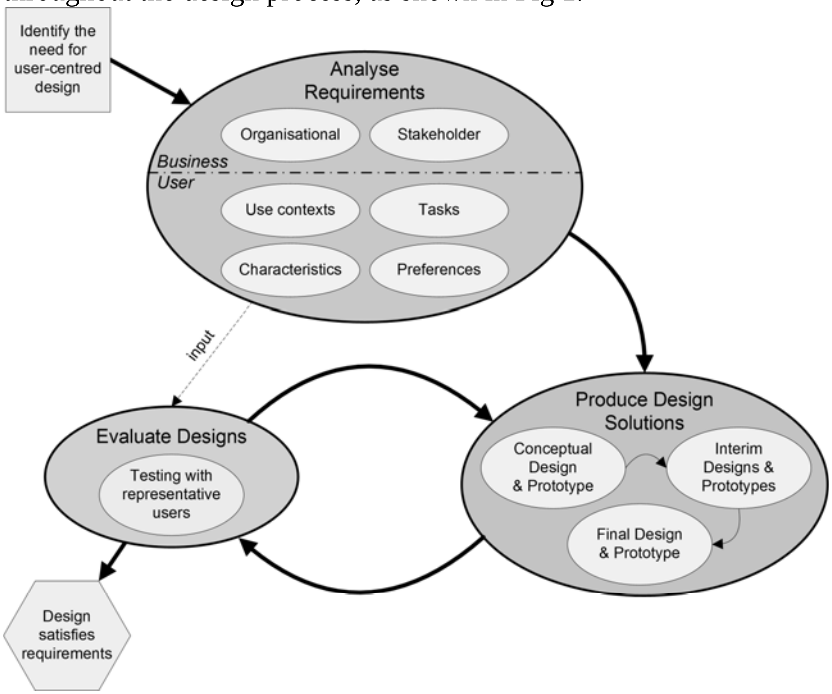

Fig 1. The user-centred design process (illustration based on Jokela *et al.* 2003; and Williams and Lafrenière 2005)

Iterative design and evaluation requires that design models (via demonstrative prototypes) are continuously tested, validated and refined, ensuring a rigorous design process that adheres to the user and business requirements initially specified (Gould and Lewis 1985; Mayhew 1999). Whilst initial iterations serve to obtain rapid and early feedback on the utility and usability of the design, at a time when there have been no major design commitments or resource investments made, later iterations are dedicated to the evaluation of usability goals in more advanced designs. Whatever the stage, it is important to collect both qualitative and quantitative evaluation data to inform on the usability of a design and its conformance to the specified requirements (Nielsen and Levy 1994).

34.3.3 Research techniques

From the point of view of the type of information sought, many traditional map use research projects are of a *quantitative* nature. For instance, one way of doing functional map use research is to measure how long it takes for a participant to execute a particular map use task and also to measure how many participants arrive at the "correct" answer (see e.g. Brodersen *et al.* 2002). Such quantitative techniques may still be applied to evaluate the effectiveness of Multimedia Cartography products. However, with the broadening of scope in use and user research in cartography, the application of *qualitative* techniques is gaining more in its importance (Suchan and Brewer 2000). In many cases we do not yet know enough about how maps or Multimedia Cartography products work for knowledge construction or geospatial problem-solving and, therefore, it is difficult to formulate hypotheses for testing by means of quantitative techniques. Similarly, qualitative techniques may play an important role in user-centred design approaches (see the Case Study description below).

The following main categories of qualitative research techniques may be distinguished within user-centred design (Kumar 1999; Suchan and Brewer 2000; van Someren *et al.* 1994):

- grounded theory;
- systematic/procedural task analysis;
- empirical usability testing and usability inspection;
- output product analysis;
- interviews;
- questionnaires; and
- observation.

Grounded theory[1] and *systematic / procedural task analysis*[2] may each play an important role in the early stages of the user-centred design process (see ‘Analyse Requirements’ in Fig). The outcomes of these research activities can be used for the design of an initial prototype of a Multimedia Cartography product or system. Conversely, *empirical usability testing* and *usability inspection techniques*[3] are most influential during the evaluation stages. Usability testing involves the collection of data relating to a set of usability parameters (e.g. learnability, user satisfaction, error rates) during observations of users interacting with a design (e.g. via a prototype) (Butler 1996). Usability inspection techniques are less formal for identifying usability problems, involving ‘inspection’ of the design by various evaluators including usability specialists, human factors experts, designers, developers and users (Nielsen and Mack 1994). The other listed techniques may play a role in all stages of the user-centred design process, although for output product analysis there should, of course, be some sort of prototype already.

Output product analysis refers to the systematic analysis of the outcomes of geospatial problem-solving activities by test participants with the help of interactive Multimedia Cartography tools, which may be in prototype format. However, product analysis alone will not be enough to learn more about the actual problem-solving behaviour. An *interview* with (prospective) users may take two different forms: structured and unstructured (Kumar 1999). During an unstructured (or in-depth) interview – which may also be executed with a focus group of participants (Suchan and Brewer 2000) – questions are formulated spontaneously, albeit within an interview framework. With structured interviews, comparability of data is more assured as the researcher consistently asks the same pre-determined set of questions, in the same order. This is also an advantage of the written *questionnaire* (Kumar 1999).

Questionnaires or structured interviews may perhaps be applied to investigate cognitive processes in problem-solving without asking the participants to actually execute one or more tasks (van Someren *et al.* 1994). But where the problem is complex, as in an exploratory cartography environment, it will be difficult to obtain useful and comparable results from such techniques. Here, it may also be useful to investigate the way in

[1] Inductive derivation of a theory of a process, action or interaction, grounded in systematically gathered and analysed participant data (Creswell 2003).

[2] Decomposition of participants’ tasks into steps taken and decisions made, as input into system design activities (Hackos and Redish 1998).

[3] E.g. heuristic evaluation, guideline review, consistency inspection, standards inspection, cognitive walkthrough, pluralistic walkthrough, formal usability inspection and feature inspection (Nielsen and Mack 1994).

which test participants use Multimedia Cartography tools while executing particular tasks. In such a research context, it is important to think of the moment at which the data are collected: i.e. during or after the problem-solving. Van Someren *et al.* (1994) mention the following examples of research methods: *retrospection; questioning and prompting* participants *during the problem-solving process*; and *introspection*. In the case of retrospection, the investigator interviews the participant in a structured or unstructured way after the completion of the task, i.e. after the problem-solving. A potential recollection problem may be reduced by trying to obtain information during the problem-solving process: here it may be either the investigator who asks questions during the process or prompts the participant to convey what he or she is doing, or it may be the participant who chooses the moments at which he or she will report on their cognitive process (van Someren *et al.* 1994). The latter is introspection.

The problem with introspection or questioning and prompting during the problem-solving process is that the data may become less valid due to disturbance of the cognitive process. This disturbance does not occur with retrospection, but the data obtained in this way may itself be invalid and incomplete due to memory errors on the side of the participants. But perhaps the biggest source of distortion and invalidity of the data obtained through retrospection, questioning and prompting during problem-solving and introspection is the danger that participants may feel inclined to interpret and rationalise their problem-solving behaviour (van Someren *et al.* 1994). Another possible problem with interviews and questionnaires is that participants may be steered too much into directions anticipated by the investigator.

These problems do not occur if information is obtained by *observing* the problem-solving behaviour while it takes place. In simple observation, the investigator may watch participants during their problem-solving and make notes. However, in this way the research results would not be verifiable and, therefore, it is required to make use of special equipment to record the observations. This also makes it possible to carefully analyse the observations at a later stage – to this end, the recordings of the observations may have been turned into so-called ‘action protocols’ (van Someren *et al.* 1994). During the observations, use can be made of video recordings and of advanced techniques to register, for example, eye movements or activities of the brain. And as in a modern Multimedia Cartography environment, where there is interaction with the geospatial data through a computer interface, there should also be some kind of logging of the changes that occur on the display screen. A general problem of using observation as a method of data collection is that participants may change their behaviour when they are aware that they are being observed. This is known as the Hawthorne Effect (Kumar 1999). An even bigger issue is that the analysis of video recordings and computer logs, just like the analysis of the resulting products, cannot provide complete in-depth information on the cognitive processes that take place in the minds of the participants. We do not only want to know what the test participants are actually doing, but we also want to know why they are doing it and what they are thinking. To find this out, use may be made of the so-called *think aloud* technique, a research practice that is becoming more popular in cartographic user research (van Elzakker 2004).

34.4 Case study: a user-centred design approach for mobile tourism applications

Mobile Location-Based Services[4] (mLBS) provide a particularly illustrative and contemporary example of use and user issues in Multimedia Cartography. Map displays constitute a major part of current mLBS user interfaces (Fig), often being the primary means of geospatial information output and, in some cases, also a means of input. It has been argued that these and other representations of geospatial information within mLBS are a result of technology-driven development and may not be appropriate considering the nature of the users and usage environments involved (Urquhart *et al.* 2004).

This case study provides an overview of a research project aimed at investigating, via a user-centred design methodology, effective Multimedia Cartography techniques for representing, presenting and interacting with geospatial information in dynamic mobile environments.

[4] Wireless services that use the location of a portable device to deliver applications exploiting pertinent geospatial information about a user's surrounding environment, their proximity to other entities in space, and/or distant entities (Urquhart *et al.* 2004).

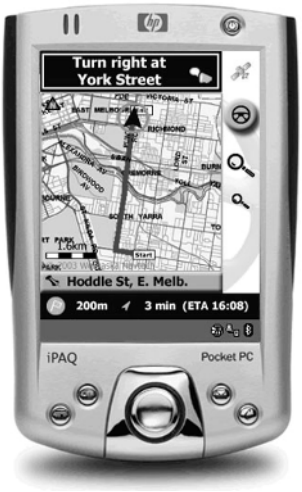

Fig 2. Example of a mLBS map display (image included with permission from Webraska Mobile Technologies, SA)

34.4.1 Mobile usage environments

The application area of mLBS chosen to demonstrate the research products is mobile tourism. The target users are therefore tourists; members of the general public who may or may not be adept at understanding traditional forms of cartographic representation. Tourism is largely characterised by open-ended goals that are realised by means of vague ‘problem solving’ or ‘decision-making’ –type tasks, without the need or presence of rigid aims (Brown and Chalmers 2003). Indeed, the purpose of much tourism is simply to experience a new location.

The environment of use for mobile tourism applications places both technological and contextual constraints on their design. To begin with the former, the handheld devices involved – e.g. mobile phones, SmartPhones and Personal Digital Assistants – present restrictions in terms of display (small screens, low resolutions and limited colours), interaction (input/output capabilities) and performance (limited storage and processing power). Collectively, these factors constrain the amount of information that can be presented to the user at a given time. Further performance issues are seen in the wireless networks used to transmit information to and from the devices. Here, slow connections and high latencies place limitations on the amount of data that can be transferred in a timely manner.

Contextually, the design of mobile tourism applications is affected by the user and their dynamic, unstructured environment. Every user is unique, having his / her own set of goals, tasks, abilities and preferences. In addition to this, in a mobile environment the user's situation (e.g. location and time) is constantly changing, with his / her attentional focus unavoidably drawn to his / her surroundings. Altogether these factors make it important, and difficult, for the design to present up-to-date and accurate information that is genuinely of interest, given the user's immediate context (Urquhart *et al.* 2004).

34.4.2 Investigation techniques

The research's aim of identifying Multimedia Cartography techniques which are appropriate for users of mobile tourism applications, logically led to adoption of the user-centred design methodology shown in Fig. When selecting specific data collection techniques, a largely qualitative approach was favoured which offered a more exploratory style of studying user issues, than would a purely quantitative approach. To this end, there were three key data collection phases during the research: (1) user profiling, (2) user task analysis and (3) evaluations. Revisiting Fig, the user profiling served to analyse the users' characteristics and preferences and context of use, whilst the user task analysis developed an understanding of users' tasks (organisational and stakeholder requirements were beyond the scope of the research). Iterative evaluations were then responsible for testing the resulting designs against the specified requirements, so as to ensure their utility and usability.

User profiling

The target user population selected for the research comprised a group of Australian leisure-based domestic travellers, whose definition was the focus of the user profiling activity. Two common data collection techniques were considered for this phase. A *questionnaire* (distributed to actual users) was the instrument chosen, in part due to the relative ease of data collection – based on time constraints and logistics – but also the view that it would prove a more reliable and accurate technique than *interviews* with parties knowledgeable about the user population (Mayhew 1999). The final questionnaire was designed to elicit the specific types of information required through both quantitative (closed) and qualitative (open-ended) questions: general information – demographics and experiences with location-based information; travel habits – recent holiday-based travel activities; travel information – use of geospatial information whilst travelling on holidays; location-based travel needs – geospatial information needs / preferences whilst travelling on holidays; and mobile device and computer skills – current use of mobile devices and computers. This was not a standardised instrument, however, thus any quantitative analysis of the results could not be considered reliable.

During the initial data aggregation, effort was made to produce a qualitative narrative of the results, yielding an emergent and comprehensive picture of the target user population from which high-level themes and trends were evolved. In-depth analysis of the narrative considered each aspect of the target user population in terms of its relevance to the profiling activity, the implications it posed to the design models and requirements for further investigation. The final user profile was formulated as a 'range' of features, categorised according to *user characteristics*, *context of use* and *user preferences*, each of which was expected to come into play during use and learning of the final product (Hackos and Redish 1998).

User task analysis

A user task analysis was planned to augment the user profile by producing a deep understanding of the target user population. Several (largely qualitative) data collection techniques were investigated, including various modes of observation, interviewing and focus groups, with a balance sought between the level of detail required, the resources available, the suitability of the technique to the study and what was possible. A specific interview technique was selected, known as the *critical incident technique* (Flanagan 1954), which focused the data collection on users' specific holidays as 'critical incidents'. The major benefit of this detailed and rapid data collection technique was that, in the absence of observation, a concentration on specific tasks and behaviours meant that generalisations and opinions could be avoided. An interview instrument (again non-standardised) was developed, incorporating questions carefully designed to elicit specific types of information about a user's recent holiday: experience and behaviour – what the user did (actions, activities); opinion and values – what the user thought about some issue or experience, i.e. their cognitive and interpretive processes (goals, intentions, desires, expectations); feeling – the user's responses to their experiences and thoughts (emotions); knowledge – what the user knew (facts); sensory – what the user saw, heard, touched, tasted and smelled (stimuli experienced); and background/demographic – how the user categorised him/herself (characteristics).

To synthesise the raw data into practical information from which appropriate themes and trends could be captured, a process of data modelling was employed. Based on the environment of use, a goal-driven approach was selected and is described in Fig. This entire process, supported by the development of personas (archetypes of actual users) and scenarios (descriptions of usage episodes), produced a model of the users' goals, associated tasks and information requirements, each related to particular aspects of the design of a mobile tourism application. This information, along with the user profile range was then fed into the design process.

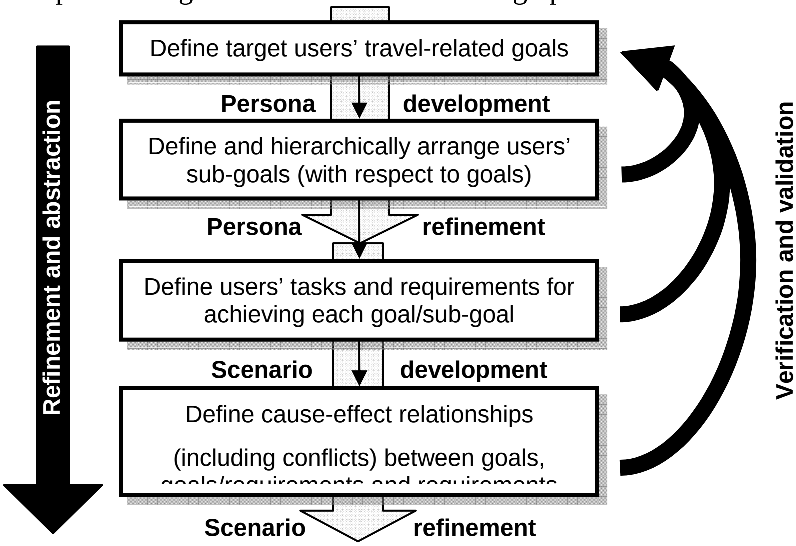

Fig 3. The UTA modelling approach for the case study (Wealands *et al.* 2005)

Evaluations

Research has shown that usability testing can uncover problems that are overlooked by inspection techniques and vice versa (Jeffries *et al.* 1991). This has lead to the suggestion that optimal results may be achieved through a combination of techniques, with the different types of evaluation having relative importance to different stages of a design project (Butler 1996). In light of this, both types of evaluation (empirical usability testing and usability inspection) were included in the research.

Pluralistic walkthrough (Bias 1991; Nielsen and Mack 1994) was selected above other usability inspection techniques, the primary reason being that it is the only one which involves representative users in the inspection process. The pluralistic walkthrough for the study followed the evolution of a number of preliminary design models and assembled a 'focus' group comprising users, a human factors expert and a cartographic expert, as well as the principal investigator. Together the participants stepped through the previously developed scenarios (using a low-fidelity, paper-based prototype), discussing perceived problems with the usability of each component representation and possible design solutions.

The usability testing has been more formal, involving a high-fidelity prototype (essentially an operational mobile tourism application). This activity is also more rigorous, comprising the collection of empirical observation data in order to measure the usability of the design, evaluating it against a set of quantitative and qualitative usability goals defined previously. The evaluations are being conducted on an individual basis, involving users, and are iterated following related refinements of the design. The testing attempts to represent actual use as far as is practical, employing scenarios ‘outside the laboratory’ and thus asking users to complete tasks using the prototype in the ‘real world’. This concept of field study is considered highly relevant to research involving mobile systems, since “mobility is very difficult to emulate in a laboratory setting, as is the dynamism of changing context” (Kjeldskov and Graham 2003).

The evaluation and design refinement activities are currently ongoing. Following the final iteration, the design should have been optimised with respect to addressing the specified requirements and ensuring high utility and usability. At this point, it will be possible to assess the effectiveness of various Multimedia Cartography techniques within the mobile medium (for tourism applications) as well as the overall success of the user-centred design methodology employed.

34.5 Conclusion

There are not yet many textbooks in the cartographic discipline with chapters specifically devoted to use and user research. The fact that this second edition of *Multimedia Cartography* contains such a chapter is a reflection of, on the one hand, the growing interest in use and user issues and, on the other hand, the required broadening of scope for use and user research in our discipline. User research is no longer limited to testing the effectiveness of already existing map displays, or finding out how they work, but now involves all stages in a user-centred design process – as demonstrated by the case-study described – and deals with the utility and usability of more aspects of the information system than the map display alone.

Spurred on by this broadening of scope and the perceived need for use and user research, the International Cartographic Association (ICA) has established a new Working Group on Use and User Issues which will focus on: the user (user characteristics / profiles, use context, user requirements, use goals, task analysis and modelling); usability (user-centred design, methods and techniques of evaluation / testing); and improving user abilities (user training, participatory / collaborative mapping, map use in education and training) in the field of cartography, including Multimedia Cartography. Both authors are involved in the activities of this new Working Group, which may be followed at http://kartoweb.itc.nl/icawguse/.

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35 Future Directions for Multimedia Cartography

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35.1 Introduction

In the previous edition of this book Taylor addressed the future of multimedia cartography. The central argument was that the major challenges for the future of cartography, of which multimedia cartography is an integral part, were not primarily technological. It was argued that technological challenges exist but that these were much more likely to be resolved than the other challenges such as: the need for a greater awareness by cartographers of the opportunities presented to the discipline; for more imaginative cartographic representations; to improve the quality of the content of multimedia cartography; and to respond to the entertainment and education markets more effectively. In addition the challenges were: to ensure that multimedia cartography responds to the needs of the user; the organizational and commercial aspects of multimedia cartography; and to involve all the senses. It was also argued that the ultimate challenge was that of dealing with human emotions and values as qualitative elements for cartographic expression and as part of the process of doing cartography.

Forecasting the future is hazardous, especially when an updated chapter is required for a second edition to appear six years after the first! Although the technological context has changed and continues to change, as several chapters in this book discuss, the basic thrust of the arguments made about future directions for multimedia cartography in the first edition remain valid today.

35.2 Multimedia and Cartography: New Opportunities

In the first edition of this book (Taylor, 1999) the concept of cybercartography was introduced to highlight the need for a new paradigm for cartography. Cybercartography was first formally introduced in 1997 and was defined as “The organization, presentation, analysis and communication of spatially referenced information on a wide variety of topics of interest and use to society in an interactive, dynamic, multimedia, multisensory and multidisciplinary format” (Taylor, 1997). Since that time the concept has been further developed as described more fully elsewhere (Taylor and Caquard, 2006; Taylor, 2003, 2005). The main elements of cybercartography include some of the key issues identified as important for the future of multimedia cybercartography and some of these will be revisited here.

Technological change is creating new opportunities. The most exciting at the moment are the emergence of the mobile telephone and associated locative media technologies, private sector initiatives such as Google maps and the growth of open source technologies. Mobile devices, especially cell phones, are a rapidly expanding consumer market which currently is larger than the market for television sets and computers combined (Thompson, 2005). Keltie (2005) has argued that the future of cartographic visualization, a key aspect of multimedia cartography, will be driven by mobile devices. Nixon (2005) sees the multimedia industry as being about “what” whereas the spatial industry as being about “where”, although this is probably more of a continuum than a clear distinction between the two. Multimedia cartography has the opportunity to present information on computer screens and mobile devices in multimedia formats and to integrate “what” with “where” in new ways. Wireless location-aware devices, global location services, online geodata repositories, Radio Frequency Identification (RFID) are making digital information accessible in situ and in real time. The physical landscape we move through is becoming “deep” with vast amounts of digital information—in text, images, and other sensory forms (Institute for the Future, 2004). Structures, artifacts and objects in the environment are becoming location aware which provides both opportunities and challenges to cartographers. The Voices of Oakland project for example, integrates Augmented Reality (AR), game consoles, hand held devices, head phones and GPS technology to provide visitors to the Oakland Cemetery a real and virtual historical audio tour. Visitors point to a grave stone or a building to hear the stories of the individual buried there or to discover architectural facts (Augmented Environment Laboratory, 2005). Gartner (2005a) discusses the use of intelligent glasses developed by Gerhard Reitmayr that broadcast route instructions in the lenses and cues onto the environment as the wearers are walking to their destinations.

The private sector, through initiatives such as Google Earth and Microsoft Virtual Earth, both introduced in 2005, has introduced online maps to the mass market (Goodchild, 2005). The reactions to these developments by cartographers and GIS specialists has been mixed with some seeing these as threats but as Thompson (2005) points out, initiatives such as Google Earth presents the user only with an online image. Users however enjoy the ability to add their own data and to see themselves on that map. There are great opportunities for multimedia cartographers to enter the marketplace and add value and increase the quality of these images in innovative new ways. The private sector has already begun to do this. The consumer in the information era is looking for a personalized on-screen response. In the first edition it was argued that "… despite the potential of multimedia as an analytical tool the field is most likely to grow in the areas of communication and presentation rather than spatial analysis, although these are not virtually exclusive" (Taylor 1999:315). This is now even more likely. As Goodchild (2005) has commented, more people became aware of Google Earth in a matter of weeks than GIS which has been in existence for decades! Alternatively, participants in open source movements, not necessarily the same community doing open source mapping, have created emergent knowledge repositories such as the Wikipedia, and have adopted practices to tag and label multimedia objects using GeoTagging techniques and services such as Geocoder.ca, Flickr or BlogMapper to name a few. These initiatives are popular culture representations of how communication technologies and digital objects are being mapped and spatially enabled. BlogMapper for example enables the georeferencing of a blog's content or the blogging of a map itself, in essence this community is creating a new qualitative geographic narrative about space and place. Cartographers will want to use the new technologies being made available to them to better communicate spatial information where people are, will want to collaborate with the private sector to increase both the quality and reliability of map content and representation, and to learn how to better enable users to add their own content. Further, cartographers need to be aware of initiatives in open source communities and popular culture Web initiatives to understand how people want to be able to participate in the creation of their own mapped stories and to learn from that culture. The challenge of accurate and reliable map content remains, as does the debate between the perfect open source code vs. the perfect cartographic map product and intellectual property.

35.3 The Nature and Quality of the Content of Multimedia Data

Good content continues to be important for the future of multimedia cartography. This is, of course, not a problem confined to cartography as it affects all online information. Keltie (2005) has argued that the user needs “ubiquity and authenticity”. Ubiquity is primarily a technological issue and a great deal of attention is being paid to the technological developments required to make information available in new forms and with increased speed as described in some of the other chapters in this book. The trade off between private information and ubiquitous technologies is however an important ethical consideration. Indeed, many multimedia cartographers give more attention to the “bells and whistles” of their products than to the quality and nature of their content or its implications and these remain as major challenges for the future.

Good metadata informs the user of the sources and quality of the data being used in a multimedia product. Developing more useful and effective metadata descriptions for multimedia data is important and this is a challenging task as Zhou (2005) outlines. Multimedia cartography requires new approaches to metadata descriptions. Metadata for geospatial data is developed through the initiatives of the International Standards Organization (ISO) such as the ISO Technical Committee (TC) 211 for geomatics and geographic information series including ISO 19115 for Geographic Information Metadata. These, however, need to be extended and linked to information object metadata standards for photographs, videos, imagery, text and other elements used by multimedia cartography. This often requires the creation of new application profiles such as that developed by Zhou (2005) using XML and much more attention to this issue is required beyond the issue of intellectual property. Multimedia metadata standards will increase access and discovery of multimedia content and ensure its reliability, accuracy and authenticity for both fit for use decisions and archival purposes. In many instances multimedia cartography is produced with inadequate metadata or, in the worst instances, no metadata at all! Producing quality metadata can be a time consuming business but it is important to indicate the reliability, accuracy and authenticity of the information used in multimedia products to the user. This is especially important given that the information used is often in a variety of different formats from a number of different sources. Automatic generation of metadata can help to reduce the time and effort required to produce them and Zhou (2005) has pointed to some important research directions to visualize metadata to help users understand it more effectively than is the case at present. Metadata descriptions and related cataloguing tools must be made easier to use and more transparent to the user. Folksonomies are emerging cooperative classification and communication practices, are social classification systems or a community based controlled vocabularies to describe multimedia objects. Their increasing popularity means they are getting more precise, but have not yet evolved to a point where a search will reliably find an object. There is however potential for communities (e.g. indigenous communities) to develop their own folksonomies to describe their own digital artifacts and stories in a language more familiar to them.

The restrictive policies of access to spatial data described in the first edition continue to be a challenge. Stuart Nixon (2005) observes that much of the mass of information available from remote sensed imagery, for example, remains "locked up" and that a large volume of potentially useful Landsat data is "rotting unused". He argues that higher resolution information is often more readily available for Mars than for many part of the earth and that a major reason for this lies in the control and pricing policies of spatial data custodians which are restricting the utilization of spatial information. Google Earth and Microsoft Virtual Earth are making spatial information available online free. The opportunity to add value to these datasets discussed earlier will be reduced if related spatial information is not made more readily available to producers and consumers alike. The custodians of data are mainly governments at various levels and the "cost recovery" mode currently in use in many instances needs to be re-examined, as do restrictive policies in the name of confidentiality and national security. Both confidentiality and national security are important issues but can be used as excuses for restricting access to information when this is not justified. The debate in India over this issue has been especially interesting (Tarafdar, 2005). Copyright and related intellectual property regulations and law are also challenging to multimedia cartographers Multimedia cartography often draws together information from a variety of sources and also in a variety of different media forms including music, photographs and videos. Increasingly this is done online and in real or near real time. Copyright and intellectual property law on the Internet remains a contested area. It is often unclear whether material can be freely used or if copyright permission must be sought. In addition to the absence of adequate metadata on many images it is often not certain if these Web versions are originals or have themselves been compiled from other online sources. Multimedia cartographers may find themselves in jeopardy of legal action if they use information from the Web, even when the sources are acknowledged in their products. The multimedia industry is very creative but multimedia cartography remains somewhat conservative as argued in the first edition of this book. Some National Mapping Agencies (NMOs) have adopted multimedia approaches and Geosciences Australia is a good example of this but the emphasis is on presenting existing information in new ways rather than on looking at innovative new topics which have previously not been "mapped" (Beard et al., 2005). The Creative Commons (creativecommons.org) is another initiative stemming from creative multimedia content creators and publishers (e.g. musicians, Web artists, etc.). Creative Commons provides a spectrum of possibilities between full copyright "all rights reserved", a voluntary "some rights reserved" or public domain "no rights reserved". Access, discovery and copyright policies remain as challenges while new initiatives and proposals are emerging to address these and multimedia cartography must respond more effectively to the needs and capabilities of the user.

35.4 The Centrality of the User

In the first edition it was argued that "Multimedia cartography like all cartography, will have to respond to user demand but if cartographers confine themselves to traditional markets then the full potential of multimedia cartography is unlikely to be realized. The reality for the future is that multimedia cartographers will have to seek new markets and new niches in existing markets for their products and their talents…." (Taylor, 1999:318, 319). This continues to be the case today. More fully understanding consumers and increased awareness of market trends is important for the future of multimedia cartography. For example, teenagers are very comfortable with communication technologies such as text messaging, and are accessing multimedia content on hand held devices or game consoles. Further, it can be argued that visual and navigation literacy in Virtual Environments is very high resulting from the experience of this group with computer gaming. Therefore, education and entertainment and the intersection between them – "edutainment" – as identified in the first edition remain as key market segments. Multimedia cartographers will want to ensure their products communicate to these growing market segments. These and new developing market areas will be considered later in this chapter.

Seeing the user as a consumer is important but the future of multimedia cartography also depends on a much deeper understanding of the user in term of both use and usability issues. Here multimedia cartography has much to learn from human factors psychology, cognitive science, and from human-computer-interaction (HCI) research in general. Many of the new consumer market opportunities lie in taking multimedia cartography to where the user is taking advantage of the new developments in mobile technology and context as outlined earlier and in several other chapters in this book. A greater understanding of use, usability and context of use of these new technologies as well as existing multimedia products is increasingly important for the future.

Before producing new multimedia maps cartographers need to more carefully and systematically assess the needs for such products (Parush et al., 2005, Wealands, 2005). Use and usability are two separate but related concepts. “Use” deals with the need to establish the demand and expectations for a product. “Usability” explores a variety of factors involved in using a product including cognitive and contextual issues. Of special importance is testing and more fully exploring the assumption made by almost all multimedia cartographers that presenting cartographic information in a multimedia format is superior to other approaches. There is overwhelming evidence in the psychological literature that interaction between the user and the map is advantageous. The evidence of other advantages of multimedia presentations is more mixed. Fabrikant (2005), for example, draws attention to the fact that cognitive science has been unsuccessful in identifying the advantages of dynamic over static display. Research dealing with multimedia cartographic products in human factors and cognitive psychology is limited and much more research in this area is required (National Research Council, 2003). This topic is a major focus of research by a team of cognitive and human factors psychologists working as part of the interdisciplinary team involved with the Cybercartography and New Economy (CANE) project supported by the Social Sciences and Humanities Research Council of Canada (SSHRC) at Carleton University (http://gcrc.carleton.ca). The research results obtained so far are reported by Lindgaard et al. (2005), Roberts et al. (2005), Trbovich and Lindgaard (2005), DeStefano and LeFevre (in press 2006).

This research has revealed that the presentation of information in multimedia formats certainly engages and can entertain the user but whether this leads to longer-term learning and retention of the information being presented is less certain. Great care must be taken when designing multimedia cartographic products to consider cognitive models and learning processes and their design implications and to develop an iterative process of testing and design on use and usability. Research so far in the Cybercartography and New Economy project has led to the development of a number of design guidelines and an increased understanding of interface design and navigation issues (Trbovich and Lindgaard, 2005; Roberts, Parush, and Lindgaard, 2004) but more research in this area is required.

One of the difficulties facing multimedia cartography in terms of taking a greater “user-centric” approach is determining who the users are in situations where material is being developed for transmission over the Web as Cartwright (2004) has pointed out. Ideally a multimedia product should have a clear purpose worked out before production and design process begin, in consultation with the users, and utilizing well established tools such as User Needs Assessment. Delivery on the Web is much less of a problem when the multimedia product is being designed for a particular purpose such as education (Baulch et al., 2005) but the particular age group and the curriculum is a variable. Multimedia cartography is also a social product and must respond to the societal context in which it is produced, regardless of its purpose. The educational needs of multimedia products for Ontario schools described by Baulch et al. (2005) are different, for example, than those described by Quinn (2005) for Australia. The general arguments of the need to actively involve the students in the learning process, the value of presenting materials to suit different learning styles, and the importance of new forms of engagement and learning still, of course, apply.

35.5 Education, Entertainment and Edutainment

It was argued in the first edition of the book that “the major market for multimedia products is the entertainment market in which interactive games are an important part. Education and training are also growing markets. ‘Edutainment’ is a process by which interaction technology is used to both entertain and educate” (Taylor, 1999:319). It was argued that multimedia cartography had the potential to penetrate this market in its own right. This is still very much the case today and Cartwright (2004, 2005a, 2005b) has explored some of the issues involved. Contemporary mapping, although providing timely and accurate products, may still be using formats which disallow them to be fully utilised. If one was to make a very general observation, the conclusion could be made that the formats and types of presentations used for the depiction of spatial data do not fully exploit the plethora of other information delivery devices in common usage. Telephones, television, faxes, computers, email, Web browsers, radio, newspapers, magazines, films and interactive mediums are all used to keep us informed in our own everyday lives. Maps can also adapt these other devices and media to enhance the communication of spatial information.

Computer games are more than just a game, designed well they are also a means to educate a certain segment of the population. The Games cluster of the Cybercartography project argue that computer games, especially character-based role-playing games can be designed to stimulate critical thinking through the process of presenting multiple points of view (Dormann et al., 2006). This multidisciplinary group has created a proof of concept modification of Neverwinter Nights (NWN) with Antarctica as the setting and climate change as the topic. The games include role-playing in a geospatial Virtual Environment, numerous characters (e.g. scientists, wizards, and penguins), points of view, emotion, and experiences. They have demonstrated that players can be stimulated to learn in an emotional and imaginatively reconstructed reality and now this group is exploring ways to push students to think about their game playing and environmental issues more deeply. Multimedia cartographers may want to consider more fully the narrative possibilities of games and their related technologies to model complex realities in a way that is both engaging and educational to the user.

35.6 Commercial Aspects of Multimedia Cartography in the Experience Economy

It was argued in the first edition of this book that "Multimedia cartography will have to find its way in an increasingly competitive commercial world and cartographers interested in the emerging field will have to form new partnerships which will have to include the private sector" (Taylor, 1999:324). In the previous section of this chapter the development of a new cybercartographic educational game within the CANE project was described. This game was developed by modifying an existing game produced by the rapidly expanding game market. Millions of dollars can be spent on developing a popular game and multimedia cartographers rarely have the resources to compete with the large players in this marketplace. Modifying existing games as described above is one route forward and the opportunities exist to do this. The market for educational gaming is expanding but multimedia cartographers have played only a limited role in these developments. To enter this marketplace multimedia cartographers will have to form new partnerships with private sector firms and with educational authorities and more clearly demonstrate the value of their products. Computer gaming draws heavily on spatial concepts and there are several computer games, such as SIMCITY, which draw on the map for their structure and content.

Geographical Information Processing (GIP), of which multimedia cartography is a part, has tended to develop in a somewhat isolated fashion from the information technology mainstream. As a result it is often under utilised. Geospatial Information (GI) must become part of the everyday Information Technology (IT) environment (Camateros, 2005; Thompson, 2005). Multimedia cartographers must work in a more interdisciplinary way to form new partnerships with industry, government and the Open Source community to ensure that their value is appreciated. These are two important non-technical elements of cybercartography (Taylor, 2005) and both require changes in attitude and perspective on the part of multimedia cartographers, and a more imaginative response to existing opportunities.

There are encouraging signs in this respect, especially in response to the rapidly growing market for cartography on mobile devices discussed earlier and as described by Klitzing (2005). Gartner (2005b) sees "telecartography" as a new means of geo-communication and several chapters of this book illustrate the kind of interesting and imaginative response required.

Thompson (2005) has argued convincingly that there is a need for those involved in various aspects of GIP to carefully follow emerging trends in the marketplace and how the private sector is responding to these. Paying attention to trends in the marketplace is certainly important to the future of multimedia cartography as mentioned earlier in this chapter and some recent trends will be discussed here.

Pine and Gilmore (1999) argue that post industrial societies are moving from the current services economy towards an experience economy. This development is not without its critics, not all who see the experience economy in a positive light but there is considerable evidence that it is continuing to expand. Pine and Gilmore argue that experiences are a distinct form of service and they describe these as interactive and multi-sensory experiences for the consumer. Two examples of this are The West Edmonton Shopping Mall that markets itself as the greatest indoor show on earth and the Southgate/Southbank, shopping and entertainment complexes along the Yarra River in Melbourne, Australia. These include a series of restaurants, shops, cinemas, galleries, indoor installations, and attractions. The Southgate/Southbank complexes include water and fire installations, restaurants represent all major national culinary traditions and the smells of these different cuisines are part of the ambience. The complexes are multilevel and walking through them requires multiple changes in direction, level and constantly changing vistas. They are designed to encourage serendipitous exploration rather than the functionality of quickly locating a store or service. There are few, if any, location maps. Sight, sound, touch and smell are combined to engage the consumer in an iterative way and spaces have been designed both to meet particular needs and to increase the emotional sense of "belonging" to a group. Australia has been described as a sports-mad nation and wall sized, high definition television screens allow the consumer to follow as many as six separate current sporting attractions at once. Overall the consumer is engaged, entertained and immersed and, as a result, the businesses involved in the complex increase their profits. Southgate/Southbank provides an "experience" which goes well beyond a service and it is this experience that draws people of all types to the complexes from families with infants and small children to senior citizens. It is an architectural simulation of reality that is designed to appeal to all of the senses in a one stop shopping environment, an experience that millions of people are seemingly looking for.

Cartography is still coming to terms with the service demands of the information economy but multimedia cartography in particular has the potential to meet some of the demands of the experience economy. It can also help to add an important locational element to that economy. This will require cartographers to go well beyond geographic and cartographic visualization and create a cartography that entertains, engages, educates, informs and immerses the user. Education and information are still central purposes of multimedia cartography and engagement, entertainment and immersion are a means to an end rather than an end in themselves. Multimedia cartography can, however, be used in a commercial sense in order to attract consumers to goods and services. “Free” online Web services depend on advertising for their services. If multimedia cartography is to enter the mainstream then it may have to follow suit.

35.7 Full Involvement of the Senses

The previous edition mentioned the importance of involving all of the senses in multimedia cartography. This continues to be a challenge today and it is interesting to note that involvement of all of the senses is one of the facets of Pine and Gilmore’s “experience economy” described above. In addition, Marin Lindstorm introduced the concept of “brand sense” in a book published in 2005. The study on which the book was based covered more than twelve countries and looked carefully at how religions use the senses. Lindstorm developed a six-step program for companies to develop brands based on all five senses, not just sights and sound, and quotes numerous examples. Smell is of particular importance and Lindstorm’s three top sensory brands are Disney, Apple and Singapore Airlines. His ideas are being embraced with enthusiasm by business worldwide. Unlike the experience economy this is not a development confined to post-industrial societies as it builds on religion and culture it can be situation specific. The use of all five senses was an element of the original concept of cybercartography in 1997 and continues to be developed.

Humans perceive the world using their senses. The world is rich in sound, texture, and smell while cartography remains primarily a visual discipline, digital maps are mostly silent, all are odourless and are touched remotely with a mouse. Sensory media such as sound, haptics and to a lesser extent smell are becoming more prevalent in Virtual Reality, information visualization, gaming, new media art installations and advertising. The Cybercartography and the New Economy (CANE) Project has provided an opportunity for researchers to explore how other disciplines such as cultural geography, anthropology, film, music, psychology, art, food and fragrance industries and marketing have studied the social, cultural and economic dimensions of how humans interact with the world using their senses. This has provided a better understanding of methods to incorporate sensory media into mapmaking. In addition members of the project are looking at both technological and conceptual methods to test and apply multisensory media in multimedia cartography proof of concepts.

Sound in particular is providing an added dimension to cartography and is being used to augment rather than replicate visual information and provides new insights into the subject matter of the map (Brauen, 2006). Brauen has created some proof of concepts in SVG and Java script programming languages and intends to experiment with Java Sound Application Programmers Interface as a possible replacement for the embedded audio components in the SVG language. He also encourages cartographers to “develop skills in the production of sound – training that is available in specialized acoustic design and multimedia curricula” (Brauen, 2006) and also recommends the development of interdisciplinary teams that include members with sound expertise to help “incorporate the consideration of the use of sound as part of the cartographic process” (Brauen, 2006).

The proliferation of relatively inexpensive handheld (e.g. portable game consoles) and multimodal devices (e.g. joy sticks) primarily designed for the gaming industry can provide an alternate method to interact with maps. As previously discussed this is being done with computer games and to a lesser extent in Virtual Reality, and these can be adopted and adapted by cartographers to provide a more interactive experience with map content.

Scented cartography is a new concept that has not been fully implemented yet scent as a medium is a growing multimedia industry. Scent is being incorporated into Websites, email, billboards, kiosks, museums, art installations, Virtual Reality, logos and some are sending scented email (Lauriault and Lindgaard, 2006). The marketing industry uses scent to brand products, subliminally persuade or to create an ambient experience of a space (Barbet et al., 1999). The food, fragrance and perfume industries are the obvious leaders in the creation and innovative uses of scent and are the experts who hold the ability to effectively use language to communicate the complex world of odours (Lauriault and Lindgaard, 2006). There are some smellscape studies (Dulau and Pitte 1998, Corbin, 1986 and Porteous, 1985), scent as a theme is making its way into cartography such as the Twin Cities Odorama: A Smell Map of Minneodorous and Scent Paul (Twin Cities Odorama Team, 2003) but there are only a few computer scented maps such as Les vins de Bourgognes - Balades Olfactives (France Telecom et al., 2005). A variety of scent broadcasting technologies exist and are primarily embedded chips or desktop machines connected via a serial or parallel port to a relay that activates a scent output device for a designated time period (Kaye, 2004). Liquids can be sprayed using a supply of compressed air (e.g., British Telecom, inStink at MIT, France Telecom). The user would click a scented icon on their screen to activate the device on their desktop that in turn broadcasts the scent. Lauriault and Lindgaard recommend that cartographers experiment with scent broadcasting technologies and also adopt and adapt tools from other communities and disciplines such as wine scent wheels, fragrance industry database structures, perfumer catalogues and curricula or sommelier ranking schemes for their own purposes. This they argue will be how to develop innovative tools and methods for creating olfactory cartography.

Multimedia cartographers will find it difficult to incorporate sound, smell or haptics on their own at the moment and they will have to collaborate with other media experts or become hybrid specialists in a number of fields in order to best represent multisensory media into their maps. In addition, it is advisable that these new cartographers work with human factor psychologists to understand sensory perception. Other sectors and communities have effectively incorporated multisensory media into their applications and it will be up to cartographers to catch up and find new imaginative ways to communicate spatial information.

35.8 Preserving Multimedia Cartography

One of the earliest examples of multimedia cartography was the impressive *Domesday* Project completed in 1986 to commemorate the 900th Anniversary of the Domesday Book produced on the order of William the Conqueror. Cartwright comments that in terms of multimedia cartography this product "…has yet to be matched in terms of coverage and innovation" (Cartwright, 1997:449). The *Domesday* Project was well ahead of its time but its subsequent history has drawn attention to a major challenge for multimedia cartography – the archiving and preservation of the cartography being produced.

Multimedia cartography products are important cultural and technological artifacts that should be made accessible to future generations. The objects in and of themselves are important as is the process of how they were created. At the moment many of the objects are created in a record keeping vacuum, without metadata, often in proprietary formats and with hardware dependencies. The Domesday project discussed above and the first North American GIS project - the Canada Land Inventory (CLI) are classic cases of very important scientific artifacts that were lost and later partially recovered but not in their entirety and not necessarily in the way the creators would have liked them to be. The CLI for example, was created in 1963 by Roger Tomlinson the father of GIS; it was a multilayer land-use with planning maps of Canada's inhabited and productive land (GIS World, 1996). In 1994 with government reorganization the project was shelved. Over time the magnetic tape upon which it was stored degraded and some files were completely lost. Eventually, the remaining files were translated into a modern GIS system through a 16 step data conversion process at a very high cost in time, human resources and data loss. Today much but not all of the CLI is now available on GeoGratis.ca.

Multimedia cartographers will want to take into consideration some very basic issues in the creation of their objects such as: technological obsolescence which includes the backward compatibility of software and hardware dependencies; interoperability between peripherals, software and file types; proprietaryship of both software and data; issues of data refreshing from one medium to another and the possible loss of functionality when doing so; data migration issues from one configuration to another, between computer generations and operating systems; the long term sustainability of data emulation; storage capacity and as previously discussed metadata (Bleakly 2002). It is important to distinguish data archiving from information preservation, the former includes strategies to maintain a record in a context while object refreshing and emulation are simply ways to preserve an object which may or may not reflect the creator’s intentions. Finally, clearinghouses and portals are not archives they are catalogues or repositories that rarely have longterm preservation as their mandate. At the moment online atlases are not archived by the agencies that create them, geospatial data infrastructures world wide do not include the archiving of geospatial data as a policy and few archives are capable of ingesting the vast amount of scientific data collected by scientists or generated by national data collection agencies in both the natural and social sciences.

The International Research on Permanent Authentic Records in Electronic Systems 2 (InterPARES 2) is a multinational and multidisciplinary archiving research project that aims at developing the theoretical and methodological knowledge essential to the long-term preservation of authentic records created and/or maintained in digital form (InterPARES, 2002). InterPARES 1 has generated a number of reports that include benchmark requirements and strategies (http://interpares.org/book/index.cfm) for some electronic records while InterPARES 2 focuses on records produced in complex digital environments in the course of artistic, scientific and e-government activities. The Cybercartographic Atlas of Antarctica (CAA) is a case study in this project and preliminary results suggest that the open source technologies upon which the CAA is built, associated technology white papers and manuals combined with the multimedia metadata standards being implemented should make the product robust and malleable enough for long-term preservation inclusive of all of its functionality in the same way the creators intended it to be. Some of the proprietary multimedia content (e.g. video and audio) in the CAA however may not stand the tests of time.

If multimedia cartographers want their artifacts accessible to future generations, they will have to include archiving at the beginning of content creation and not as an afterthought once a project is nearing completion as that may be too late. Archiving concerns need to be a part of the production process and need to be a policy formally adopted by the project with dedicated financial and human resources. Funding agencies who expect returns on their research investment are also advised to implement processes and build the infrastructures required to archive what they pay for. Funding proposals should also include a percentage of resources dedicated to the activity of archiving to ensure that the cultural and scientific multimedia content citizens are paying for are made available to them in the future. Multimedia cartographers also need to recognize that they are contributing to our collective cultural and scientific heritage that is of benefit to us all and future generations.

35.9 Conclusion

The major challenges for multimedia cartography remain primarily non-technological. Technological challenges continue to exist, especially in relation to the hardware and software required to develop the mobile, ego-centric devices for which demand is increasing. These technological challenges are, however, much more likely to be quickly resolved than some of the other challenges discussed in this chapter. Over the last several decades geographical information processing has become increasingly “scientific” and “objective” in nature and, as a result, has lost its ability to deal with qualitative information and both the artistic and emotional aspects of human existence. Multimedia cartography can retain a strong scientific framework but more effectively portray and represent a world rich in colours, texture, sounds and smells. Our current digital cartographic world is emotionally stark, largely visual and often in black and white. Computer reality is no substitute for the real world but multimedia cartography can help to make it more interesting, engaging and effective.

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36 Postscript to *Multimedia Cartography Edition 2*

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36.1 Introduction

Cartographers have always striven to make their products more accessible, current and usable. Access to our products was greatly enhanced when we embraced printing as a means for making faithful reproductions of geographical information artefacts. Printing changed how information was ‘packaged’ and delivered, including geographical information. Now the Web, wired and wireless, has also revolutionised how we address geographical information design and realisation and, with users in mind, how these products are procured and utilised. What we do has changed and what we produce has also changed.

The revolution to information provision that the Internet, and more particularly the World Wide Web (Web), has spawned has changed forever how information products are viewed. They are now wanted, no demanded, almost immediately. In newspapers terms this would be described as wanting information “before the ink has dried”, but for digital information this is probably best described as wanting information “before the data collection sensor has cooled”! Advances in data collection and telecommunications ensure that collected data is quickly and faithfully transmitted. Processing procedures and equipment, map ‘construction’ and ‘rendering’ software and geographical information delivery systems now provide the ability to deliver on-demand geo-information products in almost real time.
Everything has changed, but the underlying theory and procedural knowledge remain the same. We have powerful tools for the provision of information that has currency, accuracy and immediacy, but how we apply them depends upon adequate knowledge of cartographic theory and practices.

Yes, Web designers and graphic artists can produce elegant information displays for the Web, but the integrity of their map-related products could be questioned. Without adequate grounding in the geospatial sciences, graphical presentations with impact and panache can be produced, but they may be documents of misinformation. We need to ensure that what is delivered via discrete media. the Web (wired and wireless) and mobile devices like cellular ‘phones and PDAs (Personal Digital Assistants) relating to the provision of geographical information is produced to high standards, of both design and information content, and that users comprehend the underlying structure of the data and the manipulations, or ‘cartographic gymnastics’ that have been employed to ensure that the data is presented in the best possible manner and are thoroughly understood by users.

Better understanding about how Multimedia Cartography ‘works’ can assist this quest. This book has been produced to provide an insight into some of the theory and praxis that is being applied to make Multimedia Cartography work.

36.2 The Book

The area of multimedia cartography is relatively new, with many untried and untested elements. The contributing authors are developing concepts related to the application of multimedia to geographical information, producing prototypes or publishing products and evaluating the success of these applications. The chapters in this book reflect the endeavours of the authors in their quest to properly exploit the media.

Chapter 1 defined Multimedia Cartography and discussed the audience for Multimedia Cartography products, and their appeal to both ‘elite’ and the broader user audience. It also addressed Multimedia Cartography’s focus on presentational, rather than analytical tools. Finally, the chapter discussed the consequences for cartography in general, when Multimedia Cartography is applied to the presentation of information and how it can be used to advance contemporary mapping methodologies.

Chapter 2 outlined the development of multimedia, related simple hypermedia presentations to current discrete and distributed products. The chapter explained how multimedia began as fairly simple applications of presentational techniques, to its transformation by hypertext, to the transformation and expansion of storage possibilities with discrete media that developed from CD-ROM to DV-D.

Chapter 3 focussed on the development of distributed multimedia via the Internet and the World Wide Web. It followed the development of the Internet itself and the tools and procedures developed to ensure that information, including geographical information could be provided, globally.

Chapter 4 focussed on the Mobile Internet and Location-Based Services (LBS). It analysed the basic elements such as positioning, information modelling and presentation as the main fields of research, and the state of the art of currently used location-based systems.

Chapter 5 discussed the ‘Elements of Multimedia’, consisting of text, static graphics, animated graphics, and sound. These media are made available in a variety of formats that ultimately influence the form of the presentation. How the media formats and our conceptions about interaction/animation influence the use multimedia in cartography was outlined.

Chapter 6 developed concepts regarding the theoretical issues in Multimedia Cartography. It addressed issues that included the choice of media and the function of media in cognition and communication, as well as the functions that a medium has to fulfil and the best media types to use for particular applications.

The design of multimedia mapping products was discussed in Chapter 7. It focused on map-based access, spatial and thematic cross-referencing, active symbology, user notification stimuli and organisational structures.

Chapter 8, Map Concepts in Multimedia Products' provided an insight into the theoretical issues relating to atlases using multi- and hypermedia. It provided an introduction to multimedia atlas products described in later chapters.

The Territorial Evolution of Canada was developed in 1992 as a multimedia product for an exhibition celebrating the 125th anniversary of Canadian confederation. Chapter 9 outlined the unique features of this product. These include interactive animation of historical information; time-bar navigational tool; and a simple, intuitive user interface. The user can move freely to view and explore the territorial extent of the country at national or provincial levels at a specific time.

Chapter 10 presented information about the *Electronic Atlas of the Mi'kmaq Nation*, the 1996 Canadian Cartographic Association award winner for “best and most innovative electronic map of the year“. The chapter explained technical issues encountered during the development of the atlas.

Chapter 11 outlined the development of *The Atlas of Canada*, using a user-centered approach. The chapter covered the background to the development of the atlas and how the user-centered methodology operates. Then case studies described how the user-centered approach was applied in a practical production exercise.

Chapter 12 described *Atlas of Switzerland 2*, which is the second edition of the *Atlas of Switzerland*. The chapter gave a brief history of the *Atlas of Switzerland*, which began in 2000. It then covered the basic concepts of the atlas design. Then the organisation and implementation of the atlas production programme was outlined, followed by a description of the 2D and 3D elements of the atlas. Finally, it provided an outlook on further atlas development.

Chapter 13 covered the *AIS-Austria – Atlas Information System Austria*. It is a "cooperative scientific project with the goal of developing an online system that enables the user to explore national (Austrian) as well as international (European) statistical information". The chapter explained the *AIS-Austria* concept and detailed the atlas requirements, functionality and structure.

Chapter 14 described the development of *The Cybercartographic Atlas of Antarctica*. It outlined the context of the Atlas and then discussed the specificities of the Atlas in terms of modularity and interoperability. Finally it presented some of the cybercartographic outcomes of this process.

Chapter 15 set the scene for 3D applications by providing an overview of 3D. It covered perceptual and cognitive aspects, as well as technical aspects: user interfaces, software and communication models that could be employed.

Non-photorealistic computer graphics (NPR) was the topic of Chapter 16. It explained photorealism and its limitations for geovisualization, non-photorealistic computer graphics, non-photorealistic terrain illustration and non-photorealistic city model illustration. It concluded by outlining the potential for non- photorealistic computer graphics.

Chapter 17 covered real-time virtual landscapes. It began by discussing the potentials, limitations, and challenges of real-time virtual landscapes and how it might be employed under the 'umbrella' of Multimedia Cartography. The chapter then covered 3D landscape models and how they can be built in real-time. Then the building blocks of virtual landscapes were described, along with how building modelling is undertaken, as well as vegetation modelling, real-time rendering techniques and navigation. To conclude, a case study on the development of 3D landscapes for the Lost Italian Gardens in the Potsdam-Berlin Park was provided.

Chapter 18 focussed on Digital Globes and their potential for providing geographical information in innovative ways. It categorised digital globes and then discussed the elements that makes them an ideal method for visualizing complex information. Themes for Digital Globes were outlined and then a number of examples were provided to illustrate the various themes incorporated into production globes.

Augmented Reality as a Medium for Cartography was the topic for Chapter 19. It discussed the basic enabling technologies of Augmented Reality and provided case studies of stationary and mobile applications.

Chapter 20 provided a focussed look at the use of Virtual Reality in urban planning and design. The work of Urban Futures Consulting related to Virtual Reality (VR) presentations associated with the urban planning process was the focus of the chapter. It provided a background of the use of VR in urban planning applications and then outlined current thinking regarding the use of VR in a planning context, as well as looking at future directions.

Chapter 21 discussed the application of Virtual Landscapes for education, with particular reference to its use in e-learning programmes. It covered the use of multimedia in education generally, and then it focussed on two areas: the use of virtual landscapes in an experimental learning unit; and the use of standardised formats for delivery and presentation.

Chapter 22 addressed questions such as: “Why and when to use animation in cartography?” It also discussed the link between animation, GIS-databases and other multimedia components.

Chapter 23 covered the topic of ‘multimodal analytical visualisation of spatio-temporal data’. It focused on the exploration of changes of thematic properties of spatial objects and the subsequent visualization required. It also covered the methods for the visualization and exploration of time series developed in cartography and other disciplines.

Games and Gameplay, and its application for visualizing geographical information, was the topic of Chapter 24. It defined what games and game-style interaction are and then looked at the cultural geography of place and games. It then covered games that involve geography – strategy-based games, fact-based memory games, explorative games, affordance and constraint-based games, place-fed games and world building games. To conclude, game issues were discussed.

Chapter 25 outlined a case study for a computer game application for visualizing geography. *Virtual Queenscliff* was developed as a test-bed for development and evaluation of how computer games software can be used for geographical visualization production. The production method was outlined and thoughts about the usefulness of computer games software were presented.

Chapter 26 reported on the application of maps for Location-Based Services (LBS) and how they can be used to support wayfinding. It described the *NAVIO* indoor/outdoor navigation system and its potential application. Finally, it also provided the results of an evaluation of the system

Chapter 27 covered adaptation in mobile and ubiquitous cartography. It analysed the different types of mobile maps and their general requirements. It also discussed the concept of Web services and their functionality. The dimensions on mobile map use, interrelationships and their influence on map visualization. Finally, the general factors of geographical information adaptation within a map-based mobile service were demonstrated using two adaptation methods.

Chapter 28 provided a practical implementation example - The *Whereis® Mobile Application Suite*. The chapter gave an overview of the Sensis company's Third Generation (3G) mobile mapping applications, highlighting key learning from commercial deployment

Standards, Norms and Open Source for Cartographic Multimedia Applications were the topics of Chapter 29. It provided a brief overview of the standards and norms that relate to Open File documentation. It also covered work in Multimedia Cartography and described the formats used. It then described the possible developments for an Open cartographic environment, examining cross-media techniques that might be employed.

Chapter 30 provided a brief overview of Scalable Vector Graphics (SVG) and its use for Web mapping. It then described a prototype 'template' product that was developed for the provision of Web-delivered atlases for Brazilian school children.

Chapter 31 covered cartographic approaches to Web mapping Services (WMS). It described what WMS are and then discussed the Web map design elements that must be considered when generating maps for Web delivery. It then covered thematic information provision on WMS and how cartographic networks can be deployed for Web map provision.

Chapter 32 addressed the issue of privacy related to the use of Web-delivered and mobile telephone-provided geographical information. It looked at the issue of privacy and compromised privacy with online and wireless systems. It then covered aspects of security and privacy initiatives.

Chapter 33 focussed on the problems associated with accessibility of resource content that are related to location. It outlined the concept of 'accessibility' and discussed alternative methods for content creation that ensure accessibility for Web-delivered information. It then covered topics specific to locational information and how common language descriptors might be employed to build 'intelligent' servers.

Use and Users of Multimedia Cartography were covered in Chapter 34. It covered information use and users and designing for the user. Research techniques were outlined and the results from a user-centered design approach for mobile tourism applications were described.

Some future directions for multimedia cartography were developed in Chapter 35, providing a forecast for the use of future technologies by Multimedia Cartography. This chapter links to the chapter written in the first edition of this book. It stated that the basic thrust of arguments made about the future directions of Multimedia Cartography made in the first edition of this book remain valid today.

36.3 Acceptance of new technologies

What is more important: an effective communication device, or providing a 'must have' electronic device? This concept is not new and it can be seen with the use (and corresponding outward 'show') of 'new' technology, like notebook computers, PDAs and in-car navigation systems.

Take for example what is considered to be one of the most successful and widely-used map to support navigation and decision-making in an urban space, albeit underground - The London Underground map. When it was introduced in 1933 it was an outstanding success, with 850,000 copies of the map in circulation within two months after its introduction (Garland, 1994). By distorting geography the designer, Beck, made the map more usable and an effective communicator about how to move about London. His original design moved away from the concept that the maps had to follow the actual geographical route of the train lines. According to Hadlaw (2003), what Beck did was to set aside geographic space in favour of graphic space. However, Hadlaw (2003) further says that the actual success of the map lies in the fact that both the map and the underground users shared the same sensibility, and it was comprehensive because of the logic that underpinned the design, which was "coherent with their experience, as modern individuals, of a historically particular time and space" (Hadlaw, 2003, p. 26). Here, neither good map design nor an intimate knowledge of the 'place' of the underground was responsible for better understanding of how the map 'worked', but it was an 'agreement' between designer and user about the underpinning logic.

But the 'new' is not always accepted. Take for example weather maps provided on the British Broadcasting Service (BBC) news. Recently the BBC changed its traditional weather maps (albeit computer-generated) to Virtual Reality maps and 3D landscapes. These were seen as "the biggest change to the way the weather forecasts are presented since computer generated maps replaced magnetic symbols in 1985" (BBC News, 2005). Once the new look news graphics were introduced the BBC were inundated with complaints like those from Scottish viewers, who were upset that Scotland was distorted (this was also a view of the Scottish National Party). An on-line debate drew comments like: "I'm afraid that I'm not happy about England appearing 10 times bigger than Scotland (from an Edinburgh contributor).

There is no guarantee of success by just implementing avant-garde tools. As well, there is also no general agreement that avant-garde tools offer an alternative genre of (geo)information artefact. Also, the spatial sciences could be considered to be a relatively conservative community, compared to 'main-stream' graphics or New Media communities, and it could be said that there may exist no real impetus to trial really different delivery techniques for the non-innovative. However, there are innovative cartographers who strive to exploit the potential of Multimedia Cartography. The authors of these chapters are amongst that group.

36.4 Conclusion

Historically, the multi-media nature of map products has empowered users to exploit these information-rich products. Even hand-drawn paper maps provided multiple communication techniques such as graphics (lines, sketches, renderings and points), text (placenames, descriptions and marginalia) and numerics (co-ordinates, values and administrative descriptors and nomenclature) – truly multimedia products. Their electronic counterparts are not viewed as isolated multimedia products, but merely part of the components of multimedia packages that may consist of multi-media resources linked electronically, as in the case of distributed (Web or Intranet/intranet) mapping products, or by the human user, when using components like paper maps, printed reports and other 'tactile' multimedia elements (Cartwright. 1993), or by the human user interacting with electronics when using elements stored and retrieved from computer disk (floppy or HDD), CD-ROM or DV-D. Multimedia Cartography provides users with a plethora of devices (and their combinations) with which to provide users with tools to explore geographical spatial phenomena in real-time or to access and view stored geographical and related information and data.

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