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).

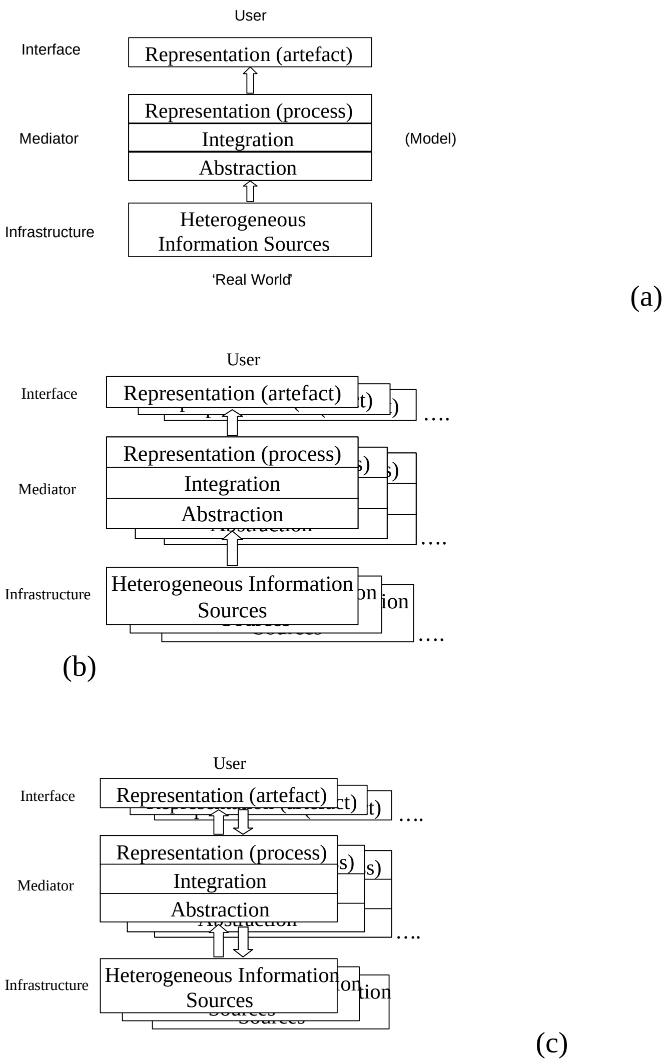

Fig. 1. (a) A depiction of a single layer, unidirectional information flow where the system is designed to meet the needs of a particular target group. (b) A multilayer, unidirectional model (current status of The Atlas) (c) multi-layer, bidirectional information flow where the system is designed to 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.

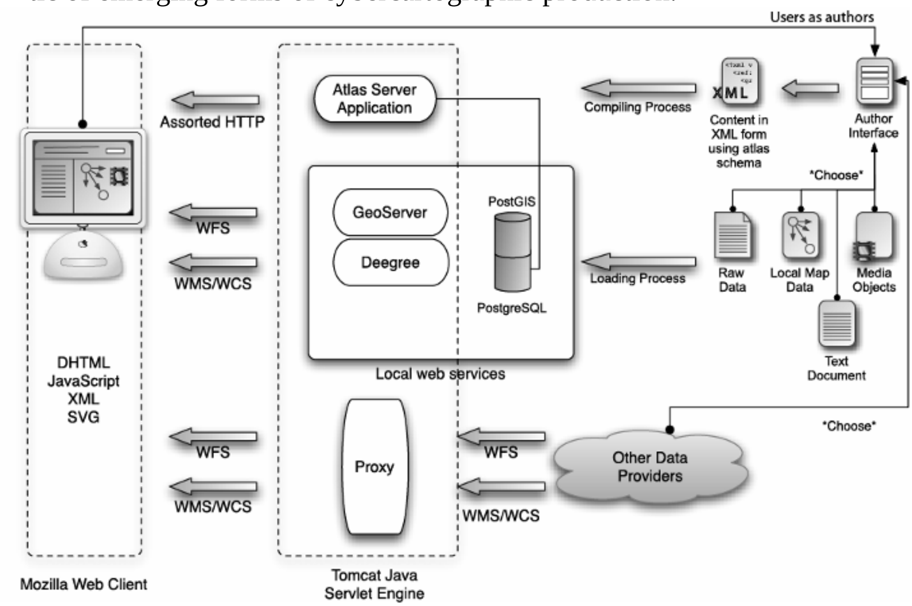

Fig. 2. The Atlas framework (Jean-Pierre Fiset, Amos Hayes and Peter Pulsifer). (Image courtesy of the Geomatics and Cartographic Research Centre, Carleton University.)

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 out-reach 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.

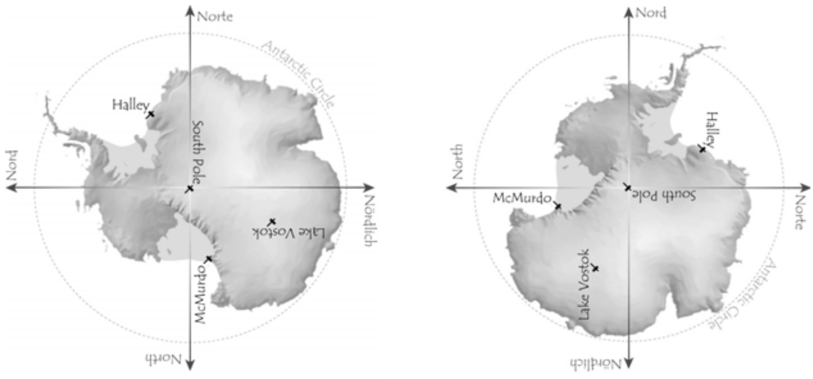

Fig. 3. In Antarctica the North is everywhere. Rotating map used in the introduction page of The Atlas. (Images courtesy of the Geomatics and Cartographic Research Centre, Carleton University.)

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.

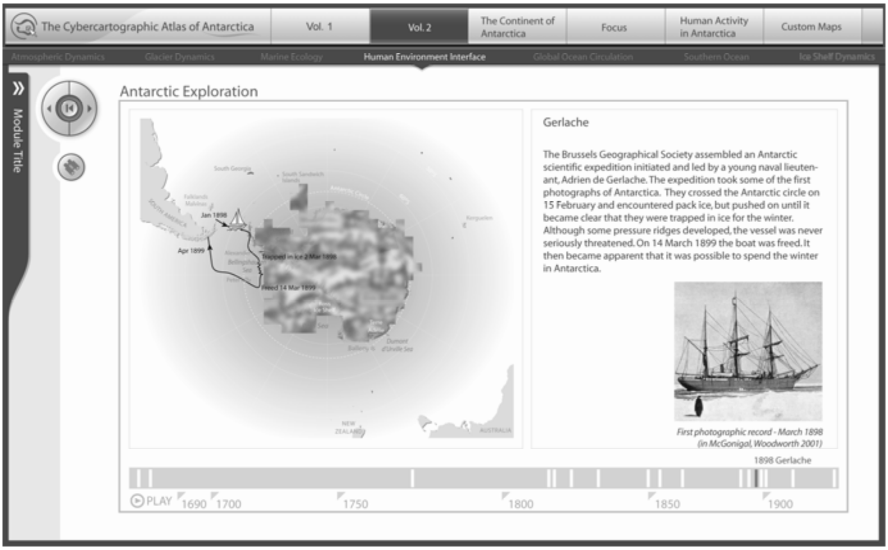

Fig. 4. The exploration module. The fabled Great South Land is "whittled down" to reveal the modern map of Antarctica. (Image courtesy of the Geomatics and Cartographic Research Centre, Carleton University.)

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.

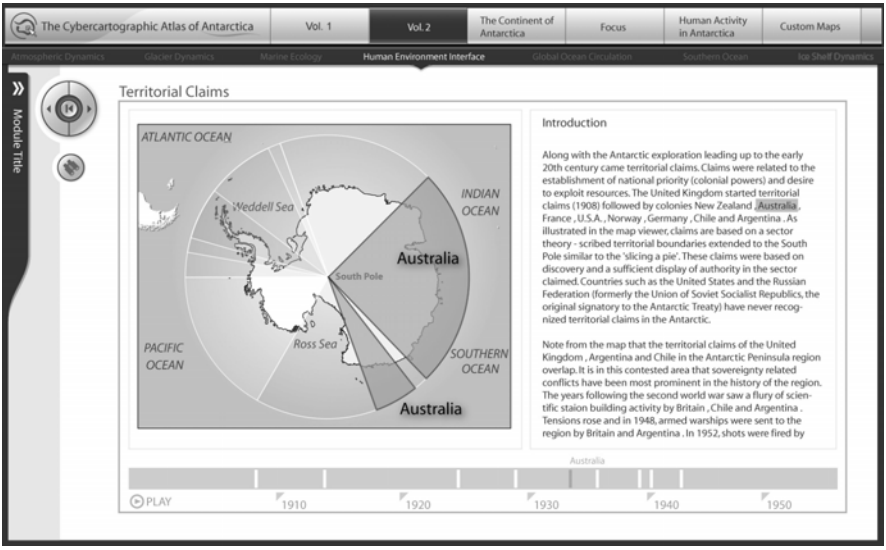

Fig. 5. The territorial claim module. The layering of voices and languages emphasizes the overlapping territorial claims over the Antarctic Peninsula. (Image courtesy of the Geomatics and Cartographic Research Centre, Carleton University.)

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).

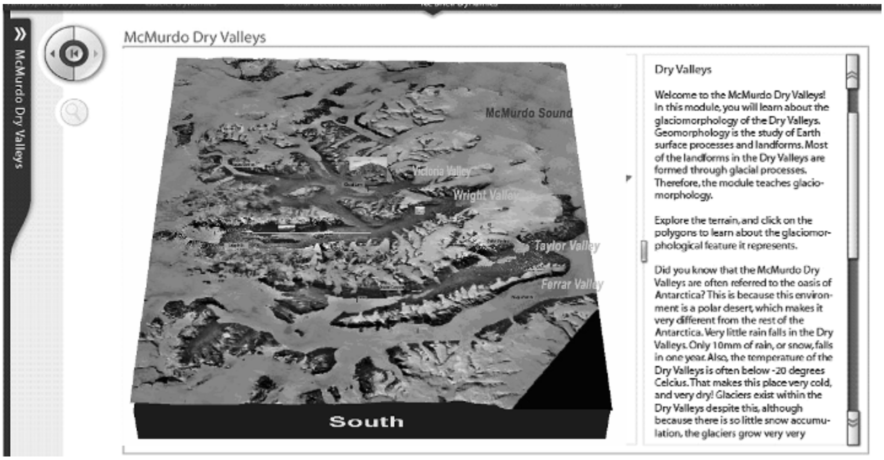

Fig. 6. The Geomorphology of McMurdo Dry Valleys module created by Birgit Woods. (Image courtesy of the Geomatics and Cartographic Research Centre, Carleton University.)

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.

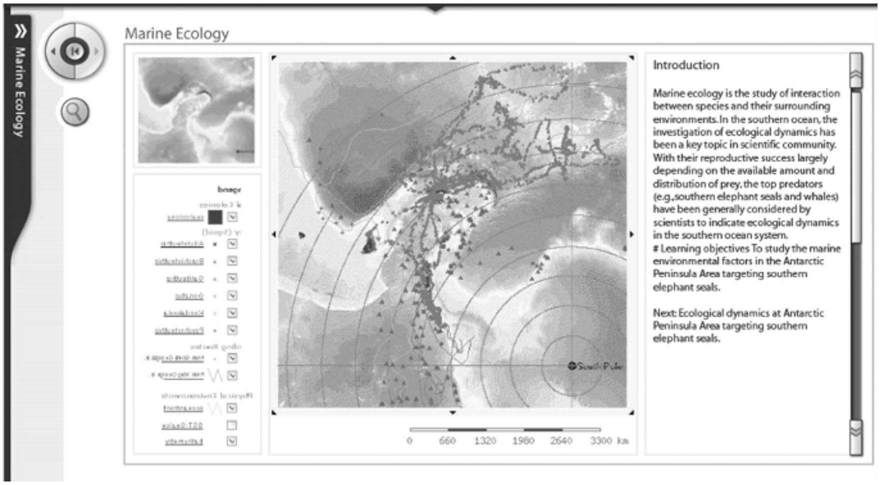

Fig. 7. The Marine Ecology module created by Xiuxia Liu. The module supports connection to distributed databases including updated observations on the state of marine mammal populations as they become available. (Image courtesy of the Geomatics and Cartographic Research Centre, Carleton University.)

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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References

Berkman, P. A. (2002). *Science into policy: global lessons from Antarctica*. San Diego, CA: Academic Press.

Bishr, Y. A., Pundt, H., Kuhn, W., & Radwan, M. (1999). Probing the concept of information communities - a first step toward semantic interoperability. In M. Goodchild, M. Egenhofer, R. Fegeas & C. Kottman (Eds.), *Interoperating Geographic Information Systems* (pp. 55-70). Norwell, Mass.: Kluwer Academic Publishers.

Brauen, G. (2006). Designing Interactive Sound Maps Using Scalable Vector Graphics. *Cartographica, 41*(1).

Caquard, S., Pulsifer, P., Fiset, J.-P., & Taylor, D. R. F. (2005). *Le concept d'acte cybercartographique: Genèse d'un atlas cybercartographique de l'Antarctique.* Paper presented in proceedings of the Colloque international SAGEO 2005, Avignon, France.

Chang, M., & Goodman, E. (2004). *FIASCO: Game Interface for Location-Based Play*. Paper presented at the DIS2004, Designing Interactive Systems, Cambridge, Massachusetts.

DiBiase, D. (1990). Visualization in Earth Sciences. *Earth and Mineral Sciences, Bulletin of the College of Earth and Mineral Sciences, PSU, 59*(2), 13-18.

Erle, S., Gibson, R., & Walsh, J. (2005). *Mapping Hacks*. Sebastapol, CA: O'Reilly Media Inc.

Goodchild, M., Egenhofer, M., Fegeas, R., & Kottman, C. (Eds.). (1999). *Interoperating Geographic Information Systems*. Norwell, Mass.: Kluwer Academic Publishers.

Goodchild, M. F., Egenhofer, M. J., Kemp, K. K., Mark, D. M., & Sheppard, E. (1999). Introduction to the Varenius Project. *International Journal of Geographical Information Science, 13*(8), 731-745.

Greenspan, B., Dormann, C., Caquard, S., Eaket, C., & Biddle, R. (2006). Live Hypernarrative and Cybercartography: You are Here, Now. *Cartographica, 41*(1), pp 35-46.

Jasen, P. (2005). Designing the Sound Identity of the Cybercartographic Atlas of Antarctica. In I. M. o. t. C. project (Ed.). Integration meeting of the CANE project, Carleton University, Ottawa.

Jezek, K. C. (1999). Glaciological properties of the Antarctic ice sheet from RADARSAT-1 synthetic aperture radar imagery. *Annals of Glaciology, 29*, 286-290.

Joyner, C. C. (1998). *Governing the Frozen Commons: The Antarctic Regime and Environmental Protection*. Columbia, South Carolina, USA: University of South Carolina Press.

Kottman, C. (1999). The Open GIS Consortium and progress toward interoperability in GIS. In M. Goodchild, M. Egenhofer, R. Fegeas & C. Kottman (Eds.), *Interoperating Geographic Information Systems* (pp. 39-54). Norwell, Mass.: Kluwer Academic Publishers.

Lauriault, T. P., & Lindgaard, G. (2006). Scented Cybercartography: Exploring Possibilities. *Cartographica*, *41*(1).

Lauriault, T. P., & Taylor, D. R. F. (2005). Cybercartography and the New Economy: Collaborative Research in Action. In D. R. F. Taylor (Ed.), *Cybercartography: Theory and Practice*. Amsterdam: Elsevier.

Lehto, L. (2003). A Standards-Based Architecture for Multi-purpose Publishing of Geodata on the Web. In M. Peterson (Ed.), *Maps and the Internet* (pp. 221-230): Elsevier Science.

MacEachren, A. M. (2001). Cartography and GIS: extending collaborative tools to support virtual teams. *Progress in Human Geography*, *25*(3), 431-444.

MacEachren, A. M., & Kraak, M. (2001). Research Challenges in Geovisualization. *Cartography and Geographic Information Science*, *28*(1), 3-12.

McGonigal, D., & Woodworth, L. (Eds.). (2001). *Antarctica and the Arctic: The Complete Encyclopedia*. Willowdale: Firefly.

Parush, A., Pulsifer, P., Philp, K., & Dunn, G. (2006). Understanding through Structure: The Challenges of Information and Navigation Architecture in Cybercartography. *Cartographica*, *41*(1), 24 - 31.

Pickles, J. (2004). *A History of Spaces: cartographic reason, mapping and the geo-coded world*. London and New-York: Routledge.

Pulsifer, P. L., Parush, A., Lindgaard, G., & Taylor, D. R. F. (2005). The Development of the Cybercartographic Atlas of Antarctica. In D. R. F. Taylor (Ed.), *Cybercartography: Theory and Practice*. Amsterdam: Elsevier.

Pulsifer, P. L., & Taylor, D. R. F. (2005). The Cartographer as Mediator: Cartographic Representation from Shared Geographic Information. In D. R. F. Taylor (Ed.), *Cybercartography: Theory and Practice*. Amsterdam: Elsevier.

Rasouli, M., Philp, K., Khan, S., Dunn, G., Lindgaard, G., & Parush, A. (2004). The application of a User-Centered Design in the Development of Two Web-Based Educational Cybercartographic Atlases, *CAGONT (Canadian Association of Geographers – Ontario Division) Conference*. University of Waterloo, Waterloo, Canada.

Taylor, D. R. F. (2003). The Concept of Cybercartography. In M. Peterson (Ed.), *Maps and the Internet*. Cambridge: Elsevier.

Taylor, D. R. F., & Pulsifer, P. (2002, July 16th). *The Cybercartographic Atlas of Antarctica: Supporting Research in Geoscience*. Paper presented at the XXVII SCAR, Shanghai, PRC.

Théberge, P. (2005). Sound Maps: Music and Sound in Cybercartography. In D. R. F. Taylor (Ed.), *Cybercartography: Theory and Practice*. Amsterdam: Elsevier.

Vasconcellos, R., & Tsuji, B. (2005). Interactive Mapping for People Who Are Blind or Visually Impaired. In D. R. F. Taylor (Ed.), *Cybercartography: Theory and Practice*. Amsterdam: Elsevier.

Woods, B. A. (2005). *Geo-Visualization for Geo-science Education.* Unpublished Master's Thesis, Carleton University, Ottawa.

Zaslavsky, I. (2003). Online Cartography with XML. In M. Peterson (Ed.), *Maps and the Internet* (pp. 171-196): Elsevier Science.

Zhou, Y. (2005). *Profiling and Visualizing Metadata for Geo-Referenced Multimedia Information in a Geospatial Portal: A Case Study for the Cybercartography and the New Economy Project.* Unpublished Master's Thesis, Carleton University, Ottawa, Canada.