Chapter 14
Potential Contributions and Challenges of VGI for Conventional Topographic Base-Mapping Programs

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Abstract This chapter introduces the context and characteristics implicit in conventional digital topographic mapping programs and then contrasts them to important underlying assumptions regarding volunteered geographic information. It defines the term "authoritative data" and challenges its use in the context of comprehensive topographic base-mapping programs. After examining prevailing cultures and assumptions that must be adjusted and workflows that must be modified to manage risk and make the best use of VGI in this role, case studies from the state of Victoria, Australia; the United States Geological Survey; and TomTom describe the early experiences of conventional mapping organizations in this regard. The author contends that VGI is *not* the ultimate solution to all geospatial data updating and maintenance challenges now faced by mapping organizations. However, it does represent an important potential channel of such updates that needs to be investigated seriously and implemented responsibly.

14.1 Introduction

Use of volunteered geographic information (VGI) by public and private comprehensive mapping organizations is now either under way or under consideration. As of summer 2011, Google Map Maker provided citizens in 188 jurisdictions with the ability to help populate and update Google Maps' graphical and attribute data (Google 2011). *OpenStreetMap*, *TomTom*, and *NAVTEQ* all routinely use volunteer contributions to maintain their databases (Coleman et al. 2010). In Australia, the Victoria State

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Government now permits (registered) individual government employees to update state-level mapping features and attributes.

Volunteered geographic information or VGI and its related terms have been discussed at length in other chapters of this book. The more general concepts of "user-generated content," "user-created content," and "crowdsourcing" are well documented (OECD 2007), and Cook (2008) offers a taxonomy of both passive and active "user contribution systems" in the consumer market. In addition to the better-referenced works defining neogeography and VGI by Turner (2007) and Goodchild (2007), respectively, more recent articles by Coote and Rackham (2008), Grira et al. (2010), and Heipke (2010) also do an excellent job of examining VGI contributors and their contributions.

Coote and Rackham (2008) describe neogeographic datasets as possessing the following characteristics:

- Creation has been stimulated by a lack of available data or by frustrations with costs, restrictions, and limitations of existing conventional data sources.
- They involve the capture, processing, and dissemination of geographic information provided voluntarily by individuals.
- Approaches to creation and management are neither intuitive nor necessarily tied to accepted standards or methods.
- Data is licensed using some open-source approach, which allows for users to consume the data without charge provided the original creator is acknowledged and any other user can do the same with anything you produce.

Web-enabled VGI has been used extensively over the past 3 years to support emergency operations by mapping the extent of affected areas, highlighting important incidents, and documenting disaster-recovery operations (e.g., Zook et al. 2010; Heinzelman and Waters 2010; Roche et al. 2011). As companies like Google, TomTom, and NAVTEQ have already discovered (Coleman et al. 2010), the potential exists for *government* mapping agencies to harness the power of Web 2.0, new media, and voluntarism in order to improve their own change-detection and geospatial data-updating processes.

There has been no shortage of online discussion regarding whether and how public-sector mapping and charting organizations might employ VGI in their map production, updating and even enriching the attributes of selected features (e.g., Casey 2009; Dobson 2010b; Ball 2010). There has also been interest from national government organizations in examining the role and potential of employing VGI in their map updating and enrichment of attributes (e.g., Guélat 2009). However, such efforts are still in their early stages.

This chapter will review the potential advantages and challenges of using volunteered geographic information as a tool in the updating and elaboration of features contained in government and commercial map databases. After examining prevailing cultures and assumptions that must be adjusted, as well as workflows that must be modified before making the best use of VGI in this role, the author discusses how existing developments are already answering important questions posed by conventional mapping organizations.

14.2 Challenges Faced by Professional Mapping Organizations

The missions, mandates, accomplishments, and perceived shortcomings of national mapping organizations have been well documented (e.g., Andrews 1970; Hardy and Johnston 1982; Cowen et al. 2003). Since the products maintained by these organizations are regarded as important information assets, most of these organizations have had to be responsive to users regarding, for example, how best to improve the content and currency of their products, update data structures to allow for more extensive geographical analyses, and modify pricing policies and distribution infrastructure to facilitate online access and increase downloads—all to meet a broad range of evolving requirements and technologies.

14.2.1 What Is "Authoritative Data"?

The term "authoritative data" has been used to describe products produced by professional mapping organizations (Goodchild 2009; Coleman et al. 2010; Ball 2010). However, no definitions of the word "authoritative" are offered in those articles.

One possibility is offered by Van der Molen and Wubbe (2007) in discussing government policy in the Netherlands. The authors describe the creation and designation of six key datasets as official "authentic" national registers, each of which was defined as "… a high quality database accompanied by explicit guarantees ensuring for its quality assurance that, in view of the entirety of statutory duties, contains essential and/or frequently-used data pertaining to persons, institutions, issues, activities or occurrences and which is designated by law as the sole officially recognised register of the relevant data to be used by all government agencies and, if possible, by private organisation's [*sic*] throughout the entire country, unless important reasons such as the protection of privacy explicitly preclude the use of the register."

In this context, two of the first six authentic registers were in fact geographically related—the cadastral registers and maps, and the 1:10,000-scale topographic base mapping (Kadaster International 2007).

Nautical charts in some countries are recognized to be "authoritative" documents (Fisheries and Oceans Canada 2011; LINZ 2011). They are updated regularly through "notices to mariners," and in some countries, producers or value-added repackagers of electronic nautical chart data may assume some liability in the event charts contain erroneous or out-of-date information (Obloy and Sharetts-Sullivan 1994). Similarly, aeronautical charts are updated regularly, and their updating has long been conducted by specialists possessing a "…comprehensive and authoritative personal knowledge" of reliable source materials and cartographic activities in a given area (UNECA 1966).

It can be appreciated how regularly maintained cadastral maps, nautical charts, aeronautical charts, and even local zoning maps may be seen to be "authoritative" sources of public information within a jurisdiction. Beyond the Netherlands, however, there is little mention in other countries of formally recognized "authentic"

or "authoritative" *topographic* map series that would adhere to a similar definition. With the exception of the Ordnance Survey of Great Britain, most national government mapping agencies have neither the funding nor the mandate to keep their mapping databases current within specified time frames. Budgets for topographic digital map maintenance activities in some jurisdictions are either declining or nonexistent. The larger the country's size, the older some of its base mapping is likely to be.

With more up-to-date mapped information now available online from other sources, referring to national or regional government topographic mapping databases as being "authoritative" has become misleading in some cases. The practice is also becoming a source of division and controversy within the geospatial user community when examining the relative merits and uses of volunteered geographic information (Ball 2010; van der Vlugt 2011).

Coote and Rackham (2008) offer the term "conventional" as an alternative to "authoritative" and suggest the following characteristics of conventional datasets:

- Created for a specific and defined set of requirements whether for legal, administrative, or commercial purposes.
- Depending on the context, these may or may not be freely available, but usually there is at least some dissemination charge and, most likely, restrictions on access and use.
- Managed by organizations established for the purpose, whether as public or commercial bodies. There may be collaboration between organizations but on the basis of legal agreements including commercial contracts.
- Collected by professional staff who are paid to do so.
- Based on established methods, standards, specifications, and practices.
- Quality assured to varying degrees during the production of the data and supplied with some information, however basic, on the quality of the data.
- Protected by some form of copyright and governed by formal agreements or licenses.
- Access limited, in many cases, to only certain organizations or individuals for reasons of security, data protection, or commercial advantage.

While some of these points are UK specific—and more conventional data may be "freely" available now than when their paper was presented—these characteristics can be seen in government topographic mapping products across Europe, North America, and Australasia. Accordingly, the adjective "conventional" rather than "authoritative" will be used through the remainder of this chapter to describe comprehensive base-mapping programs.

14.2.2 Implications of Aerial Mapping on the Characteristics of Conventional Base Mapping

Since 1945—and well before in developed countries—most national topographical map series have been produced by photogrammetric means using aerial surveys.

As a result, some important characteristics of the products involved must be kept in mind:

1. Data compilation has been done remotely by trained mapping technicians who may possess only a limited knowledge of the features in the area being mapped.
2. Mapped features are classified into relatively broad categories, with their corresponding range of attributes often limited to what can be determined from photo interpretation and a limited set of support documents.
3. Prior to any data structuring and logical consistency considerations, preliminary quality assurance concerns in map compilation center on (a) proper rectification of imagery or restitution of stereo models in advance of the mapping, (b) geometrically accurate representation of the center or selected edges of a given feature (e.g., roof lines rather than building footprints), and (c) correct classification and coding of features in accordance with the given classification scheme.
4. Field verification and completion of the mapping content is labor intensive, depends on available program funding, and may vary widely within and between programs depending on prevailing budget considerations.
5. Production and subsequent updating are organized on the basis of geographic coverage, where mapping of one or more adjacent map sheets, files, or tiles is undertaken, completed, and distributed to users within a fixed period of time. Attention and budgets then shift to a different geographic area. It may be years or even decades before attention returns to a given geographic area. (An exception is the United Kingdom, where revision cycles are much shorter.) When updating does occur on such maps or tiles, all features in the given area associated with that particular mapping product are typically updated unless otherwise specified.

Contrast this list with Coote and Rackham's proposed characteristics of neogeographic information offered in Sect. 14.1. Further, Bruns (2008) identifies four important characteristics of information "produsage" in a Web 2.0 environment as distinct from more traditional information production:

- Collection and review operations are community based rather than relying on "… a narrow elite of knowledge workers."
- Roles of produsers will be fluid, alternating between collector, reviewer, arbitrator, and user at different times.
- A given product will be never be finished—it will be under continuous review, and different aspects or portions will be updated at different times.
- Produsers favor more permissive approaches to rights in intellectual property than those found in traditional content production.

To employees within a mapping organization, then, the implications of incorporating VGI into its processes include rethinking (1) entire aspects of production workflow, (2) who should be involved, and even (3) what constitutes a "product" they are prepared to offer to users. Important cultural hurdles may include the following:

- Accepting that untrained "outsiders"—even trusted ones—may be willing and able to make reliable contributions

- Assessing whether or not some larger community of users has the willingness and capability to collectively offer some level of editing and quality assessment of individual contributions
- Moving from a coverage-based to a feature-based updating model
- Accepting that such volunteered information will be "perpetually unfinished"
- Accounting for and balancing the respective rights of individual contributors, the VGI community, and the mapping organization itself
- Accommodating practical, political, social, and possibly even legal implications implicit in the characteristics mentioned above

Allowing even trusted "outsiders" to collect and/or modify internally collected mapping can be a difficult culture shift. In Canada, it took at least 3 years in the late 1970s before internal government mapping inspectors agreed the quality of national topographic series mapping compiled by professional private-sector firms was sufficient to shift contracting out from pilot-project efforts to standard practice. Even exchanges of digital map data between different levels of government mapping agencies were undertaken with caution and only after considerable negotiation (Pearson and Gareau 1986).

The cultural and processual changes involved in shifting the planning and production focus from a "coverage-based" to a "feature-based" orientation cannot be underestimated. Road-network firms like TomTom and NAVTEQ have already made this shift and realized quicker turnaround times of updates and improved customer service (TomTom 2008), but many government topographic mapping organizations have not.

14.3 Workflow, Quality Assurance, and Risk Management Considerations

Despite the challenges mentioned in Sect. 14.2, the idea of using volunteered geographic information nevertheless remains of considerable interest to mapping organizations. The prospects of more descriptive and up-to-date information in "high-usage" geographic areas where changes may occur frequently are attractive to base-mapping organizations interested in exploring more cost-effective ways in which to improve their products. This section describes some key considerations mapping program managers should take into account when designing or reworking production processes.

14.3.1 Attracting and Retaining Volunteer Contributors

Will individuals want to contribute to government in the same way they contribute to social networks and even to commercial databases from TomTom, NAVTEQ, and others? What questions should an organization ask in determining how, if at all, it

should employ VGI? How does an organization assess the credibility of a new contributor and the degree of trust it can place in that person's contributions? How do organizations attract new volunteer contributors, and how do they keep existing volunteers engaged—or is it assumed they will cycle in and out?

There is ample evidence that interested volunteers do exist—at least in the early stages of a program. Results of early research into the nature and motivation of contributors—and the types of contributions they make—are discussed in depth by Coleman et al. (2009), Budhathoki et al. (2010), Dobson (2010b), and Cooper et al. (2011) among others. Coleman et al. (2010) further examined how three different spatial data organizations employed VGI in the updating of their map databases—and summarized in each case the respective motivator(s) the program was directly or indirectly offering.

14.3.2 Quality Assurance Considerations

If and as volunteer contributions are solicited, how will they be integrated into conventional production workflows? Given the challenges discussed in Sect. 14.2 of this chapter, how will quality assurance considerations be addressed? Who, if anyone, will assume the risks associated with the introduction and use of contributions from different sources?

As discussed in Sect. 14.2, there are fundamental differences between how quality assurance is viewed by VGI contributors versus individuals in professional mapping organizations. Conventional mapping is produced in accordance with mature, well-documented specifications and is assessed by individuals who are trained in interpreting those specifications and understanding the products themselves and well versed in the inherent errors or blunders encountered in data compilation.

The positional accuracy of volunteered geographic information in comparison with data from conventional programs is well documented. Rigorous investigations conducted by Haklay (2010), Coleman et al. (2010), and Girres and Touya (2010), among others, all attest to the acceptability and accuracy of VGI contributions to (e.g.) OpenStreetMap in relation to other well-documented map series. Moreover, the repeated capture of the same feature's location by multiple contributors through active and (especially) passive means has proven to greatly improve the accuracy of positioning and representation (Haklay et al. 2010; Dobson 2010a). Finally, related research (e.g., Zandbergen 2009; Gakstatter 2010) has isolated constraints on existing cell phones as positioning devices *and* led to technology breakthroughs that will further improve cell phone-based positioning in the near future.

Positional accuracy is only one aspect of data quality, though. Coote and Rackham (2008) point out that "quality" in the context of VGI is more subjective in nature and depends on:

1. A user's requirement and his or her expectations
2. The benefits the user wants to derive
3. What the user or contributor means by "data quality"

In this regard, currency of data and reliability of feature attributes within a given area may be far more important elements of quality to a given user or users than positional accuracy or the completeness of coverage over an entire county or map tile.

Also, in some VGI initiatives, there may be no clear line of authority regarding who is ultimately responsible for assessing the quality of positioning and representation of a given feature, nor who possesses the rights to modify those things.

This degree of subjectivity, the possible existence of multiple contexts, and the lack of clear lines of authority are possibly baffling and certainly unacceptable to a practitioner accustomed to conventional mapping workflow and practices.

Finally, from a user perspective, the potential lack of consistency in terms of up-to-date content, interpretation, and structuring may constrain a dataset's use for analysis and ultimately lead to only guarded acceptance of the product (Coote and Rackham 2008).

14.3.3 Assessing the Credibility of Contributors

One of the major concerns of using VGI as a source of input to authoritative databases is how to assess the credibility of contributors and the reliability of their contributions. The success of reputation-based services like *eBay.com* holds one key for building trust for handling VGI. *eBay* users who log in to purchase items online may leave feedback for the sellers and future purchasers based on the success of the transactions. *eBay* then uses a centralized user reputation system that drives its inputs from buyer ratings of the sellers. Social networking sites which make use of VGI contributions of point- and route-based data have adopted similar approaches and, in some cases, automated the ways in which improvements can be noted and incorporated.

Different lessons can be learned from leading wikis such as *Wikipedia.org*. Wikipedia originally relied solely upon the "wisdom of the crowds" to evaluate, assess, and if necessary, improve upon entries from individual contributors, usually with great success. However, beginning in December 2009, it has relied on teams of editors to adjudicate certain "flagged entries" before deciding whether or not to incorporate a volunteered revision (Beaumont 2009).

Theoretical approaches to characterizing VGI contributions and/or their contributors are now being formulated by the international research community. For example, Lenders et al. (2008) theorize an automated approach to establishing the level of trust inherent in different user-generated contributions to local-based services. The proposed architecture of their "secure localization and certification service" maintains user privacy by tagging volunteered content with the location and time of the contribution rather than the identity of the contributor. The level of trust in a given change increases in direct proportion to how recently the contribution was made and how close the contributor was geographically to the proposed change. Other examples of research to better categorize contributions and automate processes include work by Maué and Schade (2008), Poser et al. (2009), and Brando et al. (2011), among others.

14.3.4 Practical Examples of Managing Risk

Coleman et al. (2010) investigated how three different public and private organizations incorporated volunteered contributions into their production workflow: the state of Victoria's Notification for Edit Service in Australia, the National Map Corps Initiative of the United States Geological Survey, and TomTom's MapShare™ service. These are summarized in the following subsections.

14.3.4.1 Notification for Edit Service, Victoria Department of Sustainability and Environment, Australia

Victoria DSE's Notification for Edit Service (Thompson 2011; NES 2008) employs internal contributions of volunteered geographic information by internal government staff outside the formal mapping agencies to update widely used base-mapping databases. A network of registered "knowledgeable notifiers"—state and local government users of Victoria's Corporate Spatial Data Library (CSDL)—use a password-protected Web-based system to either correct or update selected mapped features based on field evidence found in routine government operations. Suggested updates to a given feature are routed automatically to the designated custodian agency responsible for that feature type, and then the custodian is given the option to either confirm or refute the amendment. An update tracking system provides regular reports on the status of each update, where it currently sits in the process and, if complete, whether or not it was accepted (Fig. 14.1).

14.3.4.2 National Map Corps, United States Geological Survey

The National Map Corps was a pioneering effort in using VGI to update and supplement government mapping in North America. The NMC's "Adopt-a-Map" program had by 2001 over 3,000 volunteers identifying and annotating topographic map corrections and updates to hardcopy United States Geological Survey (USGS) map sheets (Fig. 14.2) and National Map data files (Bearden 2009). Later aspects of the program included incorporation of updates and additions based on hand-held GPS observations. Still later, a Web-based map and image viewer (Fig. 14.3) enabled volunteer users to easily identify and label buildings and other structures requiring annotation (Bearden 2007b).

Although the volunteer response was very impressive, the USGS simply did not possess the internal resources necessary to act on these notifications. Traditional coverage-based map revision workflows and long updating cycles meant that the feature-based annotation work completed by the volunteers was rarely used. Volunteer numbers diminished, and the map annotation aspect of the program was ultimately stopped altogether in 2005. Further, the large number of GPS updates submitted overwhelmed the limited staff resources assigned to assessing and using the volunteered input. By 2007, there was a 16-month backlog of GPS-collected points increasing almost daily (Bearden 2007a). Due to program budget cuts, issues

1 2 3 4

Change Request ID	Description	Notifier	Status	WF	Date Last Modified	View Details
341	Apiry Point Editing with UFI=346	Local Government Authority (Towong Shire)	SUBMITTED		8/09/2008 10:16:51 AM	View Details
340	Apiry Point Editing with UFI=346	Local Government Authority (Towong Shire)	SUBMITTED		8/09/2008 10:16:42 AM	View Details
339	Apiry Point Editing with UFI=707	Local Government Authority (Towong Shire)	SUBMITTED		8/09/2008 10:16:37 AM	View Details
338	Apiry Point Editing with UFI=707	Local Government Authority (Towong Shire)	SUBMITTED		8/09/2008 10:16:31 AM	View Details
337	Apiry Point Editing with UFI=2633	Local Government Authority (Towong Shire)	SUBMITTED		8/09/2008 10:16:22 AM	View Details
336	Apiry Point Editing with UFI=1563	Local Government Authority (Towong Shire)	SUBMITTED		8/09/2008 10:16:08 AM	View Details
334	road demo	NES General Public	CHANGE ACCEPTED		5/09/2008 3:03:00 PM	View Details
332	Sept M1	Local Government Authority (Towong Shire)	SUBMITTED		3/09/2008 3:26:59 PM	View Details
330	Road name demo 1	NES General Public	CHANGE ACCEPTED		3/09/2008 3:21:41 PM	View Details
325	test change parcel	NES General Public	CHANGE ACCEPTED		3/09/2008 12:30:45 PM	View Details
324	test change	NES General Public	CHANGE ACCEPTED		3/09/2008 11:30:24 AM	View Details
298	Deleted a property	NES Sample State Org	SUBMITTED		1/09/2008 9:05:17 AM	View Details
293	name to both	NES General Public	SENT TO ROAD & ADDRESS MAINTAINERS		29/08/2008 4:39:53 PM	View Details
292	name to 2	NES General Public	SENT TO ROAD MAINTAINER		29/08/2008 4:39:41 PM	View Details
291	name to 1	NES General Public	SENT TO ADDRESS MAINTAINER		29/08/2008 4:39:27 PM	View Details
288	road name dual -2	NES General Public	CHANGE ACCEPTED		29/08/2008 3:35:30 PM	View Details
287	road name dual -1	NES General Public	CHANGE ACCEPTED		29/08/2008 3:34:37 PM	View Details
285	Add Address (Testing Add Multi-Feature Function)	Local Government Authority (Wangaratta Rural City)	SUBMITTED		29/08/2008 12:22:27 PM	View Details
284	this is road name extent - other was road name	NES General Public	CHANGE ACCEPTED		29/08/2008 3:39:21 PM	View Details
283	road name extent	NES General Public	CHANGE ACCEPTED		29/08/2008 12:32:14 PM	View Details
280	Road 5	NES General Public	DECLINED		29/08/2008 10:49:34 AM	View Details
279	Road 4	NES General Public	CHANGE ACCEPTED		29/08/2008 3:42:30 PM	View Details
278	Road 3	NES General Public	CHANGE ACCEPTED		29/08/2008 12:34:25 PM	View Details
268	m1 for Augyst	Local Government Authority (Towong Shire)	SENT TO MAINTAINER		28/08/2008 2:11:06 PM	View Details

Fig. 14.1 Tracking updates within NES (NES 2008)

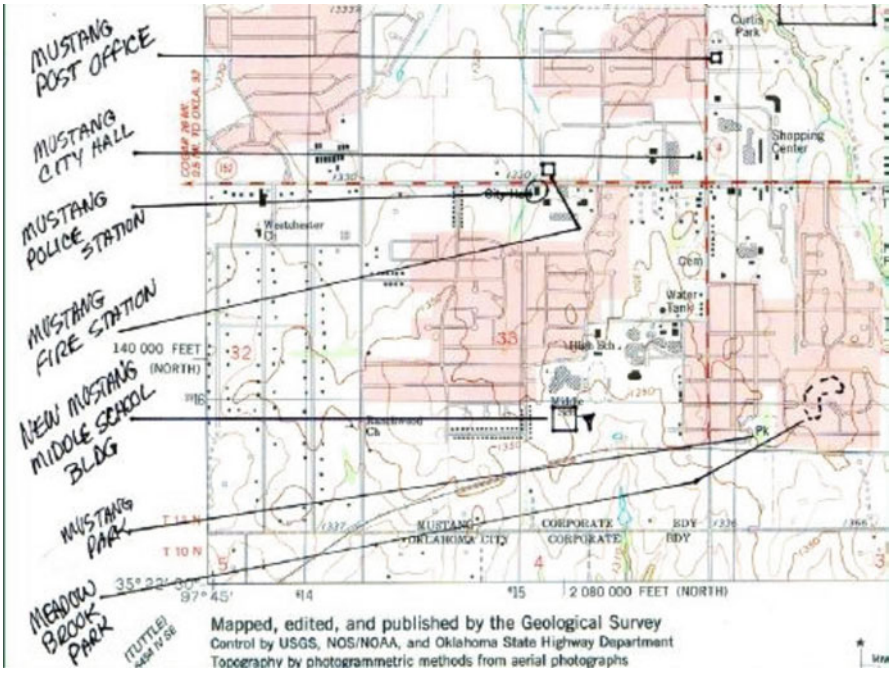

Fig. 14.2 Volunteered updates to hardcopy USGS mapping (Bearden 2007b)

Fig. 14.3 National Map Corps image and map viewer (Bearden 2007b)

over continued resourcing, and internal disagreements over the validity of volunteered content, National Map Corps activities were suspended in fall 2008 with the exception of its online viewer and labeler website (National Map Corps 2008).

Although the program itself had been suspended, interest remained strong in the concept itself. A USGS-sponsored workshop on VGI was held in 2010 (CEGIS 2011), and a collaborative pilot project with the OpenStreetMap organization, started in 2011 to have volunteers digitize new road information, is now under evaluation (Wolf et al. 2011). A follow-on pilot project to collect data on thirty different types of structures in the greater Denver, Colorado, area is now under way (National Map Corps 2011).

14.3.4.3 TomTom's MapShare™ Service

TomTom's online MapShare™ service is a popular operational example of how one large commercial data supplier manages risk in terms of assessing volunteered contributions and disseminating such noncertified updates to its customers (Club TomTom 2007). The company employs a graduated approach to sharing, assessing, and using the volunteer-provided updates. First, MapShare contributors have the choice of only using their updates on their own TomTom units, of sharing within their own group, or of sharing them with the general TomTom community. Second,

Fig. 14.4 Customer choices in selecting MapShare updates to be used on own TomTom unit (Club TomTom 2007)

TomTom itself assigns a progressively higher level of credibility to a given update through its independent confirmation by (1) more than two independent contributors, (2) many independent contributors, (3) a "trusted partner" or corporate user, and finally (4) its own crews or contractors in the field. Finally, it allows its customers to interactively select the "level of trust" they desire for the data used on their navigation unit (Fig. 14.4). Customers may elect to use only updates reported by TomTom/Tele Atlas field crews, by trusted commercial partners and many customers, by only a few customers, or even only by themselves.

Chapter 17 by Dobson in this volume offers a much more detailed description of TomTom's MapShare service and the data collection production workflow it employs. As well, it provides valuable comparisons with TomTom's competitor NAVTEQ and with the hybrid approach to collection and updating adopted by Google.

14.4 Discussion

Coleman et al. (2009) suggested important questions that conventional public and private mapping organizations should ask themselves when considering the opportunities and risks posed by introducing and employing VGI in their production processes. *What problems or objectives are we trying to address? To what extent should we initially adopt VGI? How may credible contributors be distinguished from those who are mischievous or malicious? How do we cultivate the volunteers—whether they are one-time or regular contributors? Who makes the final decisions regarding the reliability and integrity of a given update?*

These are legitimate questions, and early lessons can already be drawn from reviewing these volunteered contributions as well as those to other online communities.

Regarding the Programs Themselves

- Experience has shown that, once the request goes out, the number and extent of volunteered contributions can be significantly underestimated. Organizations that

underresourced the VGI acceptance and verification aspects of their production workflows have found themselves overwhelmed and unable to use all the input. Unless the rationale and goals of a VGI initiative—be it pilot project or mainstream activity—are clearly defined, communicated, and measured, the initiative risks being curtailed when the next round of budget cuts occur. Program managers need to be clear on their rationale, their goals, and the metrics used to assess progress towards those goals. "Shortening updating cycles," "verifying selected attributes," and "adding new attributes" for specific features are all examples of legitimate and measurable goals.

Regarding Contributors

- The size and scope of the "contributor pool" may be controlled. Initially, it may be restricted to employees of the organization and knowledgeable, long-standing users of the data. Access may be opened up gradually as confidence grows in the contributions received and as the organization provides additional resources to accept and process the growing number of contributions.
- Volunteer contributors value some recognition of their contribution. This may range from prompt recognition of the contribution by a return e-mail message (Tele Atlas and Google both acknowledge such contributions to their Map Insight and My Map websites) to more formal inclusion of contributors in metadata or tags associated with the feature.
- Contributors want to see their contribution used—and quickly. Case studies cited from both the Wikipedia and the open-source software communities identified the importance of contributions being acted upon and either incorporated or refuted quickly. The falloff of National Map Corps volunteers after their updates were not acted upon quickly is just one example of this. It may take a while to verify a contribution, but early acknowledgement of its receipt and follow-on communication that it is being reviewed are both signs of good service that contributors value.
- As a program matures, failing to retain all volunteer contributors is not necessarily a sign of failure. Experience has shown that the majority of contributors of new information to such databases may make only one or two contributions—a new road, an update or correction to a given feature in their neighborhood, etc. A limited group of dedicated and long-serving members of the volunteer community then assess that contribution and refine it to fully meet existing specifications.
- This, in turn, implies that mature programs must have separate but integrated interfaces. A simple, easy-to-use interface with limited functionality—but perhaps more extensive postprocessing—is required to satisfy occasional or one-time-only contributors. With an appropriate hierarchy of access privileges in place, a more sophisticated and multifunctional Web interface would be employed to accommodate more extensive edits by internal production staff and external "power users."

Regarding Their Contributions

- The majority of contributions—especially to road networks—deal with amendments or additions to a feature's *attributes* rather than to its location or representation.

- Major private-sector initiatives like TomTom's have already recognized that they must develop hybrid systems that accommodate different channels of volunteered input. Following the examples discussed in this chapter, a conventional mapping organization may start by accepting only amendments to attribute data and active contributions of positional data collected using GPS. They may subsequently add the capability to incorporate active contributions of features digitized from online satellite or aerial imagery. As technologies and attitudes evolve, their system may grow to include approved passive contributions of a person's position in real time as he or she travels in a car or ATV, on a bicycle, or even on foot.
- There *are* established and tested ways to validate the reliability of VGI contributions and the credibility of their contributors. Certain spatial and temporal considerations make VGI contributions unique, and these may be used to support or refute the credibility of a given contributor. Tools built atop early technologies like WikiScanner (Borland 2007) may help identify the rough geographic location from which a contribution originated. Geotagged cell phone images may be used to provide supporting evidence of a given update.

  Some VGI activities—for example, digitizing features from satellite imagery in areas with limited vector mapping or where a natural disaster has occurred—may not lend themselves to this type of validation. However, this is where engagement of other volunteers helps to validate or refute a contribution, or assess the reliability of competing or contradictory contributions.

14.5 On the Future of Conventional Public-Sector Mapping Programs

The significant growth and notoriety of *private-sector* mapping services and their more rapid adoption of VGI beg questions as to the future of *public*-sector mapping programs. Certainly government budgets are shrinking. Funding for both in-house *and* subcontract production has declined in some jurisdictions. Where new or updated production *is* under way in national- and state-level programs, funds are more likely to be directed towards creation of image-based mapping products and higher-accuracy digital elevation models rather than towards updates to vector mapping.

Moreover, rather than compete, many governments have opted to provide a base upon which *others* can develop and provide value-added applications. Even in cases where the basic road centerline and cultural information may come from government base mapping, that information is now perceived to have originated from the Web service provider itself. This places program executives in the position of having to explain to their public-service and political masters the reasons why they should continue to be funded at all.

Why indeed? While they may form the vast majority of operations conducted, can we assume that *all* users will be satisfied solely by the map display, address-finding, routing, area-based query, and point-mapping capabilities of services like Google and Bing?

The largest and most intensive groups of users of multipurpose government mapping are usually found in other government departments. Clearly, a full investigation of this larger question is beyond the scope of this chapter. However, the following focused questions would help drive such an investigation:

1. By virtue of its mission, to what extent must a government or private organization commit to certain norms or expectations of areal coverage and consistency of reliability or currency of a geospatial dataset in a given jurisdiction? Have such expectations become negotiable?
2. What assumptions are taken into account when using conventional base mapping for specific applications? What operations (if any) must be undertaken to convert or prepare this conventional mapping for use in internal applications?
3. Under what conditions can geospatial data provided by commercial suppliers like Google, Bing (Microsoft), and others be used by organizations to meet their own unique mission-driven requirements? (The act of "importing" per se may be a misnomer in this era of cloud computing.) What are the legal, financial, technological, and labor implications involved?
4. To what extent do the geospatial data content, coverage, accuracy, attribute correctness, currency, and structure of commercial datasets meet the requirements of specific applications to be found in such customer organizations? Does the potential heterogeneity of such data across a jurisdiction represent a concern? Under what circumstances?
5. Under what conditions are commercial providers prepared to upgrade the quality or consistency of their data to meet the needs of specific customers? Are these upgrades subsequently available to all users and under what conditions?
6. To what extent are user organizations now prepared either to independently update such commercial information, to update their own datasets, or even to collect and use their own geospatial data from scratch in their GIS applications as a project requires?
7. To what extent is a government organization prepared to tie itself and its data holdings to any one particular service provider? What conditions and provisions should be considered by that organization in order to protect its investment in its own data holdings?

Responses to these and other questions should have a real bearing on the nature of enabling infrastructure, products, and services provided by public-sector mapping programs in the future.

14.6 Concluding Remarks

This chapter has introduced the context and characteristics implicit in conventional digital topographic mapping programs and contrasts them to important underlying assumptions regarding volunteered geographic information. Despite claims to the contrary, government topographic mapping products in most countries are not

"authoritative" by any practical definition. Far from it. They are typically out of date, possibly inconsistent, and usually the victims of diminishing maintenance budgets.

At the same time, claims that VGI in itself—or VGI-supported private data suppliers—will replace the overall role of conventional mapping organizations in developed countries in the near term are likely overblown. Research has demonstrated that there remain remote areas in which change may have occurred but which are not being mapped by volunteers. As well, further research is required to determine the conditions under which such suppliers would have the interest and resources required to satisfy the varied requirements of such conventional programs.

VGI is *not* the ultimate solution to all geospatial data updating and maintenance challenges now faced by mapping organizations. However, there is growing agreement that it represents *one important channel* of such updates—one that needs to be investigated, prototyped, and introduced in a reasonable, informed manner.

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References

Andrews, G. (1970). *Administration of surveys and mapping in Canada, 1968*. Report of the National Advisory Committee on Control Surveys and Mapping to the Surveys and Mapping Branch, Dept. of Energy, Mines and Resources Canada, Ottawa, Canada.

Ball, M. (2010). What's the distinction between crowdsourcing, volunteered geographic information, and authoritative data? Editorial in *v1 Magazine*. http://www.vector1media.com/dialog/perspectives/16068-whats-the-distinction-between-crowdsourcing-volunteered-geographic-information-and-authoritative-data.html. Accessed 1 Aug 2011.

Bearden, M. J. (2007a, Dec 13–14). *The national map corps*. Paper presented at workshop on volunteered geographic information, University of California at Santa Barbara, Santa Barbara, CA. http://www.ncgia.ucsb.edu/projects/vgi/docs/position/Bearden_paper.pdf. Accessed 10 Feb 2009.

Bearden, M. J. (2007b, Dec 13–14). *The national map corps*. Presentation from workshop on volunteered geographic information, University of California at Santa Barbara, Santa Barbara, CA. http://www.ncgia.ucsb.edu/projects/vgi/docs/present/Bearden_USGS_MapCorps19.pdf. Accessed 10 Feb 2009.

Bearden, M. J. (2009). Personal communication with national map corps program coordinator, U.S. Geological Survey National Geospatial Technical Operations Center, Rolla, Missouri, USA, 21 April.

Beaumont, C. (2009, Aug 26). Wikipedia ends unrestricted editing of articles. *The Telegraph.* http://www.telegraph.co.uk/technology/wikipedia/6088833/Wikipedia-endsunrestricted-editing-of-articles.html. Accessed 11 Aug 2011.

Borland, J. (2007). See who's editing Wikipedia—Diebold, the CIA, a Campaign. Politics/Online Rights Blog. *Wired*. http://www.wired.com/politics/onlinerights/news/2007/08/wiki_tracker. Accessed 14 Jan 2012.

Brando, C., Bucher, B., & Abadie, N. (2011). Specifications for user generated spatial content. In S. Geertman, W. Reinhardt, & F. Toppen (Eds.), *Advancing geoinformation science for a changing world* (pp. 479–495). New York: Springer.

Bruns, A. (2008). *Blogs, Wikipedia, second life, and beyond: From production to produsage*. New York: Peter Lang.

Budhathoki, N., Nedovic-Budic, Z., & Bruce, B. (2010). An interdisciplinary frame for understanding volunteered geographic information. *Geomatica, 64*(1), 11–26.

Casey, M. (2009, May). *Citizen mapping and charting: How crowdsourcing is helping to revolutionize mapping & charting*. Proceedings of the 2009 U.S. Hydrographic Conference, Norfolk, VA. http://www.thsoa.org/hy09/0512A_02.pdf. Accessed 15 Aug 2011.

CEGIS. (2011). *U.S. Geological Survey volunteered geographic information workshop*. http://cegis.usgs.gov/vgi/index.html. Accessed 30 June 2011.

Club TomTom. (2007). *Get to know MapShare™. The official blog for TomTom in North America*. http://www.clubtomtom.com/general/get-to-know-tomtom-mapshare™/. Accessed 15 Apr 2009.

Coleman, D. J., Georgiadou, Y., & Labonte, J. (2009). Volunteered geographic information: The nature and motivation of producers. *International Journal of Spatial Data Infrastructures Research,* 4, 332–358. http://ijsdir.jrc.ec.europa.eu/index.php/ijsdir/article/view/140/198. Accessed 14 Jan 2012.

Coleman, D. J., Sabone, B., & Nkhwanana, N. (2010). Volunteering geographic information to authoritative databases: Linking contributor motivations to program effectiveness. *Geomatica, 64*(1), 383–396.

Cook, S. (2008, Oct). Why contributors contribute. *Harvard Business Review*. http://usercontribution.intuit.com/The+Contribution+Revolution+linked+version. Accessed 3 Aug 2011.

Cooper, A., Coetzee, S., Kaczmarek, I., Kourie, D., Iwaniak, A., & Kubik, T. (2011, May 31–June 2). *Challenges for quality in volunteered geographical information*. Proceedings of the AfricaGEO 2011 Conference, Cape Town, South Africa. http://researchspace.csir.co.za/dspace/handle/10204/5057. Accessed 20 Aug 2010.

Coote, A., & Rackham, L. (2008, Sept). *Neogeographic data quality—Is it an issue?* Paper delivered at the 2008 AGI Geocommunity Conference 2008, ConsultingWhere Ltd., Stratford-upon-Avon, UK.

Cowen, D. et al. (2003). *Weaving a national map: Review of the U.S. Geological Survey concept of the national map*. Report of the National Research Council (U.S.). Committee to Review the U.S. Geological Survey Concept of the National Map. Washington, DC: National Academies Press.

Dobson, M. (2010a, Aug 29). TomTom, TeleAtlas and MapShare. *Telemapics Blog*. http://blog.telemapics.com/?p=323. Accessed 2 Aug 2010.

Dobson, M. (2010b, Sept 22). Crowdsourcing—How much is too much? *Telemapics Blog*. http://blog.telemapics.com/?p=328. Accessed 2 Aug 2010.

Fisheries and Oceans Canada. (2011). About CHS: What we do. http://www.charts.gc.ca/about-apropos/wwd-qfn-eng.asp. Accessed 30 Aug 2011.

Gakstatter, E. (2010, June 1). The dawn of a new era in GPS accuracy. *GPS World Column*. http://www.gpsworld.com/gis/gss-weekly/the-dawn-a-new-era-gps-accuracy-10016. Accessed 3 June 2010.

Girres, J.-F., & Touya, G. (2010). Quality assessment of the French OpenStreetMap dataset. *Transactions in GIS, 14*(4), 435–459.

Goodchild, M. F. (2007). Citizens as voluntary sensors: Spatial data infrastructure in the world of Web 2.0. *International Journal of Spatial Data Infrastructures Research, 2,* 24–32. http://ijsdir.jrc.ec.europa.eu/index.php/ijsdir/article/view/28/22. Accessed 25 Aug 2011.

Goodchild, M. F. (2009). NeoGeography and the nature of geographic expertise. *Journal of Location Based Services, 3*(2), 82–96.

Google. (2011). Countries editable in Google map maker. http://www.google.com/mapmaker/mapfiles/s/launched.html. Accessed 10 Aug 2011.

Grira, J., Bédard, Y., & Roche, S. (2010). Spatial data uncertainty in the VGI world: Going from consumer to producer. *Geomatica, 64*(1), 61–71.

Guélat, J-C. (2009, Aug). *Integration of user generated content into national databases—Revision workflow at Swisstopo*. 1st EuroSDR Workshop on Crowdsourcing, Federal Office of Topography swisstopo, Wabern, Switzerland. http://www.eurosdr.net/workshops/crowdsourcing_2009/presentations/c-4.pdf. Accessed 8 Dec 2011.

Haklay, M. (2010). How good is volunteered geographical information? A comparative study of OpenStreetMap and ordnance survey datasets. *Environment and Planning B: Planning and Design, 37*(4), 682–703.

Haklay, M., Basiouka, S., Antoniou, V., & Ather, A. (2010). How many volunteers does it take to map an area well? The validity of Linus' law to volunteered geographic information. *The Cartographic Journal, 47*(4), 315–322.

Hardy, G. A., & Johnston, W. F. (1982). The future of the ordnance survey? *The Geographical Journal, 148*(2), 155–172.

Heinzelman, J., & Waters, C. (2010). *Crowdsourcing crisis information in disaster-affected Haiti* (Special Report 252). Washington, DC: United States Institute of Peace. http://www.usip.org/files/resources/SR252%20-%20Crowdsourcing%20Crisis%20Information%20in%20Disaster-Affected%20Haiti.pdf. Accessed 15 Aug 2011.

Heipke, C. (2010). Crowdsourcing geospatial data. *ISPRS Journal of Photogrammetry and Remote Sensing, 65*(6), 550–557.

Kadaster International. (2007, Sept). Abroad. Special issue on how e-government and land information align. *Periodical newsletter of Kadaster International*. http://www.kadaster.nl/pdf/abroad_092007.pdf. Accessed 25 July 2011.

Lenders, V., Koukoumidis, E., Zhang, P., & Martonosi, M. (2008). Location-based trust for mobile user-generated content: Applications, challenges and implementations. In *Proceedings of the 9th workshop on mobile computing systems and applications* (pp. 60–64). New York: ACM.

LINZ. (2011). About notices to mariners. Land information New Zealand. http://www.linz.govt.nz/hydro/ntms/about-ntms. Accessed 20 Aug 2011.

Maué, P., & Schade, S. (2008, May). *Quality of geographic information patchworks*. Proceedings of the 11th AGILE International Conference on Geographic Information Science, Girona, Spain. http://plone.itc.nl/agile_old/Conference/2008-Girona/PDF/111_DOC.pdf. Accessed 30 May 2009.

National Map Corps. (2008). Important notice concerning national map corps. http://nationalmap.gov/tnm_corps.html. Accessed 29 May 2009.

National Map Corps. (2011). The national map corps pilot projects. http://nationalmap.gov/TheNationalMapCorps/pilot.html. Accessed 20 Aug 2011.

NES. (2008). NES help module 3 change request/easy editor, p. 31. http://www.land.vic.gov.au/CA256F310024B628/0/DA7C602F526419D8CA25750D00053B7B/$File/NES+Quick+Module3.pdf. Accessed 29 July 2011.

Obloy, E. J., & Sharetts-Sullivan, B. H. (1994, Oct). *Exploitation of intellectual property by electronic chartmakers: Liability, retrenchment and a proposal for change*. Proceedings of the conference on law and information policy for spatial databases, Tempe, AZ. http://www.spatial.maine.edu/~onsrud/tempe/obloy.html. Accessed 20 Aug 2011.

OECD. (2007). *Participative web: User-created content: Web 2.0, wikis and social networking*. Report of the Working Party on the Information Economy, Committee for Information, Computer and Communications Policy, Directorate for Science, Technology and Industry, Organization for Economic Co-Operation And Development. 12 April. Paris: OECD Publishing. ISBN 9264037462, 9789264037465.

Pearson, M., & Gareau, R. (1986). Exchanging digital base mapping data. In *Proceedings of the second international symposium on spatial data handling* (pp. 611–615). Williamsville: International Geographical Union.

Poser, K., Kreibich, H., & Dransch, D. (2009). *Assessing volunteered geographic information for rapid flood damage estimation*. Proceedings of the 12th AGILE International Conference on Geographic Information Science, Leibniz Universität, Hannover, Germany, pp. 1–9.

Roche, S., Propeck-Zimmermann, E., & Mericskay, B. (2011). GeoWeb and crisis management: Issues and perspectives of volunteered geographic information. *GeoJournal*. doi:10.1007/s10708-011-9423-9.

Thompson, Y. (2011, July 20). Notification for edit service (NES). *Mygeoplace Blog*. http://mygeoplace.com/2011/07/30/notification-for-edit-service-nes/. Accessed 10 Aug 2011.

TomTom. (2008, Dec 16). TomTom announces five millionth map share™ improvement. *TomTom News*. http://www.tomtom.com/news/category.php?ID=4&NID=660&Lid=4. Accessed 1 May 2009.

Turner, A. (2007, Dec 6). *Neogeography—Towards a definition*. A weblog posted on *High Earth Orbit*. http://highearthorbit.com/neogeography-towards-a-definition/. Accessed 15 Aug 2011.

UNECA. (1966, Sept 12–24). *Maintaining current base information for aeronautical charts*. Paper submitted by the United States Government to the 2nd United Nationals Cartographic Conference for Africa, Tunis, Tunisia. United Nations Economic and Social Council. http://repository.uneca.org/bitstream/handle/123456789/15884/Bib-64431.pdf?sequence=1. Accessed 25 Aug 2011.

Van der Molen, P., & Wubbe, M. (2007). *E-government and E-land administration. As an example: The Netherlands*. Proceedings of the 6th Regional FIG Conference 'Coastal Areas and Land Administration—Building the Capacity', San Jose, Costa Rica. http://www.fig.net/pub/costarica_1/papers/ts10/ts10_02_wubbe_vandermolen_2480.pdf. Accessed 15 Aug 2011.

van der Vlugt, M. (2011, Jan 4). PSMA, sensis or OpenStreetMap: What makes spatial data "authoritative"? *Spatial Information in the 21st Century* Blog. http://spatial21.blogspot.com/2011/01/psma-sensis-or-openstreetmap-what-makes.html. Accessed 1 Aug 2011.

Wolf, E. B., Matthews, K. M., & Poore, B. S. (2011, June). *OpenStreetMap collaborative prototype, phase one*. Open-file report 2011–1136. http://pubs.usgs.gov/of/2011/1136/pdf/OF11–1136.pdf. Accessed 31 Aug 2011.

Zandbergen, P. A. (2009). Accuracy of iPhone locations: A comparison of assisted GPS, WiFi and cellular positioning. *Transactions in GIS, 13*(1), 5–26.

Zook, M., Graham, M., Shelton, T., & Gorman, S. (2010). Volunteered geographic information and crowdsourcing disaster relief: A case study of the Haitian earthquake. *World Medical & Health Policy, 2*(2), 7–33.