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# THE SCALE OF VGI IN MAP PRODUCTION: A PERSPECTIVE ON EUROPEAN NATIONAL MAPPING AGENCIES

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## ABSTRACT

The perspective of European National Mapping Agencies (NMA) on the role of citizen sensing in map production was explored. The NMAs varied greatly in their engagement with the community generating volunteered geographic information (VGI) and in their future plans. From an assessment of NMA standard practices, it was evident that much VGI was acquired with a positional accuracy that, while less than that typically acquired by NMAs, actually exceeded the requirements of the nominal data capture scale used by most NMAs. Opportunities for VGI use in map revision and updating were evident, especially for agencies that use a continuous rather than cyclical updating policy. Some NMAs had also developed systems to engage with citizen sensors and examples are discussed. Only rarely was VGI used to collect data on features beyond the standard set used by the NMAs. The potential role of citizen sensing and so its current scale of use by NMAs is limited by a series of concerns, notably relating to issues of data quality, the nature and motivation of the contributors, legal issues, the sustainability of data source, and employment fears of NMA staff. Possible priorities for future research and development are identified to help ensure that the potential of VGI in mapping is realized.

**Keywords** VGI · National Mapping Agency · Quality · Crowdsourcing

## 1 Introduction

Mapping practices and policies have evolved considerably over recent decades. Advances in geoinformation technologies have changed the way information is collected, analysed, stored and distributed. Moreover, the development of inexpensive location-aware devices and the rise of Web 2.0 initiatives has seen considerable growth in citizen sensing, notably linked to the acquisition of volunteered geographic information (VGI) [1] in mapping. This type of activity is sometimes described by different terms, including crowdsourcing and neogeography [2] and although the distinctions between them can be important, the focus in this article is simply on citizen derived data. Together with a strong drive for openness, this growth in citizen sensing has revolutionized aspects of mapping, notably in the development of projects such as OpenStreetMap [3] and Wikimapia [4].

With the adoption of Open Data Policy, many government data sets are now freely available to the public. The latter includes data from some European National Mapping Agencies (NMAs). For example the NMAs of Finland, The Netherlands, Germany, Great Britain and France have released at least a part of their data for free access. In most cases these data were integrated in OpenStreetMap (OSM). This has resulted in enhancements to the OSM data set but, critically, may have benefits for the NMAs. For example, Begin [5] describes how the Canadian NMA released data to OSM and as a consequence data updates could be received from OSM contributors instead of NMA surveyors. The potential role of citizen sensing in the work of bodies such as the NMAs has been identified [6, 7] but has not focused on the actual and potential use of citizen sensor data in the mapping practices of official government agencies.

The vast potential of citizen sensing in mapping [8] is, however, limited by concerns especially in relation to data quality [9, 10] and the trustworthiness of the data sets generated as compared with those from authoritative bodies such as the NMAs. However, authoritative bodies often struggle to acquire data at appropriate spatial and temporal dimensions and could potentially benefit from data provided by citizen sensors [11]. This article explores the current and potential role of citizen sensing in the work of authoritative European regional and national mapping, drawing on the results of a survey conducted from December 2013 to February 2014 and two workshops organized by the French Mapping Agency (IGN France) in March 2014 and by Swisstopo in February 2015. The work was conducted as part of COST Action TD1202 “Mapping and the Citizen Sensor” [12]. In particular, Section 2 explores the mapping practices followed by NMAs in relation to VGI and critical data issues. Section 3 focuses on existing and potential future use of VGI by NMAs including specific examples and discussion on key issues. Concluding remarks are made in Section 4 and future research directions outlined.

As the article is constructed from an analysis of the outputs of a survey and two workshops involving members of NMAs it is not a comprehensive review of VGI involvement with NMAs. It will reflect an NMA perspective and be naturally light in areas such as the motivation of VGI contributors. Such areas are likely to be explored in more detail as the COST Action proceeds.

## 2 The Survey about Mapping Practices and Use of VGI in NMAs

A total of 41 different organizations across Europe and Greenland who are members of EuroSDR and/or EuroGeographics were invited to take part in a survey to illustrate their mapping practices and their use, actual and potential, of VGI. The organizations included often had a wide range of responsibilities, so the focus here was constrained to core issues of topographic and topologic (network) mapping that were common to all except one NMA.

The survey was web-based using the Survey Monkey service as the method of delivery. It sought to obtain summary information organized in three sections: (1) the organization’s role; (2) its survey specifications, maintenance regimes and validation/verification activity; and (3) its current and proposed future engagement with VGI including quality control. In total, 39 organizations responded to the invitation but only the data from 23 were complete and useable. The discussion below is based on the responses from these 23 organizations which arose from 19 countries (Table 1). Note that in some cases, such as Germany, there were responses from both national and regional agencies. Additionally, for the UK, participating organizations for Great Britain and Northern Ireland were treated as national rather than regional. Regarding the responsibilities of these organizations, the great majority focused on topographic surveying but other functions were also noted (Figure 1). The results of the survey informed two follow-on workshops that involved 11 of the organizations and which focused on their specific engagement and concerns with VGI. Three NMAs that had not participated in the survey (Cyprus, the Netherlands and Romania) joined the workshops.

### 2.1 Data Capture and Accuracy

The nominal capture scale relates to the largest cartographic scale at which the mapping will be published and is important as it has been used by mapping agencies to determine the field survey accuracies required. In the context of using VGI, a key concern is that volunteers typically digitize information from aerial sensor imagery with a positional error that is often  $>3$  m [13] or use uncorrected GNSS systems with positional accuracies that typically lie in the range 5–15 m [14].

The survey showed that the mapping agencies differed greatly in terms of their capture scale (Figure 2) and in the positional quality required in data collection (Figure 3). In particular, it was notable that most agencies captured data for mapping at scales of 1:10,000 or smaller and were acquiring the data for this mapping at a level of positional accuracy that was far greater than required to meet the needs of mapping at the nominal capture scale. More critically, for most NMAs volunteers could provide data with sufficient positional accuracy to meet NMA needs, even taking into account any confusion in reporting by the NMAs between accuracy and precision. Figure 4 shows a scatterplot of the nominal capture scale and survey accuracy for the NMAs together with an estimate for OSM. This latter estimate was inferred

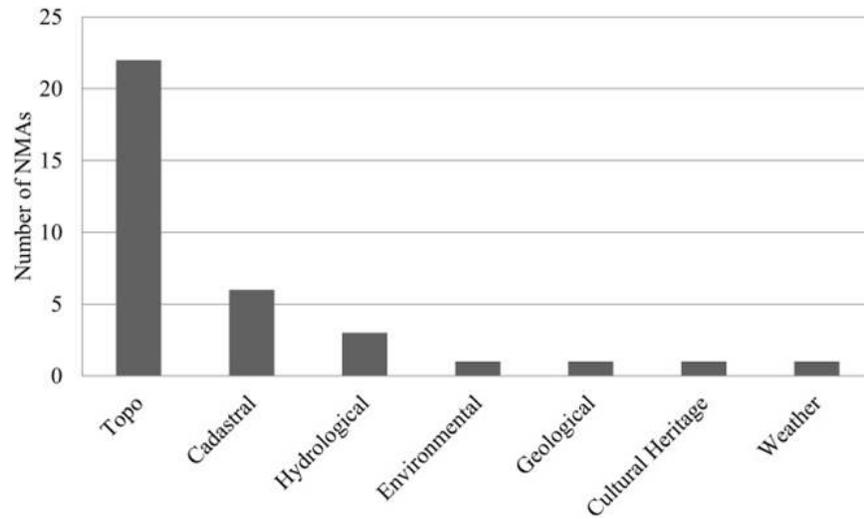


Figure 1: Organizational responsibilities by function.

Country	Organization name	Scope of the Organization
Belgium	National Geographic Institut of Belgium	National
Cyprus*	Lands and Surveys of Cyprus	National
Finland	National Land Survey of Finland	National
France	National Institute for Geographic Information and Forestry	National
Germany	Federal Agency for Cartography and Geodesy	National
Germany	Bavarian Agency for Surveying and Geographical Information	Regional
Great Britain	Ordnance Survey of Great Britain	National
Greece	Hellenic Military Geographical Service	National
Greenland	Asiaq - Greenland Survey	National
Iceland	National Land Survey of Iceland	National
Ireland	Ordnance Survey Ireland	National
Italy	Bruno Kessler Foundation	National
Latvia	Latvian Geospatial Information Agency	National
Lithuania	National Land Service	Regional
Netherlands*	National Agency for Cadastre and Land Registration	National
Northern Ireland	Land and Property Services, Northern Ireland	National
Norway	Norwegian Mapping Authority	National
Portugal	Direção-Geral do Território	National
Romania*	National Agency for Cadastre and Land Registration	National
Serbia	Republic Geodetic Authority	National
Spain	National Geographic Institute of Spain	National
Sweden	Mapping, cadastral and land registration authority	Regional
Switzerland	Federal Office of Topography-Swiss topo	National

Table 1: European countries participating in the survey, plus Greenland (\*NMAs participating only to the workshop).

from studies on geometrical accuracy [15, 9], and on studies that tried to find the reference scale or level of detail for OSM [16, 17, 18].

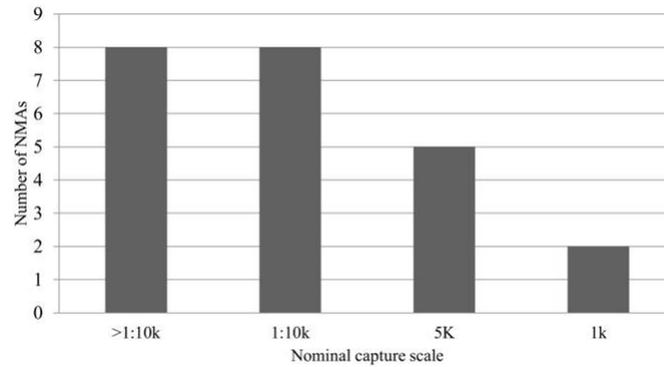


Figure 2: Nominal capture scale by mapping agencies.

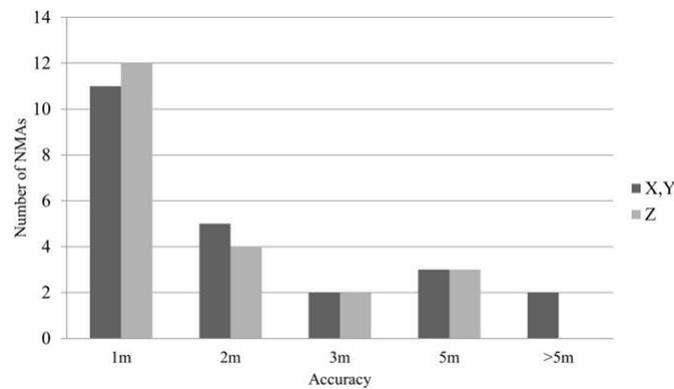


Figure 3: Survey accuracies by organizational count.

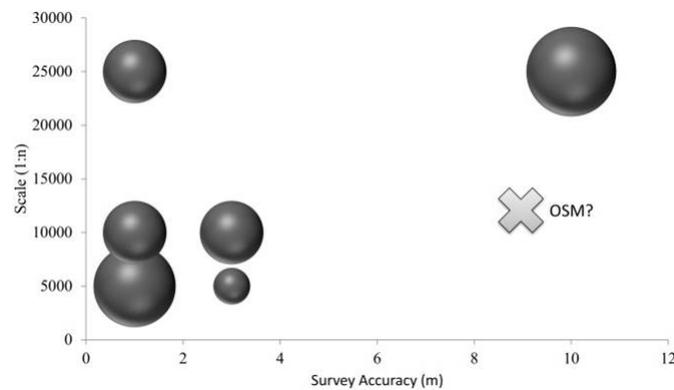


Figure 4: Survey accuracy vs. nominal capture scale. Symbol size is proportional to the number of NMAs.

## 2.2 Data Maintenance and Updating

Each mapping agency has a policy for the maintenance of data that involves systematic updating and map revision. Two maintenance policies are in common usage: cyclical or sweep revision, and continuous revision. Cyclical revision is the most traditional method and involves systematically updating areas corresponding to map sheets or tiles on a regular basis. Continuous revision consists of revising the map in order to capture changes in the whole area but with updates prioritized by the rate of change. Hybrid approaches also exist. For example, a policy based on continuous revision may also employ cyclical revision to acquire information and changes missed due to failings in change intelligence.

The survey shows that cyclical policies were more widely adopted than continuous policies. Specifically, 11 mapping agencies adopted a cyclical policy, six a continuous policy and two used both cyclical and continuous updating, although their primary revision policy was continuous. Unexpectedly, the survey showed that four of the organizations had not yet established policies, reflecting that they are relatively new. In the context of using VGI it is anticipated that volunteers might be particularly able to contribute information on change that is most suited to continuous revision. Volunteers might, for example, highlight areas that a mapping agency might wish to send professional survey staff to visit or submit new data that could be integrated into existing databases. It would still be possible for volunteers to contribute to cyclical revision but this might be best achieved in a highly steered activity with, for example, volunteers encouraged to focus on particular areas at a particular time. Continuous revision is only possible because of advances in the way that mapping data is held with databases and no longer managed as discrete map tiles. As more agencies develop this capability, it is strongly suggested that they also adopt continuous revision, as this is likely not only to lead to more up-to-date mapping, but also to facilitate the use of VGI.

### 2.3 Provenance of Meta-Data and Verification

The registration of metadata is regarded as a good practice since it aids the evaluation of internal and external (fitness for use) quality [19, 20]. Here, the concern is with the provenance of metadata (i.e. recording how the data was obtained). The survey showed that all except one of the agencies recorded this information. Seventeen of the NMAs also acquired data and associated metadata from authoritative professional sources (e.g. emergency services) and most of them, 15 in total, verified this information. On the one hand, the verification practice reflects the priority of the agencies to produce high quality, homogeneous and consistent data, and on the other hand, the lack of methods allowing automatic verification and integration of new features. In the context of VGI this is important, as it indicates that in some circumstances the costs of verifying VGI data may make it uneconomic unless more automated means can be found or consistent high quality demonstrated.

## 3 Existing and Potential Future Use of VGI

VGI is not an entirely new issue for mapping agencies. The US Geological Survey (USGS) seems to be the first national mapping organization that allowed citizens to contribute information, starting with the Earth Science Corp, renamed later to the National Map Corps, in 1991 [21]. Such pioneering efforts were limited by the available technology of the time but the vast technological advances made in recent years have reignited interest in VGI. In practice, all mapping agencies have traditionally used a kind of VGI by responding to reports of mapping errors and inconsistencies reported to them by members of the public. However, it is important to differentiate between this ad hoc process where the mapping agency is essentially a passive participant and processes in which the agencies actively engage with VGI, either to organize their own volunteer contributors, or through extracting information from existing VGI resources. The survey and following workshops sought to reveal the level of proactive engagement with VGI.

The survey and workshops indicated that 12 out of 23 agencies reported that they use VGI for: change detection, report alerts, the collection of new content, vernacular place names and photo interpretation. Figure 5 provides an overview of the use of VGI in the NMAs. Most of them have organized their own VGI collection processes whilst three agencies (Germany, Greece, Serbia) harvested and use data collected by OSM or GeoNames [22]. In most cases the information gathered was on traditional features included in standard topographic maps. This is evident in the information provided by seven mapping agencies that indicated the nature of the VGI used in detail (Figure 6). One near universal feature was that each agency that actively engaged with VGI checked the information received using a variety of sources of information including that acquired by their own survey staff directed to relevant sites. These are often time-consuming processes and a need for more automated methods for the assessment of the quality of data received was identified. Overall, it was apparent that the mapping agencies were significantly engaged with VGI and that several organizations that do not currently exploit VGI plan to get involved in the near future. It is also apparent that in most cases current involvement is limited to change detection and error correction. Only two agencies use VGI as a primary data source or to collect data they would not otherwise collect. This situation suggests that mapping agencies do not currently fully exploit the new opportunities offered by VGI perhaps because of various concerns, some of which are discussed further below.

Nine NMAs have plans either to start collecting VGI (six agencies) or to expand further what they currently collect (three agencies). Those that did not have firm plans had a range of concerns that included worries about: infringement of copyright of data when using third-party VGI such as OSM, data quality, and data reliability. The remainder of this section focuses on some specific examples issued from workshops of how NMAs have engaged with VGI and their concerns with the use of VGI.

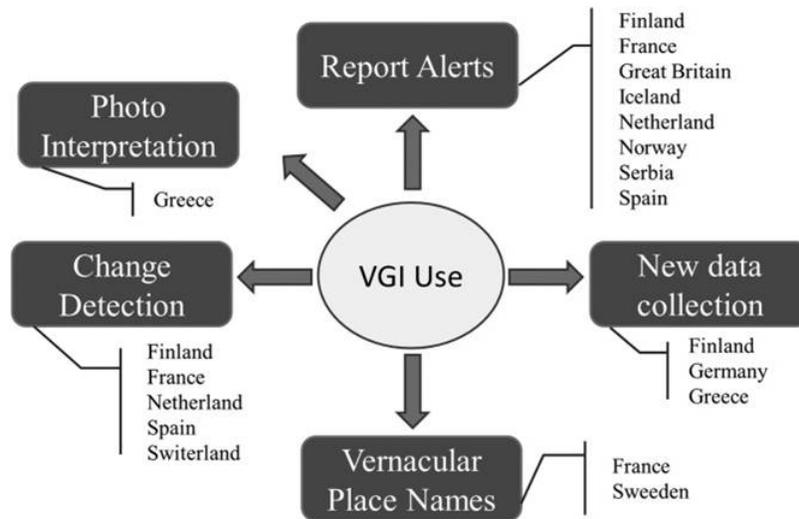


Figure 5: VGI use in the European NMAs.

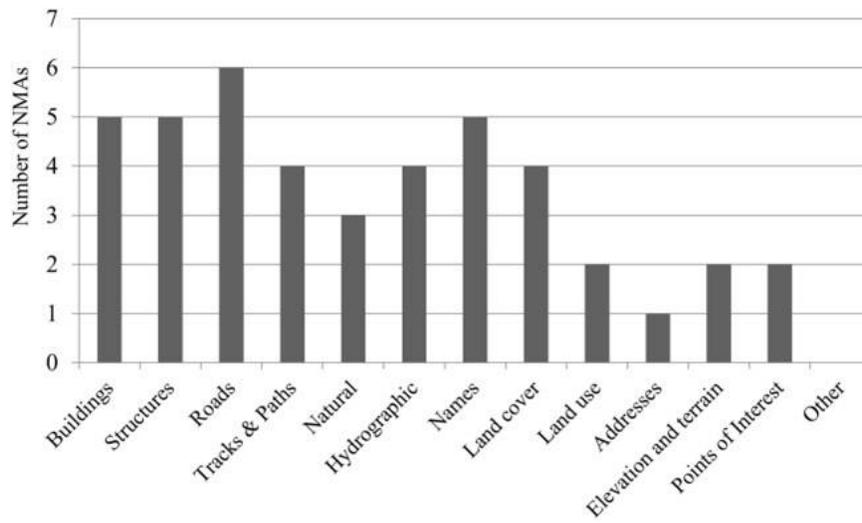


Figure 6: Feature types reported on through VGI.

### 3.1 Examples of VGI Use

While open source tools are available such as OSM tools, it was evident that most of the mapping agencies surveyed had developed their own tools to collect data from the crowd or public partners. It should be noted that the maturity of tools varied from those developed for research projects to well-proven, fully operationally tools. This section gives an overview of some of the tools that have been developed and examples of the use of VGI in relation to the topics defined in Figure 5.

#### 3.1.1 Report Alerts

IGN France developed a report alert system called Ripart, which has been in service since 2008 [23]. It is a community-sourcing system where professional partners, such as the fire service, propose updates to IGN data by completing a form and providing location information using GPS tracks, photographs or drawings on a map. Ripart's reporting process provides overlapping sketches of the proposed changes on an inert base map. Thus, the contributing partners do not have the ability to act directly on features belonging to the authoritative IGN database; to overcome this inconvenience a new version of the tool is being tested that allows partners access to a copy of topographic database (the last update: Day 1) and are able to directly add or modify geographic features.

The National Land Survey of Finland, which made its topographic database open to the public, has developed both a map interface (<http://www.karttapaikka.fi>) and a mobile application (<http://www.karttaselain.fi>) to collect feedback from citizens. Annually, it is estimated that some 500-700 reports are made using the map interface as well as 200-300 from the mobile application. The messages received are checked, replied to and most generate modification(s) in the agency's topographic database. Some updates are checked in the field or await to be verified and captured from scheduled aerial imaging.

In The Netherlands, Kadaster has developed a feedback system, Topographical Key Register (BRT) to collect feedback from map users. The system is deployed on tablets, smartphones and web platforms and is based on ArcGIS solutions. The data collected are validated after quality analysis and integrated in the database by surveyors from Kadaster. The agency of Switzerland, swisstopo, has a similar system in operation, which is integrated in the Web infrastructure of the Federal Spatial Data Infrastructure (FSDI). The so-called revision client allows feedback from citizens from all standard platforms. The feedback from the citizens is validated and directly used in the map update process by the operators.

IGN Spain developed a report tool based on the National Geographic Information System (SIGNA) Geoportal. An online earthquake survey has also been developed that allows citizens to report earthquakes having at least 2.5 Richter scale magnitude or those that were just felt by the population.

The Ordnance Survey of Great Britain has traditionally taken error and change reports from citizens via landline telephone calls and letters. A web-based tool has been successfully trialed with public sector customers for reporting errors and omissions in a range of Ordnance Survey products. The TELL OS tool based on a five step process (i.e. select product, find location, submit data, contribution acknowledged, data stored) has a good use level with almost 1,500 reports per year.

### 3.1.2 Change Detection

Change detection is an important activity for most mapping agencies and can benefit from VGI. In The Netherlands, Kadaster undertook a pilot test for change detection relating to roads and buildings in its 1:10k dataset (TOP10NL) from external sources (e.g. local administration datasets and OSM). This found that changes could be detected much more quickly than with the methods used conventionally at Kadaster.

At IGN France, change detection is made by land surveyors that analyse a range of alert types and contact local administrators. It estimates that 75% of working time was dedicated to change detection, leaving only 25% for field work. It plans to develop a system to automatically infer change from the sources used by the surveyors, and from additional sources found on the web, including VGI from OSM, GPS tracks from hiking websites or Wikipedia. There are a range of concerns about the validation and integration of the data into the main database and tools to aid quality assessment and conflict management are being explored.

### 3.1.3 Vernacular Place Names

Citizens frequently use vernacular rather than official place names. Given that a vernacular place name may be in common usage but also different from the official name, there is a need to capture both. The OS undertook research with the UK Maritime and Coastguard Agency to improve the ability of the Coastguard to use vernacular place names to locate people in emergency situations. Preliminary results show that only 1% of names acquired in the study were not in current use and more critically that 95% could be accurately located.

The Swedish NMA, cadastral and land registration authority, proposed a smartphone application, named "Platsnamna", to collect vernacular place names, which was tested in urban areas, being supported by the professionals and the public. Satisfactory results were obtained, new place names being suggested.

### 3.1.4 New Data Collection

VGI provides potential to capture new content, data on features not previously collected by the mapping agencies as not within their mission priorities or excluded for political or economic reasons. The Federal Agency for Cartography and Geodesy of Germany uses VGI to collect new content, features or attributes, such as buildings, structures (e.g. bridges, pylons, silos, dams), roads, tracks and paths, hydrographic features (e.g. rivers, lakes, canals), names, points of interest (e.g. tourist attractions, cash machines). New data are collected via secondary sources such as OSM. The NLS of Finland also found that cadastral boundary information could be acquired from owners with a high level of precision, typically within 0.5-4.0 m of reality.

In spring 2015 IGN France launched a crowdsourcing application dedicated to outdoor activities (<http://espaceloisirs.ign.fr/>). The application targets individuals with interests such as trekking and community

sourcing with outdoor activity companies, who are able to reserve data for exclusive use, e.g. a rafting company provides a smartphone application to its customers, with its own data conflated with the IGN data.

### 3.2 Concerns With VGI

It was notable that in some cases VGI may be of sufficient accuracy for NMA needs and may even sometimes be more accurate in terms of clarity and level of detail than the available professional geographic information [24]. On the other hand, the use of VGI by mapping organizations involves risks which raise a number of critical issues that need to be resolved. Five major barriers to the use of VGI were identified during the workshops: data quality and validation, legal issues, nature and motivation of the crowd, sustainability, and employment fears.

#### 3.2.1 Data Quality and Validation

The quality of data arising from citizen sensors was viewed by all of the agencies as a concern, reflecting in part the importance that the mapping agencies place on maintaining their reputation for high quality products. Some research suggests that the quality of VGI increases with the number of contributors [25, 15, 26] and hence if mapping agencies want to maintain high quality standards they may need to involve many contributors.

Most academic research on data quality has focused on the issues of positional accuracy and completeness [9, 15, 27], semantic accuracy [28] or currency [29], especially with regard to OSM. However, as noted above, the positional accuracy of much VGI may actually be sufficient for the needs of mapping agencies. Other aspects of mapping practice have attracted little research. There has been little research on the perceived lack of homogeneity of VGI (e.g. a lack of overall consistency in terms of what is mapped, how detailed the mapping is, and how it is then classified) and its impacts; but some recent research on OSM showed that the scale or level of detail of individual features can be inferred. For example, in some VGI data sets the information on buildings in some places may be very detailed because it has been imported from available cadastral data, but less detailed elsewhere as, perhaps, captured from satellite imagery. It has been shown that key details of individual features may be inferred from their geometry, semantics or metadata [16, 17, 18] allowing the variation to be quantified. This then offers the potential to allow it to be integrated into NMA's mapping processes that are made for homogeneous data, as the variability of detail can be clearly differentiated.

Some applications require the use of authoritative data such as for cadastral tasks, planning and design at various levels. On the other hand, VGI could be sufficient for applications such as preliminary planning (e.g. national, regional and urban), car navigation, transport management systems and visual analysis.

#### 3.2.2 Legal Issues

Integrating VGI data in authoritative mapping agency databases also raises legal concerns, including those connected with intellectual property rights, privacy, and legal liability [30]. VGI hosts generally protect their intellectual property interests in their websites by copyright laws. Since authoritative databases also have copyright laws, although the scope of protection may vary significantly, it becomes unclear who owns and is responsible for the data if different sources of data are integrated or used. Research on copyright and public domains should help the mapping agencies address some of the important legal concerns that they have [31, 32]. As an example of licencing issues, IGN France and OpenStreetMap France are collaborating on a joint project to build an open dataset for the crowdsourced collection of unified addresses. One of the main technical problems is the incompatibility between OSM's ODBL licence and the French administration's open licence, which has forced the duplication of data on several servers.

Legal liability is an important issue for national mapping agencies since errors in the data due to the integration of imperfect VGI data could cause physical injuries or even the loss of life. In such cases, the issue of who is liable for the incorrect decision-making and consequential damages arises. This issue is linked closely to the concerns with data quality noted above. Scassa [32] argues that legal liability of VGI would encourage contributors to produce quality data but discourage non-confident contributors. The creation of associations of volunteers can also help volunteers to avoid legal liability risks [33]. In the case of authoritative organizations which integrate VGI, Rak et al. [34] study the questions "who is liable and when" under Canadian law and provide guidelines for risk management techniques related to VGI. When mapping agencies are responsible for cadastre, the authoritativeness of VGI could be decided by court decisions [32] which is a clear barrier for agencies until jurisprudences clarify the case.

Furthermore, it may not be obvious that the source of VGI is legitimate. For example digitizing from other mapping or imagery for which permissions had not been obtained would be illegitimate. Whilst this may occur in only a minority of cases NMAs will need to develop ways to protect themselves against such incidents.

Making general statements is further complicated by the variation in law between nations. For instance, the French outdoor activities crowdsourcing application being launched in spring 2015 (see above) has specific terms of use stating that each contributor has copyright on his/her contributions and is responsible for their correctness.

### 3.2.3 Nature of the Crowd and Motivation

The nature of the crowd and the credibility of volunteers is also a key point for NMAs. Although potentially anyone can contribute VGI, the community of volunteers is often very unrepresentative of the population. For example, with OSM, the typical contributor is a male, well-educated and technology-savvy [35]. Additionally, it seems that males may mostly contribute through private interest while females do so in the context of their work [35]. OSM contributors also vary greatly in terms of activity [36]. Coleman et al. [37] recognize five overlapping categories of VGI contributors reflecting the wide spectrum of motivations: “neophyte”, “interested amateur”, “expert amateur”, “expert professional” and “expert authority”.

Developing means to measure the credibility of contributors and/or their contributions may help mapping agencies to make use of VGI. Flanagan and Metzner [38] focus on the measurement of credibility in web 2.0 applications (i.e. forums or social networks). Skarlatidou et al. [39] focus on the assessment of trust through reputation and expertise. Bishr and Janowicz [40] also apply social network reputation measures to VGI with, for instance, a contributor’s credibility assessed by votes from other contributors. Others propose methods to rank an OSM contributor according to the time spent on OSM, or the use of its local knowledge [41, 42]; and others such as Kessler and de Groot [43] compute credibility measures on contributions rather than contributors showing some correlation between quality and credibility. Foody et al. [44] assess the accuracy of VGI contributors from the data that they provide via a latent class analysis.

A key attraction of VGI is that the contributor often has in-depth local knowledge [1]. The data provided may not be homogenous but with some themes such as roads can be of better quality than authoritative data sets, certainly in terms of completeness and required positional accuracy, at least for urban areas [9]. The desire to exploit this information and engage a large community has driven research on the motivation of the volunteers. People are motivated in a variety of ways. They may be motivated emotionally, as in a natural disaster [45] or when the action is in their own best interest. Cadastral mapping is an example where contributors (generally owners) are motivated to map and update the cadastre helping to reduce costs and time as well as removing errors [46, 47]. Maintaining the interest of contributors was seen as important and this benefited from the provision of feedback to contributors and the rapid update of the topographic database. There is a risk here that VGI contributors may possibly be motivated by building an alternative to authoritative data (a kind of libertarianism) and may not be attracted to NMA’s VGI systems. More specifically, it is quite unlikely that capturing authoritative VGI will attract all OSM contributors, so the NMAs will have to motivate different contributors to build a community large enough to support their needs. This is an issue that should be studied in future work. Mapping agencies from Finland, France and Netherlands mentioned that people feel rewarded when they notice that their contribution is taken into account. For example, Netherlands’ Kadaster has good experience in collecting VGI data by providing a prototype system comprising web, mobile phone and tablet applications; emails, tweets and an interactive human computer interface are used to inform users who reported changes or errors.

### 3.2.4 Sustainability

Related to the motivation to contribute VGI, the mapping agencies were concerned about the sustainability of the volunteer community and its data flow. Mapping agencies have concerns over the stability and the long-term viability of VGI initiatives, founded on an untested belief that volunteers may be motivated notably for one-off capture. This is of course not a problem if a one-off contribution is what is required, with further data capture the responsibility of the agency itself. The issues, however, are complex, as citizen contributors may be motivated in different ways; some may be volunteers, others responding to small payment incentives and some may be open to direction. It is known that VGI can be effectively organized; for example, the mayor of a village in France (Brocas, Landes, approximately 800 inhabitants) organized a mapping party and invited OSM contributors through the website of the French community to produce open data [48]. However, given the diverse nature of the VGI community, mapping agencies wish to know more about how to keep volunteers motivated and how to grow the volunteer community.

A variety of motivations may be observed, notably fun, fame or fortune [37, 49, 50]. Games can be motivating for some contributors. For example, gaps in OSM coverage have been filled through the use of a game to motivate OSM contributors [51]. Similarly, GeoCaching is a most successful location-based game, with millions of caches and users. Understanding the motivations of the geocachers would help mapping agencies to propose attractive game-orientated VGI projects [52, 53]. It may also be possible to build on the success of social media such as FourSquare in which people locate themselves in places that they recommend such as shops or restaurants [54]. Indeed, a similar idea was supported by IGN Spain in which a location-based game named Town Conquer, to validate toponyms, was developed



Figure 7: Feature types reported on through VGI.

[55]. In this, players fill in the names of places in order to win points and conquer the territory starting with provinces, then regions, up to the entire country. Other systems may be used to involve people in games to collect valuable VGI. For example, competitions and games with different levels of difficulty in capturing data on croplands, in order to improve land cover data and which offer contributors incentives such as small prizes, have been run in association with the Geo-Wiki system [56]. Given the previously noted importance of reputation, mapping agencies are however concerned about managing the potential conflicts of being a “serious” agency linked to the fun of crowdsourcing.

### 3.2.5 Employment Concerns

A concern noted by the mapping agencies was the fear their staff may have in relation to their job security. The staff concerns perhaps reflect an understandable viewpoint in which VGI is seen as a potential replacement for authoritatively collected data. As such mapping agencies may need to develop new communication policies to inform staff of the role of VGI and how it can facilitate the work of the agency. Given the aforementioned concerns with VGI it is also evident that it cannot currently emulate the authoritative mapping of the professional mapping agencies. The continuing evolution of the mapping profession could, however, reflect the potential of VGI. For example, the role of the authoritative surveyor might adapt to one in which greater emphasis is given to activities such as the integration of complementary data from VGI sources or validating updates coming from citizen sensors. Critically, VGI should not be seen as a replacement for authoritative data or a threat to the professional mapping community but as a potentially useful resource to aid mapping by combining VGI with professionally acquired geographic information for broader social benefit [24]. Some researchers, however, highlight that VGI may be a threat to citizens. Renee Sieber advised that care was needed to avoid a kind of techno-libertarianism that would “control” contributors [57], while others have compared crowdsourcing with microfascism [58].

From the authors’ point of view, a better relationship between NMAs and the VGI community could be the key to success. This involves a win-win relationship where both NMAs and VGI communities’ expectations are satisfied. Figure 7 summarizes the most important expectations from the authors’ point of view. For the VGI community one of the most important expectations is feedback. The NMAs should give immediate notification, show all contributions, and validate and integrate them into the authoritative data immediately. To this purpose, one possibility is for the NMAs to make citizen data available as a citizen layer that can be associated with the authoritative data layers, keeping the citizen and authoritative data separate but enabling both to be used together if desired. At the same time, NMAs expect from the VGI community motivation, stability over time, no fakes, consistency with others layers proposed by the mapping agencies or uniformity (e.g. spatial and attribute completeness and homogeneity). To improve the relationships with the VGI community, the NMAs expect from the research community new methods, reliable processes for conflict resolution and data integration, new techniques and guidelines to break down the identified barriers.

## 4 Conclusions

The survey and workshops that underpin this article sought to better understand the practices, experiences and needs of national mapping agencies concerning VGI, especially as a means to share information and support a wider engagement with the VGI community. It was evident that most of the mapping agencies involved had some engagement with the VGI community and others have plans to develop this. Opportunities for the use of VGI were apparent, especially given the positional accuracy of some VGI data sets and the potential for use with respect to continuous revision. Indeed, in agencies using citizen sensor data, VGI was often used for change detection and the identification of errors. Only very rarely, however, was it integrated directly into the authoritative databases. The activities of communities such as those linked to OSM has not changed the way mapping agencies produce data and the majority did not view OSM data as currently being highly useful. The reasons for this may be quite complex. Most of the NMAs have some concerns regarding the quality and the heterogeneity of VGI. Moreover, legal uncertainties, and the manner in which much data is collected as typified by aspects such as the applied classifications, are among the reasons behind this situation.

Most of the current or planned activity with VGI was conservative: the mapping agencies were trying to fit VGI activity around existing capture specifications. The majority of agencies were currently against some activities that could encourage greater use of VGI such as incorporating and clearly identifying VGI data as such and allowing less strict validation. Thus, the agencies did not wish to provide a “citizen layer” where citizen updates are publicly available but not authoritatively checked. Indeed, for most NMAs, the integration of VGI data directly in authoritative databases was not viable. The inexpensive nature of VGI was not an issue to the NMAs. It was evident that for countries where the data coverage was incomplete VGI was not being used, nor planned for use, to complete it. This happens because NMAs are state entities that are officially responsible for providing accurate and reliable spatial data infrastructure (SDI) to all potential users; hence, they are wary of potentially flawed VGI provided by the public.

Although VGI offers the mapping agencies potentially useful data, a series of obstacles to its use were evident, notably relating to issues such as data quality, legal issues and sustainability. Some research on these has been undertaken but further research needs to be conducted to enhance the ties between mapping agencies and VGI community. Much of the research on issues of data quality has so far focused on issues such as positional accuracy and to a lesser extent completeness and classification accuracy; much more research is needed into issues such as updatedness, maintenance or currency and legal issues. Priorities need to be established to help define strategies that can make use of VGI. Many of the mapping agencies are developing tools to collect data from public partners or the crowd and hence activity to identify good/best practices will be helpful. How can mapping agencies create dedicated communities that persist over time? Should there be active collaboration with groups such as those contributing to OSM? How will mapping agencies use VGI while respecting INSPIRE rules? The INSPIRE directive aims to create a European Spatial Data Infrastructure. This will enable the sharing of spatial infrastructure provided by public sector authorities to all citizens so it should considerably enhance public access to spatial infrastructure across Europe. INSPIRE should enhance VGI by providing several free data; on the other hand VGI will continue to provide complementary and updated information (where NMAs cannot afford to do this) not available by INSPIRE. Some VGI can be included in the near-term within INSPIRE if there are adequate validation mechanisms for improving or just reporting its quality.

Issues such as legal issues, nature and motivation of the crowd and sustainability were identified not only as a barrier but also as a goal for any NMAs who could reduce these barriers by responding to questions such as: How to keep contributors and grow the community of contributors? How to motivate them? How to deal with legal issues and licenses? There was great uncertainty over legal issues connected with the use of VGI. Developing from the survey and workshop, it is intended to study further the current practices of national mapping agencies and compare them between national and regional bodies (e.g. Germany, Italy) as well as explore how others organizations such as Microsoft, Google or USGS manage the legal issues.

While the activity of the various VGI communities has not yet substantially changed the way the NMAs produce data, change in the future could be anticipated and the role of the VGI community and NMAs could be reviewed. Nevertheless, it is difficult to identify a clear direction towards which NMAs in Europe are headed in regards to VGI since most of them are public bodies and they are often affected by political decisions. Moreover, the development of the VGI is heterogeneous across Europe, as it is across the world, which leads to many different positions of NMAs regarding VGI. To the best of the authors' knowledge, the economic models of NMAs are changing and need to be adapted to the new reality in which VGI is abundant by, for example, proposing paid services based on geographic data rather than just data or “win to win services”. From the authors' point of view, even if some barriers are broken down, VGI cannot completely replace authoritative data; the authors, without engaging the institution to which they belong, do however believe that NMAs will exploit the potential of VGI in order to reduce their production costs and improve currency by defining new workflows for VGI integration and quality assurance on the one hand and building trust and cooperation with VGI communities and citizens on the other hand.

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