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Collaborative Custodianship through Collaborative Cloud Mapping: Challenges and Opportunities

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Abstract: Collaborative custodianship refers to an arrangement where a number of custodians work together to produce integrated datasets for a spatial data infrastructure (SDI), e.g. local authorities contributing address or street data to a national SDI dataset. Collaborative cloud mapping allows for ubiquitous, convenient, on-demand, configured and tailor-made mapping with resources shared between various entities collaborating on a specific initiative, such as an SDI or for disaster management. This paper presents the results of a workshop in South Africa during which case studies from the Netherlands, Belgium and Austria of collaborative custodianship of address data were presented, and OpenStreetMap as a case study of collaborative cloud mapping. Subsequently, challenges and opportunities for implementing similar initiatives in the context of the South African SDI were debated in break-away sessions. The results from these sessions were analysed using the PESTEL framework.

Keywords: SDI, spatial data infrastructure, custodianship, collaborative mapping, cloud

1. Introduction

Drawing on the definitions for 'infrastructure' in Dictionary.com (2018) and Wiktionary (2018), a spatial data infrastructure (SDI) can be defined as the facilities, services, systems and installations to provide a country, city or area with spatial data and services that are required for the functioning of society. The Commission on SDI & Standards (and its predecessors) of the International Cartographic Association (ICA) used the Reference Model for Open Distributed Processing (RM-ODP) (ISO/IEC 10746-1:1998) to develop formal models of an SDI, describing an SDI from the Enterprise and Information Viewpoints of RM ODP (Hjelmager et al. 2008), from the Computational Viewpoint (Cooper et al. 2012), and describing SDI stakeholders in detail (Cooper et al. 2011, 2013). Subsequently, the Commission examined academic SDIs, i.e. SDIs for research and education, and how they differ from 'regular' SDIs (Coetzee et al. 2017).

Collaborative custodianship refers to an arrangement where a number of custodians collaborate to produce a national SDI dataset, e.g. local authorities contributing address or street data to a national SDI dataset (Coetzee et al. 2018). Such datasets can become massive – what is often referred to as big data .

Collaborative cloud mapping allows for ubiquitous, convenient, on-demand, configured and tailor-made mapping with shared resources between various entities collaborating on a specific initiative such as an SDI or for disaster management. It is also a methodology that allows for a more productive and precise manufacturing process on the basis of service-oriented architectures (Döllner et al. 2018). Main drivers to apply this methodology are earth observation data streams, data integration across thematic domains and data quality enhancing issues. The main concept behind such architectures is keeping spatial data at the place of creation. Data shall not be duplicated, but accessed. Derivative products may be redistributed from other sources (creators of the derivative product) and

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intensify importance of specific values. The main requirements are FAIR (findable, accessible, interoperable and reusable) interfaces (Wilkinson et al, 2016). At the moment, several activities at W3C, ISO and OGC move technologies towards spatial data on the web (OGC & W3C, 2017).

The main advantage of collaborative cloud mapping is that it is ubiquitous, i.e. any user anywhere with Internet access (even in outer space) can share, access and update many different types of data (including big datasets). Additionally, sophisticated tools for complex geospatial analysis are available via the cloud, generally at a lower cost than otherwise available in an organization. Many geospatial products and services are now cloud-based and their capabilities are improving rapidly, e.g. ArcGIS Online, MangoMap and CartoDB (Schmitz et al., 2019).

Collaborative cloud mapping can support small and medium-sized local authorities, which have limited skills and budgets, to do spatial analysis needed for their planning, service delivery, administration and governance. For an SDI, such as that being developed in South Africa, the cloud provides reliable, fast and vast storage for geospatial datasets and relevant services, without the custodians having to worry about the quality of their own Internet services. Further, the cloud facilitates integrating all these datasets, without interfering with the custodians' control over their data.

In September 2018, two Commissions of the International Cartographic Association (ICA), namely the Commission on SDI & Standards, and the Commission on Map Production & Geoinformation Management, hosted a two-day workshop at the University of Pretoria in South Africa. The workshop introduced attendees to collaborative custodianship and collaborative cloud mapping through case studies from the Netherlands, Belgium and Austria. As a very outstanding example of cloud based collaboration with community based custodianship the OpenStreetMap framework was presented and discussed. Subsequently, challenges and opportunities for implementing collaborative custodianship through collaborative cloud mapping in countries like South Africa were explored in break-away sessions.

In this paper, the results of the workshop are presented. Section 2 briefly summarizes the case studies. Section 3 provides the context for the discussions with background information about the South African spatial data infrastructure (SASDI). The results of the break-away discussions are presented in section 4, namely challenges and opportunities for collaborative custodianship and collaborative cloud mapping respectively. Section 5 concludes.

2. Case studies

2.1 Collaborative custodianship in the Basisregistraties Adressen en Gebouwen (BAG) in the Netherlands

The *basisregistratie adressen en gebouwen* (*BAG*) (English: Base Register Addresses and Buildings) is a single national dataset that contains base information on addresses and buildings in the Netherlands. The address and building data of the *BAG* is an important part of the national SDI, because this data facilitates reliable linking of data about people, organizations and services (Coetzee and Bishop, 2009). The information is captured and maintained by 380 municipalities and integrated into a national base register by *Kadaster*, the Dutch Cadastre. The goals for the BAG are: a base register that facilitates a more effective and efficient government and an open dataset that can be used by everybody in the society. The BAG has been available and operational on a national scale since 2011 and contains more than 9 million addresses. The national dataset is supplied by *Kadaster* through various products (database extracts, web services, linked data, APIs). In 2017 the BAG was used more than 1.6 billion times directly.

There are different roles for organizations for maintaining the quality of the *BAG* and for determining the development of the *BAG*:

- The *Ministry of the Interior and Kingdom Relations* is responsible for policies, legislation, supervision and control.
- The *Kadaster* is responsible for the national provision, functional management, IT, national quality management and support.
- The municipalities are responsible for data entry, maintenance and quality assurance of the local *BAG*.
- The suppliers (private parties) supply the necessary software for the municipalities.

There is also user involvement organized for the *BAG* at three levels:

- The *BAG BAO* (*BAG* custodians and users committee) is a strategic steering committee that can give advice to the minister of the Interior and Kingdom Relations. The committee forms a board of municipalities, *VNG* (Cooperation Agency of the Association of Netherlands Municipalities), mandatory government users, *Kadaster* and the Ministry;
- The *Agendaoverleg BAG BAO (BAG* agenda committee) is a tactical steering committee that prepares the strategic committee. The same parties as in *BAG BAO* are represented.
- The *BAG* user council gives operational feedback and advice, which may lead to requests to the *BAG BAO*. In the *BAG* user council, municipalities, government users and private parties represented.

Kadaster, the municipalities, the Ministry of the Interior and Kingdom Relations and the *VNG* have the largest relative influence on developments of the *BAG* (Coetzee et al., 2018).

For building up and maintaining the national dataset, different instruments are used, besides the governance framework described above. Legislation and financial resources and a system of quality assurance on a national and local scale are needed. While building up the *BAG,* a four-stage approach was used with a mix approach of 'the carrot (compliance) and the stick (non-compliance)'. In 2009, after the BAG legislation came into force, there was little encouragement for municipalities to contribute data to the BAG, apart from the BAG legislation itself. The Ministry realized that interventions were needed. Therefore, it conducted a dedicated three-year campaign to assist municipalities with their implementations of the BAG. A team of account managers paid regular visits to municipalities who were in the process of implementing the BAG. They offered advice and guidance, and also built up pressure by signing contracts and monitoring administrative meetings. The campaign led to compliance regarding data contributions to the national BAG dataset by all municipalities at the end of the campaign in 2011 (Coetzee et al., 2018).

2.2 Collaborative custodianship in the Centraal Referentieadressenbestand (CRAB) in Flanders

Governments in Flanders provide well over a thousand different public services[1] to citizens, businesses and organisations. To provide public services, such as environmental permits, government administrations manage large amounts of data using different information systems and data definitions. Reuse of already obtained information is limited and citizens and businesses are repeatedly requested for the same information (Krimmer, 2017).

The e-government decree (Belgisch Staatsblad, 2018) makes it compulsory for all Flemish government administrations to reuse information from authentic sources.

The Flanders Information Agency focuses on the development of base registries. These registries form a coherent system of interconnected authentic data sources and facilitate re-use of information in the public and private sector. The base registry '*Centraal ReferentieadressenBestand* (CRAB)' (Central Reference Address File) is a digital authoritative address dataset for Flanders, one of three regions in Belgium. CRAB contains well over 4 million addresses (Belgisch Staatsblad, 2009). Each address has a geographical position and a 'locator' to distinguish it from neighbouring addresses. In the CRAB data standard, an address is defined as information constructed from a combination of address components (e.g. the municipality, postal code, street name, house number and box number). The address points to an addressable object, such as a building, building unit or land parcel.

CRAB was managed centrally by the Flemish government until 2011 when the CRAB decree came into effect (Belgisch Staatsblad, 2011). It provides the technical, legislative and organisational framework for an authentic geographic data source for addresses in the Flemish region. The CRAB decree appoints municipalities as initiators of address data in the CRAB, while the Flemish government has ownership of this authoritative dataset of addresses (Belgisch Staatsblad, 2009). A set of web services and a web application are available to municipalities to register their address data in the registry. The data in the address registry are made available via download, through a number of web services and via various platforms, including the Flemish geoportal (https://geopunt.be/).

At the national level, the inter-federal memorandum of understanding on 'Belgian Streets and Addresses' (BeSt Add) (Belgisch Staatsblad, 2016), agreed between the federal government and the three regions, aims to establish the organisational framework and data model for address data maintenance according to a common standard so that address data can be exchanged across the country.

The BeSt Add cooperation agreement makes the collaborative custodianship of address data in Belgium complete. All administrative levels in Belgium have their own role and responsibilities in contributing to the address registries:

- Municipalities are responsible for maintaining the address data for their territory autonomously in the address registries.
- The regional governments host the central address registries.

Government administrations from all levels (local, regional and federal) are obliged to only use address data derived from the regional address registries and to report identified errors.

2.3 Collaborative cloud mapping for federal address and street network datasets in Austria

In Austria the legal framework for collaborative cloud mapping is diverse. The national "GeoDIG" act (RIS, 2018a) and the nine legal acts of federal provinces determine the implementation of the INSPIRE Directive (European Union, 2007) and its coordination board, but not a national coordination structure for collaboration in geoinformation. Instead collaborations for selected spatial core datasets (UN-GGIM 2018), like orthoimagery or addresses, are done individually as described below.

The production of orthoimagery is a collaboration of two ministries and the nine federal provinces of Austria, which commission a three-year cycle for the area of Austria. The challenge of this collaborative production was the resulting licensing agreement, which does not restrict participants in their dissemination process. This means that one institution can sell the dataset, whereas others may offer the content as open data.

The addresses data theme goes beyond a financial and license agreement. Its collaborative approach is determined in the act "Adressregisterverordnung" (RIS, 2018b), which regulates the production procedure, georeferencing for addresses, the central register provision, as well as the flat data model. In Austria, about 2500 municipalities are responsible for the recording and management of addresses (ADR Register, 2018).

Georeferencing is done in the form of a spatial data service by the National Mapping and Cadastral Agency (NMCA). The National Statistical Agency (Statistik Austria) embeds the register for data-integration in other registers and statistical services. The NMCA provides a web shop for the register dissemination.

[1] https://productencatalogus.vlaanderen.be/search/products

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The high grade of data-integration leads to quality challenges for addresses in Austria. The different layers of addresses, the address layer and the buildings layer, have to be checked for their plausibility. For example, an address point is related to the position and naming of its cadastral parcel. These plausibility checks are solved with a system of various spatial data services in the background during the procedure of georeferencing. Dependencies for a cross-availability of these services are reduced in a way that georeferencing is still possible when one service is unavailable.

In 2016, the project GeoGIP focused on enhancing the quality for addresses in Austria with a collaborative cloud mapping approach. The reason for this activity was the observation that neither addresses nor transport network graphs could support the routing on authority level and therefore for emergency units. Transport network graphs missed the nodes at the entrance to the cadastral parcel; address points were located as centroid on the cadastral parcel in the best case. The connecting key of the “street code”, which is also stored at the address point, allowed to establish spatial data services, which move the address point to the corresponding street graph, one meter within the parcel. For most of the cases this position is the entrance to the address. For the others the local familiar contributor can change the position with a graphical user interface and the orthoimagery in the background. The dropped perpendicular foot on the street graph is stored in the transport network graph as routing entry point to the parcel´s address. Spatial data services in the transport network register, as well as other spatial data services in the address register, calculate and store the information. Operation agreements with all contributing parties assure quality of services and therefore functionality of the overall system.

2.4 OpenStreetMap as an example of a volunteered collaborative framework

Volunteered geographic information (VGI) has grown expansively as a source of data in the last decade. Organising collaboration between volunteers will always be a problem that needs solving. OpenStreetMap is an example of a real-life and evolving solution to this problem. As a framework, OpenStreetMap and its data are aimed to be open and accessible by all, as stated in the core values of the OpenStreetMap Foundation's mission statement (OpenStreetMap Foundation 2018). Since its beginning in 2004, the quality of the data and the value of the information derived from it has been the focus of many research studies (see Arsanjani at al., 2015).

Because OpenStreetMap does not define what is allowed to be mapped on the platform, the community sharing similar interests has over the years organised itself into subgroups aimed at specific use cases and requirements, implementing some kind of custodianship. One such group is the Humanitarian OpenStreetMap Team (HOT), aimed at organising volunteers in response to disasters or other humanitarian aid projects. The response of the global community to the earthquake that struck Haiti on January 12, 2010 is a testament to the valued impact of volunteered geographic information (Soden and Palen, 2014). OpenStreetMap allowed remotely located volunteers to participate in the relief effort by mapping affected areas. This provided ground teams with rich geographic information, facilitating better resource management and decision making.

There are also cases where local government and decision makers used OpenStreetMap as a platform to provide volunteered geographic information in making decisions (Vaz and Arsanjani, 2015, Haklay et al., 2014). For example, in Tanzania a coalition named Data Zetu has mapped access to sexual health services. This lead to understanding how communities utilise these services and insight into the impact of development decisions impact on communities (Data Zetu, 2019). Not only was it cost effective, it also provided the most current data in combination with traditional surveying methods which led to improved planning and governance.

OpenStreetMap and its ecosystem of tools support a wide spectrum of communities, each with diverse requirements for geographic information, with the opportunity to solve their problems with the help of a global community – even without officially appointed stakeholders and clear custodianships.

3. Context: South African SDI (SASDI)

The Constitution of the Republic of South Africa (1996), the supreme law of the land, sets out basic values and principles of cooperative government and intergovernmental relations, which promote coordination, collaboration and cooperation amongst organs of state. The Spatial Data Infrastructure (SDI) Act, No. 54 of 2003 (section 16) echoes the same principles, encouraging organs of state who are appointed as data custodians to exchange spatial information in terms of collaborative agreements and to support each towards achieving synchronised updates of spatial datasets.

The SDI Act establishes three main components:

1) SASDI as a national technical, institutional and policy framework to coordinate the collection and management of spatial information. The objective of the SASDI is to promote the sharing and use of spatial information, and to provide for the avoidance of duplication of spatial data capture.
2) The Electronic Metadata Catalogue (EMC) as a clearinghouse to promote the capturing and publishing of metadata.
3) The Committee for Spatial Information (CSI) comprises of members from a pre-defined list of institutions appointed by the Minister with clear powers and functions to oversee the implementation of SASDI and the EMC, and to also advise the Minister, the Director-General or an organ of state dealing with spatial information on any matter the CSI considers necessary or expedient for achieving the objectives of the SASDI.

The implementation of the SASDI was not immune to challenges. There was a lull period, between 2004 to 2009, leading to a delay in the implementation of SASDI.

According to Clarke (2011), the passing of the SDI Act was not immediately followed by the development of the SASDI as had been anticipated by the community.

The situation improved in 2010 with the appointment of the CSI. The CSI, echoing the same principles of coordination and collaboration in letter and in spirit, put forward the Base Dataset Custodianship (BDSC) Policy (CSI, 2015a) and the Policy on the Pricing of Spatial Information Products and Services (CSI, 2015b).

The BDSC policy makes provision for the CSI to appoint base dataset custodians and to hold them accountable for the spatial data they are entrusted with. To date, custodians have been identified for the following datasets: administrative boundaries (Chief Surveyor General and Municipal Demarcation Board); satellite imagery (South African National Space Agency); aerial photography, land cover and geodesy (National Geospatial Information); transport (National Department of Transport); Hydrology (Department of Water and Sanitation); Conservation (Department of Environmental Affairs) and cadastre (Chief Surveyor General). The policy explicitly embraces the concept of collaborative custodianship as it promotes cooperative relationships among base dataset custodians and other entities or organisations to ensure access to, and availability of, relevant base datasets.

Through the same policy and in support of the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) Fundamental Dataset Framework (UN-GGIM n.d.), the CSI identified and appointed base dataset coordinators for ten themes.

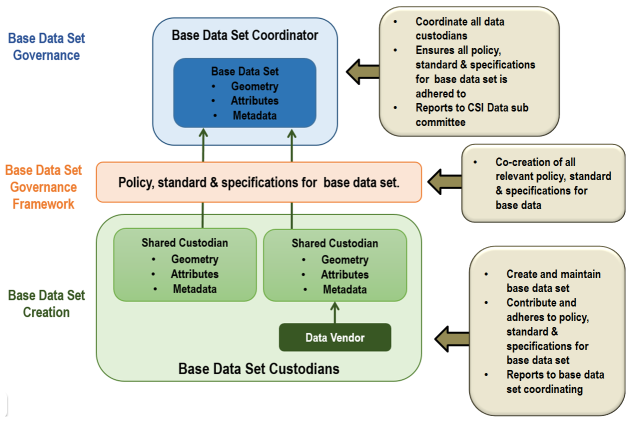

Figure 1. BDSC/Custodian Governance Model (Fourie 2018)

To achieve optimal collaboration amongst coordinators and custodians, the CSI adopted the Base Dataset Coordinator/Custodian Governance Model illustrated in Figure 1. The model illustrates the respective roles of the coordinator and custodians in the creation and maintenance of a base dataset. The emphasis is on the co-creation of policies, standards and specification by all parties involved. Partnership and teamwork are encouraged without elevating the coordinator into a superior role or undermining the role of the contributing custodians, hence base dataset governance is at the centre of the model. The model also acknowledges the role of shared custodianship in circumstances where more than one organisation is appointed as custodian for a single base dataset. For example, one organisation could be the custodian for the spatial data and another organisation for the attribute data.

As the CSI is determined to ensure full implementation of this model, more work still needs to be done to address challenges, particularly the lack of funding and skills, and seize opportunities, such as sharing data, presented by the implementation of the collaborative custodianship model.

The deep-rooted silo approach supported by the system of fixed, conservative mandates remains a challenge. Different organizations continue to collect the same data resulting in wasteful and fruitless expenditure. Implementing the collaborative custodianship model presents positive prospects as data collection will be coordinated and efficiencies will be realised.

4. Results

The challenges and opportunities of the two break-away sessions are presented in section in 4.1 and 4.2 according to the Political, Economic, Social, Technological, Environmental and Legal (PESTEL) framework, useful for analysing macro-environmental factors while starting a new initiative or business endeavor (Morrison, 2012, Dcosta, 2018). *Political factors* include the national, provincial, or local politics, governing bodies that have an influence on business, as well as internal politics of the organisation. *Economic factors* that may have an impact on the initiative include cost, inflation, interest rates and unemployment. Understanding the individuals in the market and the aspects influencing the demographics are *social factors*, such as education levels, distribution of wealth, and lifestyles. *Technological factors* include new relevant discoveries and innovations, as well as obsolescence. *Environmental factors* look at the physical surroundings and the influence on or from them (e. g., the built, as well as the natural environment). *Legal factors* refer to laws, regulations and policies that may influence the initiative.

4.1 Collaborative custodianship: Challenges and Opportunities

4.1.1 *Challenges*

Politically, the organisational goals and silos, accompanied by perceived individual goals, objectives and "hidden agendas" are challenges that may hamper progress in terms of collaborative custodianship. The governance, in terms of structure, to support collaboration is lacking in many instances. Maturity regarding accountability, ownership, and shared responsibility is questionable. Clearly defined roles, responsibilities and duties regarding collaboration are lacking.

Economically, the lack of funding to support collaboration and the cost implications of practically putting measures in place are inhibiting. Hosting, maintenance, and upskilling of staff across the three spheres of government, especially in smaller organs of state, may be untenable, especially in an austere environment.

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Socially, mistrust in other parties' data, a lack of common understanding, an unwillingness to share, and apathy are reasons to be apprehensive about collaboration. The fear of sharing due to mis-interpretation, confidence in own data quality, or uncertainty about mandates, further complicate matters. There is also a sense that skills and HR capacity may be a challenge.

Technologically, the challenges relate to non-standardised settlement and service delivery topology, lack of common data standards and common identifiers, a perceived lack of appropriate hardware and tools, lack of broad network connectivity and a gap in guidance for business and technology units to implement solutions.

Environmentally, the public sector is often perceived to be bureaucratic and dragging its feet. In the current milieu, the role of the private sector is indeterminable, sometimes seen as duplicating efforts and using public data without adding value or improving on the data quality.

Legislatively, there is a myriad of challenges. These include uncertainty on mandates to collect specific themed data due to conflicting legislation such as the SDI Act No. 54 of 2003 and the Statistics Act No. 6 of 1999 regarding geospatial statistics; a lack of formal agreements or mechanisms to share; current inability for identified custodians to comply with regulations, privacy and confidentiality issues; and questions related to the Protection of Personal Information Act (Act 4 of 2013) and the European Union's General Data Privacy Regulations (2016b); questions about intellectual property rights; SITA[2] constraints, such as procurement red tape and lack of resources; and the lack of a national SDI strategy 15 years after the ratification of the Act.

4.1.2 *Opportunities*

Politically, the governance of collaboration can be clearly defined through guidelines and toolkits, the strategic intent could produce a "golden thread" from Sustainable Development Goals down to institutional goals, and the advantages and greater chance of sustainability where collaboration exists could be advocated.

Economically, the cost saving in terms of collaboration, avoiding duplication in data management as a whole, and speeding up decision-making and processes is achievable. Add to this, the derived value of shared datasets, such as unlocking hidden potential and value to a wider audience, and it starts making sense economically.

Socially, with exposure of the data to more people it increases the chance of improving the quality of the data, improved data quality leads to better data and information and subsequently better decisions, and wider access and use among organs of state. Including crowdsourcing would expand the known data landscape, while skills and expertise would be shared naturally, and with more eyes on the data to check and report on quality, trust will improve. Forums could help with discussions on collaboration, learning from one another, documenting solutions, and training and e-learning, by tapping into existing resources and agreeing to shared responsibilities. A stakeholder and data landscape analysis could identify who is using the data, what data they need, at which level, and for what purpose. Benefits and value can be demonstrated by getting buy-in using use cases that are relevant to each audience and taking a "carrot approach".

Technologically, the hardware and software are available, and solutions exist. Improved data quality will happen through collaboration on solutions and infrastructure, joint responsibilities, and holding each other to account. Creating a Single Point (version) of Truth (SPOT[3]), also referred to as the 'once-only principle' in Flanders, will avoid duplication (unless the context requires it).

Environmentally, the public sector should be providing their authoritative datasets, including derived data where the original source has constraints, such as confidentiality. Focus should start at the regional level to establish a data catalogue, before progressing to national.

Legislatively, government should move from a compliance driven ("stick approach") to a benefit or value driven ("carrot approach"). Legislation should recognise or reward parties that comply or show good practice. Tender clauses should force contractors to provide data in appropriate formats; the contractor may retain authorship, but the tenderer retains intellectual property. National Treasury should issue supporting directives, e.g. no funding of spatial data collection without approval of CSI. The metadata standard should also apply at object level, while processes related to quality, standards and best practice should be advocated.

4.2 Collaborative cloud computing: Challenges and Opportunities

4.2.1 *Challenges*

Politically, challenges include ignorance and apathy; losing a perceived mandate or control; differing policies and practices between governments; viability due to power struggles; lack of accountability; and change in political focus. The ignorance relates to the technology of cloud computing and the perceived risks (real, imagined or unanticipated) associated therewith. Governments on all levels need to work with one another, but their policies and practices can be incompatible, such as classifying geospatial data differently (e.g. land use, land cover or transportation networks), working to different spatial resolutions or using different quality or metadata standards. This can be exacerbated when municipalities are merged (South Africa reduced the number of municipalities from 278 to 257 in 2016) or move from one province to another.

Economically, the austere environment, scarce skills and capacity, ill-defined business cases and requirements, and previous failures hamper buy-in. There is a lack of focus on the value it will add to the organisation and the greater public good.

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[2] State Information Technology Agency as established by the SITA Act (Act 88 of 1998)

[3] https://data.gov.au/dataset/single-point-of-truth-spot-metholodogy

Socially, the lack of a common lexicon and terms causes confusion and distrust. Trust is vital when anyone can edit a map. Clarity is required to know who would have access to and the rights to edit maps. People perceive it as a risk if anyone can edit a map without due diligence. Objectives are not aligned to common benefits and there is a lack of a "working together" culture. People are in a comfort zone and are afraid to change. Open technology is feared, whether that be due to poor understanding or irrational thought.

Technologically, if data is captured that is not of survey quality, it may be questioned or be inconsistent. Imagery displacement may be off-putting, but could easily be addressed through training. People may still wonder whether the data was approved and by whom. If there is a need to comply with laws and regulations, these may be a challenge. The question of how to "ring-fence" sensitive data also remains. The updating of data off-line has some perceived difficulties. Finally, current challenges, such as municipal boundaries that change over time, will not disappear when the data is moved into the cloud.

Environmentally, no challenges were recorded.

Legislatively, the legal implications, whether perceived or not, relate to storage and access of data in the cloud, especially across borders. The Protection of Personal Information Act No. 4 of 2013, which relates to privacy, confidentiality and security, is in the back of many people's minds.

4.2.2 *Opportunities*

Politically, the opportunity is there to gain support for "doing the right thing" and to take the lead in driving this approach for the benefit of all concerned; the public good.

Economically, savings could be realised through sharing resources, and free hosting opportunities. At a local level, authorities without sufficient funds for their own GIS divisions could capture data through cloud platforms. It may also assist in linking spatial datasets from alternate contexts, either thematically or spatially. This reduces the need for servers. Some additional economic benefit can be derived from available data by providing economic opportunities for companies to add value to data. The custodians or providers of authoritative data could then provide free access, while gaining benefits in return, such as additional fields, interoperability, and improved quality.

Socially, the use of relevant use cases could lead to a common lexicon and understanding, and would help with the definition of the "most relevant common denominator" and spatial context. A stakeholder analysis would assist in understanding what people want to see on an "OpenStreetMap" solution, which base datasets should be there, and what level of access to the individual datasets should be assigned. Principally, access should be open to all and promoting the sharing of data is essential. Accessibility should be advocated in all public access facilities, e.g. schools and libraries. OpenStreetMap is user friendly and easy to use and could be considered as a common sharing platform, like in the activities of the Humanitarian OpenStreetMap Team (HOT). Educating the public, students, learners and citizens to assist in capturing their own neighbourhood, recreation, point of interest, etc. can assist populating the datasets and establish joint responsibility and ownership. It is perceived that youth and younger workers have the necessary skills required. This data democratisation is a form of crowdsourcing where everyone owns, updates, shares, and updates the content. The provision and focus on service delivery is bottom-up, and possibly less buy-in is required. This kind of collaboration leads to synergy, where the whole is greater than the sum of its parts[4].

Technologically, data gaps can be addressed through collaborative mapping, the data may be the best and most complete version at the time, interoperability would be possible due to open standards, the latest technology would always be taken advantage of (e.g. block chain), hard drive issues and space are a thing of the past as "cloud" is scalable, no funds for software licensing are required as the OpenStreetMap platform is freely available, easy-to-use tools enable map editing in OpenStreetMap, and JOSM[5] is an extendible editor that allows advanced users to develop their own back-drops.

Environmentally, no opportunities were recorded.

Legislatively, the Constitution (Act 106 of 1996) and White Paper on Public Service Transformation (DPSA, 1997) provide for the fundamental rights of access to information, transparency, and open government. The SDI Act and Regulations also stipulate defined processes to deal with incorporate authoritative data (base datasets), where any updates to the data need to be communicated to the Committee for Spatial Information.

A great opportunity exists for collaboration on an actual requirement of Section 37 of the Public Service Regulations (DPSA, 2016), which states that all organs of state need to annually publish a list of service delivery points. A pilot collaboration project among primary role players, who already understand each other and already work together, could be formalised and implemented to ensure there is a master list of service delivery points per organ of state that is maintained using a standard and sustainable process.

5. Discussion and conclusion

This paper has presented case studies from a workshop of collaborative custodianship of address data and collaborative cloud computing. Specifically, these are the Base Register Addresses and Buildings in the Netherlands (Basisregistraties Adressen en Gebouwen (BAG)); the Central Reference Address File in Flanders in Belgium (Centraal Referentieadressenbestand (CRAB)); the collaborative cloud mapping for federal address and street network datasets in Austria (GeoGIP); a volunteered collaborative framework, OpenStreetMap; and the South African SDI (SASDI).

In the Dutch case, collaborative custodianship is implemented through legislation, a governance

[4] https://www.etymonline.com/word/synergy

[5] https://josm.openstreetmap.de/

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framework, and support and technical services by the Ministry and *Kadaster*. It reveals the different kinds of roles and responsibilities required in a collaborative custodianship agreement. The Flemish and Belgian cases show that legislation and collaboration agreements are required to implement collaborative custodianship at different levels of government, especially if some of the collaborating agencies are autonomous.

For all different cases of collaborative cloud mapping in Austria, there is one main lesson to be learned: the collaborative approach was successful and sustainable when all collaborating partners benefited from its results. For example, each of the address recording municipalities receives recognition in the form of a small payment, IT service provision or data exchange. It is not about producing revenue, but about receiving recognition for the most important part of the geoinformation management process.

The OpenStreetMap case is interesting because the collaboration is coordinated by volunteers with varying levels of geospatial knowledge and skills, and it shows that even in the case of VGI, some form of governance with rules and guidelines is required to achieve collaboration on a dataset. The OpenStreetMap framework includes a set of tools that are useful for cloud-based collaborative mapping approaches.

Break-away sessions at the workshop identified and discussed challenges and opportunities for implementing collaborative custodianship of base datasets and collaborative cloud computing in a country such as South Africa. These were analysed using the PESTEL framework: political, economic, social, technological, environmental and legal factors. Next, we plan to experiment with collaborative custodianship through collaborative cloud mapping by designing and evaluating solutions for the opportunities and challenges identified in this paper.

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7. References

ADR Register (2018). *Österreichisches Adressregister* http://www.adressregister.at/ [2018-12-02]

Arsanjani, J. J., Mooney, P., Zipf, A. and Helbich, M. (2015). OpenStreetMap in GIScience: Experiences, Research, Applications. 10.1007/978-3-319-14280-7.

Belgisch Staatsblad (2009). *Decreet betreffende het Centraal Referentieadressenbestand*.

Belgisch Staatsblad (2011). *Besluit van de Vlaamse Regering houdende de uitvoering van het decreet van 8 mei 2009 betreffende het Centraal Referentieadressenbestand*.

Belgisch Staatsblad (2016). *Samenwerkingsakkoord tussen de Federale Staat, het Vlaamse Gewest, het Waalse Gewest en het Brusselse Hoofdstedelijk Gewest met betrekking tot de eenmaking van de wijze waarop gerefereerd wordt aan adressen en de koppeling van adresgegevens*.

Belgisch Staatsblad (2018). *Decreet betreffende het elektronische bestuurlijke gegevensverkeer*.

Clarke, D.G. (2011). Initiatives and challenges of SDI in South Africa. PositionIT, pp.33–35.

Coetzee, S. and Bishop, J. (2009). Address databases for national SDI: Comparing the novel data grid approach to data harvesting and federated databases. International Journal of Geographical Information Science, 23(9), pp.1179–1209.

Coetzee, S., Odijk, M., Van Loenen, B., Storm, J. and Stoter, J. (2018). Stakeholder analysis of the governance framework of a national SDI dataset – whose needs are met in the buildings and address register of the Netherlands? International Journal of Digital Earth. https://doi.org/10.1080/17538947.2018.1520930.

Coetzee S., Steiniger S., Köbben B., Iwaniak A., Kaczmarek I., Rapant P., Cooper A.K., Behr F.-J., Schoof G., Katumba S., Vatseva R., Sinvula, K. and Moellering, H. (July 2017) The Academic SDI – Towards understanding spatial data infrastructures for research and education. International Cartographic Conference 2017, pp 99-113. Springer Lecture Notes in Geoinformation and Cartography. ISBN 978-3-319-57335-9.

Cooper, A.K., Moellering, H., Hjelmager, J., Rapant, P., Delgado, T., Laurent, D., Coetzee, S., Danko, D.M., Düren, U., Iwaniak, A., Brodeur, J., Abad, P., Huet, M. and Rajabifard, A. (2012) A spatial data infrastructure model from the computational viewpoint. International Journal of Geographical Information Science, 27(6):1133–1151.

Cooper, A.K., Rapant, P., Hjelmager, J., Laurent, D., Iwaniak, A., Coetzee, S., Moellering, H. and Düren, U. (July 2011) Extending the formal model of a spatial data infrastructure to include volunteered geographical information, 25th International Cartographic Conference, Paris, France.

Cooper, A.K., Coetzee, S., Rapant, P., Laurent, D., Danko, D.M., Iwaniak, A., Peled, A., Moellering, H. and Düren, U. (August 2013) Exploring the impact of a spatial data infrastructure on value-added resellers and vice versa. 26th International Cartographic Conference (ICC 2013), Dresden, Germany, pp 395–406, doi: 10.1007/978-3-642-32618-9.

CSI (16 February 2015a). Base Dataset Custodianship Policy, made in terms of the Spatial Data Infrastructure Act, 2003 (Act 54 of 2003), Government Gazette 38474.

CSI (16 February 2015b). Policy on Pricing of Spatial Information Products and Services, made in terms of the Spatial Data Infrastructure Act, 2003 (Act 54 of 2003), Government Gazette 38474.

Data Zetu (2018). https://www.hotosm.org/projects/data-zetu/.

Dcosta, A. (2018). Review of PESTLE analysis history and application, Project planning for PMs https://brighthubpm.com/project-planning/100279-pestle-analysis-history-and-application/ [2018-11-29]

DPSA (18 September 1997). White Paper on Transforming Public Service Delivery (Batho Pele White Paper), Department of Public Service and Administration, Government Gazette 18340.

DPSA (29 July 2016). Public Service Regulations. Department of Public Service and Administration, Government Gazette 40167.

Dictionary.com (2018). Infrastructure.

Döllner, J, Jobst, M, and Schmitz, P (Eds) (2019). Service-Oriented Mapping: Changing Paradigm in Map Production and Geoinformation Management. Springer, ISBN 978-3-319-72434-8

European Union (2007). Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE). 108/1 .

European Union (2016a). Access to base Registries, Publications Office of the European Union, Luxembourg.

European Union (2016b), General Data Protection Regulation, Regulation (EU) 2016/679.

Fourie, N. (2016) Requirement for a Marine SDI in South Africa. Geomatics Indaba 2016 Conference, 12-13 September 2016, Ekurhuleni.

Fourie, N. (2018) Introduction To Collaborative Data Custodianship in SASDI. Joint ICA Commission Workshop, 14 September 2018, University of Pretoria

Haklay, M., Antoniou, V., Basiouka, S., Soden, R., Mooney, P. (2014). Crowdsourced Geographic Information Use in Government. Report to GFDRR (World Bank). UCL-Geomatics, London.

Hjelmager, J., Moellering, H., Cooper, A.K., Delgado, T., Rajabifard, A., Rapant, P., Danko, D., Huet, M., Laurent, D., Aalders, H.J.G.L., Iwaniak, A., Abad, P., Düren, U. and Martynenko, A. (2008) An initial formal model for spatial data infrastructures, International Journal of Geographical Information Science 22(11&12):1295-1309.

ISO/IEC 10746-1 (1998) ISO/IEC 10746-1:1998, Information technology – Open Distributed Processing – Reference Model: Overview. International Organization for Standardization (ISO), Geneva, Switzerland.

Krimmer, R., Kalvet, T., Toots, M., Cepilovs, A., and Tambouris, E. (2017, June). Exploring and Demonstrating the Once-Only Principle: A European Perspective. In: Proceedings of the 18th Annual International Conference on Digital Government Research (pp. 546-551). ACM.

Morrison, M. (2012). The PEST analysis. https://rapidbi.com/history-of-pest-analysis/ [2018-11-29]

OGC and W3C (28 September 2017) Spatial Data on the Web Best Practices. Open Geospatial Consortium and World Wide Web Consortium Working Group. https://www.w3.org/TR/sdw-bp/ [2018-12-02].

OpenStreetMap Foundation (2018). Mission Statement. https://wiki.osmfoundation.org/wiki/Mission_Statement [2018-12-03].

Pestle Analysis (2018). An overview of the PESTEL framework. https://pestleanalysis.com/pestel-framework/ [2018-11-27].

South Africa (1996). The Constitution of the Republic of South Africa, Act No. 108 of 1996.

South Africa (1999). Statistics Act, No. 6 of 1999.

South Africa (2003). Spatial Data Infrastructure Act, No. 54 of 2003.

South Africa (2013). Protection of Personal Information Act, No. 4 of 2013.

South Africa (2017). Regulations made in terms of the Spatial Data Infrastructure Act (No. 54 of 2003), Regulation 579, Government Gazette 40920.

RIS (2018a). *Bundesgesetz über eine umweltrelevante Geodateninfrastruktur des Bundes (Geodateninfrastrukturgesetz – GeoDIG), Fassung vom 03.12.2018.*

RIS (2018b). *Verordnung des Bundesministers für Wissenschaft, Forschung und Wirtschaft über Inhalt und Struktur der Angaben des Adressregisters (Adressregisterverordnung 2016 – AdrRegV 2016), Fassung vom 03.12.2018.*

Schmitz P, Heymans J, Claassens A, Carow S and Knight C. (2018). Humanitarian Demining and the Cloud: Demining in Afghanistan and the Western Sahara. In Döllner, J., Jobst, M. and Schmitz, P. (Eds.) Service-Oriented Mapping: Changing Paradigm in Map Production and Geoinformation Management. Springer. ISBN 978-3-319-72434-8.

Soden, R. and Palen, L. (2014). From Crowdsourced Mapping to Community Mapping: The Post-earthquake Work of OpenStreetMap Haiti. In: Rossitto C., Ciolfi L., Martin D., Conein B. (eds) COOP 2014 - Proceedings of the 11th International Conference on the Design of Cooperative Systems, 27-30 May 2014, Nice (France). Springer, Cham.

UN-GGIM (2018). UN-GGIM: Europe Working Group A: Core Data. United Nations Committee of Experts on

Global Geospatial Information Management (UN-GGIM) http://un-ggim-europe.org/content/wg-a-core-data [2018-12-02].

Vaz, E. and Arsanjani, J. J. (2015). Crowdsourced mapping of land use in urban dense environments: An assessment of Toronto. The Canadian Geographer / Le Géographe canadien, 59(2), pp.246-255.

Wiktionary (2018). Spatial data infrastructure.

Wilkinson, M.D., Dumontier, M., Aalbersberg, I.J., Appleton, G. and 49 others (2016). The FAIR Guiding Principles for scientific data management and stewardship, Scientific data, vol 3, article 160018.

Proceedings of the International Cartographic Association, 2, 2019.
29th International Cartographic Conference (ICC 2019), 15–20 July 2019, Tokyo, Japan. This contribution underwent
single-blind peer review based on submitted abstracts. https://doi.org/10.5194/ica-proc-2-19-2019