

A review of the ICA model of stakeholders in a spatial data infrastructure (SDI)

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Abstract:

The Commission on SDI & Standards (and its predecessors) of the International Cartographic Association (ICA) has developed formal models of a spatial data infrastructure (SDI), using the viewpoints of the Reference Model for Open Distributed Processing (RM-ODP) and the Unified Modeling Language (UML). The Commission described an SDI from the Enterprise Viewpoint (purpose, scope and policies for an SDI), Information Viewpoint (semantics of information and information processing in an SDI) and Computational Viewpoint (functional decomposition of the SDI into a set of services that interact through interfaces). The Enterprise Viewpoint model included six types of stakeholders in an SDI: Policy Maker, Producer, Provider, Broker, Value-added Reseller and End User. Subsequently, the Commission identified 39 sub-types of these stakeholders, though a better description of them might be as specializations, special cases, attributes, activities or roles.

We have reviewed the literature and several authors have applied the ICA SDI stakeholder model, proposed improvements to the model and have highlighted parts of the model that are not well understood. The key contributions they have made concerning the stakeholder model are summarised here, together with others that we have identified when reviewing the model. This paper proposes some revisions and expansions on this ICA model of the stakeholders in a spatial data infrastructure.

Keywords: spatial data infrastructure, SDI, stakeholder, ICA model

1. Introduction

1.1 Spatial data infrastructure

No mapping agency can expect to capture and process entirely by itself, all the geospatial data needed for its products. The agency will need to obtain some data sets from other organisations and will generally also contract professionals to provide geospatial data. The agency then needs workflows and protocols for its various products and for each of its data sources, including in-house data capture and processing. Unsurprisingly, such workflows and inter-institutional arrangements have evolved into broader collaborations, particularly as *spatial data infrastructures* (SDIs) (Cooper, 2016).

An SDI is an evolving concept about facilitating and coordinating the exchange and sharing of geospatial data and services between stakeholders from different levels in the geospatial data community (Hjelmager et al., 2008). An SDI is more than just the technology of a distributed geographical information system (GIS): it is generally considered to be the collection of technologies, policies and institutional arrangements that facilitates the availability of, and access to, geospatial data. It provides a basis for geospatial data discovery, evaluation and application for a variety of users and providers (Nebert, 2004, Cooper et al., 2011). An SDI can range from having a rigid, well-defined framework, to one that is fluid and unconstrained (Cooper et al., 2011).

Many countries and regional organisations are developing SDIs to manage and use their geospatial data assets better, at the local, provincial, national, regional and global levels. This resulted in different forms of SDI developed at, and between, these levels. Typically, an SDI is populated with data from government entities with formal mandates (and hence funding!) to provide, update and maintain geospatial data: that is, they are the *data custodians*.

Such custodians are generally required to adhere to government policies and legislation, such as the European Union's INSPIRE Directive (European Parliament, 2007) or South Africa's Spatial Data Infrastructure Act (South Africa, 2003). These entities include not only the mapping, geodetic and surveying agencies, but also national and provincial government departments providing geospatial data specific to their domain (eg: socio-economic statistics, water, health, environment or education), local authorities and other agencies (Cooper, 2016).

An *inverse infrastructure* is user-driven and self-organizing, with decentralized governance and with development influenced from the bottom-up. An inverse infrastructure involves all levels of government and the private and non-governmental sectors. SDIs seem to be evolving from top-down, centralized government-funded initiatives to decentralized and bottom-up initiatives. However, few SDIs are self-organized or user-driven systems (Coetzee and Wolff-Piggott, 2015).

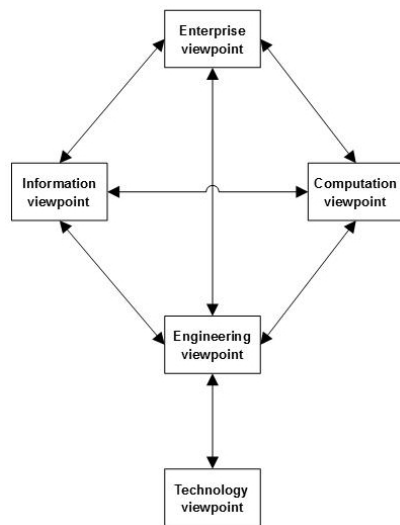


Figure 1: RM ODP model, adapted from (Hjelmager et al., 2008).

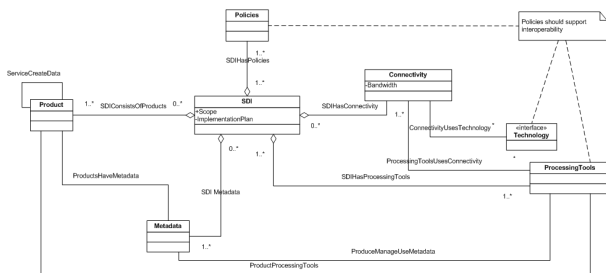


Figure 2: High-level UML classes of the enterprise viewpoint of an SDI (Hjelmager et al., 2008).

The Internet has spawned the development of virtual communities which share data with one another, and with the public at large. Such *user generated content* is most obvious in Web sites such as Wikipedia (Wikimedia, 2019), the free, online encyclopaedia consisting of contributions in many languages, mainly from the public at large. Mobile electronic devices, particularly smartphones, have increased dramatically the ability of people to generate and disseminate user-generated content (Cooper, 2016).

Within geographical information science (GISc), user generated content is also known as volunteered geographical information (VGI) (Goodchild, 2007), and is made available as maps on public Web sites, such as OpenStreetMap (OSM, 2019); as third-party data overlaid on virtual globes, such as Google Earth (Google, 2019); and as contributions to SDIs, especially for change detection (Guélat, 2009, Siebritz, 2014, LINZ, 2019). While national mapping agencies have broader mandates than just collecting data and producing maps (eg: establishing and maintaining national reference systems, or authoritative control over private data), they do need to exploit the opportunities offered by VGI (Devillers et al., 2012).

1.2 SDI viewpoints

The Commission on SDI & Standards (and its predecessors) of the International Cartographic Association (ICA) has developed formal models of an SDI, using three of the five viewpoints of the *Reference Model for Open Distributed Processing (RM-ODP)* (ISO, 1998), and the *Unified Modeling Language (UML)* (ISO, 2005) for the de-

tailed modelling. Figure 1 shows the five RM ODP viewpoints and their relationships with one another. The Commission described an SDI from the *Enterprise Viewpoint* (purpose, scope and policies for an SDI) and *Information Viewpoint* (semantics of information and information processing in an SDI) of RM ODP (Hjelmager et al., 2008). For example, Figure 2 shows the high-level UML classes of the enterprise viewpoint of an SDI (Hjelmager et al., 2008). The Commission also described an SDI from the *Computational Viewpoint* (functional decomposition of the SDI into a set of services that interact through interfaces) (Cooper et al., 2012). The Enterprise Viewpoint model included SDI *stakeholders*, defined as:

An individual or group with an interest in the success of an SDI in delivering its intended results and maintaining the viability of its products. Stakeholders either affect the SDI or are affected by it (Hjelmager et al., 2008)¹.

The ICA Commission did not investigate the *Engineering* and *Technology Viewpoints* of an SDI, because they are implementation-specific and the Commission has aimed at providing technology-independent models for an SDI (Cooper et al., 2012). Others have looked at the Engineering and Technology Viewpoints, such as for the corporate SDI for a power company (Oliveira et al., 2017, Torres et al., 2017a, Torres et al., 2017b). Unsurprisingly, they also modelled this corporate SDI from the other three viewpoints (Oliveira et al., 2016a, Oliveira et al., 2016b).

1.3 SDI stakeholders

Six types of stakeholders were identified by the Commission, as shown below (Hjelmager et al., 2008). Any one person, group, committee or organisation can have multiple stakeholder roles, which could be simultaneously. A stakeholder in an SDI could also be considered to be an *actor* (Oliveira and Lisboa-Filho, 2015).

Policy maker: A stakeholder who sets the policy pursued by an SDI and all its stakeholders.

Producer: A stakeholder who produces SDI data or services.

Provider: A stakeholder who provides data or services to users through an SDI.

Broker: A stakeholder who brings users and providers together and assists in the negotiation of contracts between them. They are specialised publishers and can maintain metadata records on behalf of an owner of a product. Their functions include harvesting metadata from producers and providers, creating catalogues and providing services based on these catalogues.

Value-added reseller (VAR): A stakeholder who adds some new feature to an existing product or group of products, and then makes it available as a new product.

End user: A stakeholder who uses the SDI for its intended purpose (Hjelmager et al., 2008).

¹This definition was adapted from the glossary of the Interoperability Clearinghouse, which is no longer available online.

In retrospect, the definition of the *Producer* should also include explicitly, the production of metadata.

The ICA Commission also developed a table correlating the six types of stakeholders (actors) with some of the classes in the Information Viewpoint model of the SDI (Hjelmager et al., 2008), which is reproduced here in Table 1. Several activities were identified for these classes and the role of each of the stakeholders was identified for them, be it active, as the ‘maker’ of the activity; passive, as the ‘receiver’ of the activity; or not applicable.

Both of the trends towards VGI and inverse infrastructures increase the number of stakeholders in the SDI, their associated diversity and heterogeneity, and the resources at their disposal. Hence, the Commission subsequently assessed whether or not these SDI models catered for VGI (Cooper et al., 2011). The models are sufficiently robust to do so, though it was then realised that the SDI stakeholders needed to be described in more detail as *specializations* or *subtypes* or *special cases* of the general roles of the six types of SDI stakeholders.

The ICA Commission identified 39 subtypes for the stakeholders, with several of these subtypes having further sub-subtypes (Cooper et al., 2011), see Figure 3 for a model of all 45 stakeholder types (which were shown in six figures in (Cooper et al., 2011)). For example, a *Producer* could have a subtype *Status*, which in turn could have the subtypes *Official Mapping Agency*, *Commercial Mapping Agency*, *Community Interest* or *Crowd Source*. The *End User* could have two subtypes, *Naïve Consumer* or *Advanced User*, though this really would be a continuum and not two discrete subtypes (Cooper et al., 2011). At the time, the Commission did not consider it useful to divide up this continuum of subtypes of *End Users* into multiple subtypes.

Collectively, these Enterprise, Information and Computational Viewpoints and the detailed stakeholders (Hjelmager et al., 2008, Cooper et al., 2012, Cooper et al., 2011) form what is known colloquially in the literature as the *ICA model* or *ICA’s formal model* of an SDI, such as by (Box, 2013, Oliveira and Lisboa-Filho, 2015, Oliveira et al., 2016a, Oliveira et al., 2016b, Sinvula et al., 2017, Torres et al., 2017a, Torres et al., 2017b).

2. Issues with the stakeholders

It is important to realise that the ICA SDI model (and probably other such models as well) is not meant to be a *prescriptive* model of an SDI, but rather a *descriptive* one. That is, the model is not meant to specify exactly how an SDI should be established and operated, but is more of a prompt to ensure that all the relevant issues related to stakeholders are addressed in the development, operation and management of an SDI. The ICA SDI model is also implementation-independent and hence somewhat abstract.

Thus, the different components of the ICA SDI model may be rearranged or renamed for any specific implementation as appropriate, without invalidating the model. Further, there are likely to be more detailed specializations, special cases, attributes, activities or roles for the stakeholders in any specific SDI implementation. The ICA model also does not cater for relationships between stakeholders, such

as between an Official Mapping Agency and a Data Distributor contracted to disseminate their products.

2.1 Confusion between types of stakeholders

All of these subtypes or specializations of the SDI stakeholder were given definitions (Cooper et al., 2011), though it subsequently became clear that some of the types and subtypes of stakeholders were confused with one another. In particular, the *Producer* was sometimes confused with the *Provider*, particularly because many Producers are also Providers, and the *Broker* with the *Value-added reseller* (VAR), because Brokers are sometimes also VARs. Perhaps the least understood subtype is the *Négociant*, a subtype of Broker. All their definitions are given below.

*** *Is there any confusion over Producer?*

Producer: “A stakeholder who produces SDI data or services, such as a lay person who generates VGI” (Cooper et al., 2011).

Provider: “A stakeholder who provides data or services, produced by others or itself, to users through an SDI. Examples include an aggregator of VGI, such as Ushahidi, and the provider of the infrastructure for collecting VGI, such as OpenStreetMap” (Cooper et al., 2011).

Broker: “A stakeholder who brings End Users and Providers together and assists in the negotiation of contracts between them. They are specialised publishers and can maintain metadata records on behalf of an owner of a product. Their functions include harvesting metadata from Producers and Providers, creating catalogues, and providing services based on these catalogues. An example for VGI is a community-based organisation that enables the members of its community to provide updates and corrections to the published information of their local authority, such as addresses” (Cooper et al., 2011).

VAR: “A stakeholder who adds some new feature to an existing product or group of products, and then makes it available as a new product. An example is searching for, evaluating and integrating VGI (possibly also with official information), to create a new data set or product. It is important to realize that a VAR does not necessarily sell its products, but could generate its income from other sources (eg: support services)” (Cooper et al., 2011)).

Négociant: “A stakeholder who brings End Users and Providers together and assists in the negotiation of contracts between them. They are specialised publishers and can maintain metadata records on behalf of an owner of a product. Their functions include harvesting metadata from Producers and Providers, creating catalogues and providing services based on these catalogues. A VGI example is a community-based organisation that enables the members of its community to provide updates and corrections to the published information of their local authority” (Cooper et al., 2011).

Hence, a *Producer creates* a product or service and a *Provider makes it available*. For example, an *Official Mapping Agency* (which is a subtype of a *Producer*) might distribute their own products as a *Producer that is its own*

Data Provider (a subtype of Provider) and also allow commercial *Data Distributors* (another subtype of Provider) to distribute them as well.

“The Broker and the VAR are at the interface between the SDI and the End Users and are the bridge between the Producers and/or Providers and the End Users” (Cooper et al., 2013). The key difference between a VAR and a Broker is that the VAR needs to anticipate what the market will need, to be able to add value to the available data and/or services and provide something new. On the other hand, the Broker needs to assess the supply and demand of data and/or services to be able to exploit any opportunities to bring together the existing, but unmatched, supply and demand.

Typically, the offerings from a VAR are more immediate than those from a Broker, are available off the shelf and meet broader needs. A VAR extends the usefulness of an SDI’s products, because high quality and useful VAR products help to ensure continued funding by governments of publicly provided data (Cooper et al., 2013). It is important to note that a VAR does not necessarily sell the data and services to which they have added value, as the value they add is either their mandate as a public organisation, or to market their offerings they do sell. Further, a Broker will generally deal with people while a VAR will focus primarily on their new products.

The *Négociant* is the classic or nominate form of the Broker, who brings together the Providers and End Users. Hence, the two have the same definition which might be confusing, so the definition of the *Broker* should probably be improved to encompass the other brokering roles of *Crowd-sourcing Facilitator*, *Finder*, *Harvester* and *Cataloguer*.

2.2 Negative SDI stakeholders

SDIs do not always succeed: (Makanga and Smit, 2008) found that there were two African countries with active SDIs in 2003 and three in 2008, but the two from 2003 were not operating by 2008. An SDI can also stumble along as a zombie by consuming resources without really delivering anything of value, just unread reports, duplicated spending, scope creep, unused metadata, poor and limited data, etc (Harvey et al., 2015).

The ICA model of the stakeholders in an SDI (Cooper et al., 2011) assumed that all the stakeholders had positive relationships with the SDI. As stated by others, “The actors are individuals with an interest in the success of the SDI, and they may use it or contribute to it” (Oliveira et al., 2017). This is also implied by the definition of *End User*: “A stakeholder who uses the SDI for its intended purpose” (Hjelmager et al., 2008).

Unfortunately, it became clear that not all stakeholders have benevolent relationships with SDIs, whether the stakeholders be malevolent, or just too idle or incompetent to help the SDI succeed. In addition to “normal” errors and bias, a stakeholder can prevent an SDI from succeeding, if not deliberately helping it fail, such as by:

- Restricting the use of data, eg: for alleged security reasons;
- Ignoring the requirements of end users, as opposed to just those of the custodians;

- Having a faulty business model, particularly without adequate and sustained funding;
- Constraining the required resources: funding, skills, equipment, connectivity, data, metadata, services, etc;
- Key stakeholders not cooperating;
- Steering the SDI towards promoting any particular political, religious or social agenda;
- Not providing enabling legislation;
- Providing poor, incorrect or contradictory data and metadata to the SDI (malicious data might well have detailed metadata, albeit fraudulent!);
- Criminal acts, such as cyber attacks on the SDI to disable the system, attempting to manipulate asset prices, stealing confidential data, or tampering with the geospatial data or services provided by the SDI; and
- Simply out of mischief (Cooper, 2016, Coleman et al., 2009).

Antagonism towards an SDI could be due to ignorance; self-aggrandizement (empire-building); promoting a particular political, religious or social agenda; personal feuds; to denigrate someone or some community; perceived threat to one’s status or position; or concerns over the exposure of the poor quality of one’s geospatial data or metadata. Hindering an SDI could be active (an act of commission) or passive (by not delivering or through pretence) — though having a neutral stance towards an SDI is not necessarily negative, if it keeps that stakeholder out of the way of those who are making the SDI happen without the need for grandiose policies, etc. If there is conflict within an SDI, the easy option might well be to do nothing, because then no one loses — though no one wins either!

Activists might target an SDI that is perceived to entrench a regime as the SDI disseminates or promotes biased or fraudulent geospatial data. However, any decent SDI should reduce the risks of this happening by having transparent processes and involving the broader community in the SDI. With the right leadership in an SDI, particularly amongst the *Policy Makers*, the effects of the negative SDI stakeholders can be limited, or even eliminated.

3. Comments from the literature on improving the SDI stakeholder model

As mentioned in Section 1.3, the ICA model of stakeholders in an SDI has been widely used and some have commented on the stakeholder model and made suggestions for improving it. Their comments and suggested improvements are summarised below.

3.1 The SDI model of Béjar et al (2012)

(Béjar et al., 2012) extended the ICA model of an SDI to cater for relationships amongst different SDIs and amongst the stakeholders participating in them. They used the term *actor* for the stakeholders, and identified 12 *actor role types*. The authors probably had not seen the expanded ICA stakeholder model (Cooper et al., 2011) by the time they submitted their paper. (Oliveira and Lisboa-Filho, 2015) also compared these actors of (Béjar et al., 2012) to the stakeholders in the ICA SDI model, see Section 3.4 below. These 12 actor role types (Béjar et al., 2012) are presented here.

User: this is the same as the *User* in the ICA model.

Contributor: who contributes and/or withdraws assets (datasets or services) to or from the SDI, and is hence a *Provider* in the ICA model. Note that the *Contributor* controls their assets explicitly, as they can withdraw them from the SDI.

Custodian: this is the same as the *Producer* in the ICA model.

Governing body: this is the same as the *Policy Maker* in the ICA model.

Operational body: this is the same as the *Secretariat* in the ICA model.

Contact: who represents a community in their interactions with other SDIs. (Béjar et al., 2012) saw some similarities with the *Broker* in the ICA model. However, this actor's activities probably also overlap with those of other stakeholders, such as the *Decision Maker* and the *Champion*. Hence, it might be useful to add the *Contact* separately to the ICA model.

Educator: who is responsible for teaching and training to “cultivate the skills, technical competence, knowledge and best practices needed to maintain and use an SDI” (Béjar et al., 2012). An *Educator* should probably be added to the ICA model and similarly, perhaps a *Researcher* as well.

Promoter: this is the same as the *Champion* in the ICA model.

Funder: who provides the funding needed for the SDI itself and for all of the relevant stakeholders to function. A *Funder* should probably be added to the ICA model, though “the role of releasing resources for the SDI to work” (Oliveira and Lisboa-Filho, 2015) also exists in the *Secretariat*.

Member: this represents all communities involved with an SDI, including federations of communities. Effectively, this is the same as the *Stakeholder* in general in the ICA model, but (Béjar et al., 2012) found it useful to include the *Member* for their modelling.

Communication channel: this actor is not a person or a group of people, but is the collection of technologies enabling communication between the stakeholders and the SDI, and presumably with one another. It is needed for their SDI models (Béjar et al., 2012). The ICA Commission defined a stakeholder explicitly as “an individual or group”, and hence did not consider including technologies as stakeholders. The *communication channel* is probably similar to the *connectivity* class in the Enterprise Viewpoint of the ICA model, see Figure 2.

SDI catalog: again, a collection of technologies, this time for obtaining metadata (Béjar et al., 2012).

They also included *artifact roles*, *enterprise objects*, *policies* and the *interactions and processes* in their SDI models (Béjar et al., 2012), but these are not directly relevant to modelling stakeholders specifically in an SDI. There is also a class for *Policies* in the Enterprise Viewpoint model, see Figure 2. While the *enterprise object* does include *person*, *team* and *organization*, as stakeholders these are catered for by the *actor role types* discussed above. However, this does raise the question of whether or not the ICA stakeholder model should include how stakeholders could be assembled together.

3.2 The SDI governance model of Box (2013)

The ICA SDI stakeholder model does not cater for *oversight* explicitly, which is probably a stakeholder role distinct from the others of the *Policy Maker*. The oversight role is to keep the *Legislator*, *Decision Maker* and *Secretariat* honest, accountable and responsive — while the *Champion* should really be too biased to have an oversight role as well! Such a stakeholder could be responsible in the SDI for ensuring ethical behaviour, shared principles and adherence to codes of conduct, and for peer review, monitoring and evaluation of the SDI and the stakeholders in the SDI. The stakeholder could be labelled as an *Ombud*, which is a clipped form of the word *ombudsman* to make it gender-neutral (used in South Africa, at least).

Adding the *Ombud* would ensure that the *Policy Maker* covers all the aspects of governance described by (Box, 2013). He defined *SDI governance* as “an overarching and enabling decision-making and accountability framework comprising authority structures, roles, policies, processes, and mechanisms that enable collective decision-making, and collaborative action to achieve common goals” (Box, 2013).

3.3 Improvements suggested by Sinvula et al (2017)

A research team that included some members of the ICA Commission on SDI & Standards (see Section 3.6) applied the ICA stakeholder typology to the SDIs of Ghana, Namibia and South Africa (Sinvula et al., 2012, Owusu-Banahene et al., 2013, Sinvula et al., 2013, Sinvula et al., 2017). While they found it useful for comparing stakeholders, they made several suggestions for improving the typology (Sinvula et al., 2017).

- The key issue is how the original six types of stakeholders are expanded upon, because the “subtypes” of these stakeholders are not necessarily subordinate to, or special kinds of, the more general type of stakeholder. The “subtype” of a stakeholder could be a descriptive attribute, such as the status, motivation, legal mandate or skill of the stakeholder. Hence, the typology could be improved by including both attributes and subtypes, and renaming and restructuring the original subtypes appropriately.
- The current ICA stakeholder model does not characterise the maturity of the stakeholder or organisation.
- *Producer* should be expanded to include public-sector producers that are not an *Official Mapping Agency*, such as a statistical agency, or to distinguish between local, provincial and national government Producers. A single Producer may also be represented by multiple individuals.
- Further roles for a *Producer* could be a coordinator, an integrator and a producer of derived datasets. However, an integrator is already catered for as the *Aggregator/Integrator* form of VAR and a producer of derived datasets is probably a *Publisher* form of a VAR (as a VAR can be a public-sector body). The confusion probably arises because any person or organisation can have multiple stakeholder roles, so a mapping agency can be both a *Producer* (being a part of the organisation at the start of the value chain for

that organisation) and a *VAR* (at the end of that value chain).

A *coordinator* was described as playing “a coordinating role by arranging that street centrelines from local, provincial and national government are integrated into a single national base dataset” for the SDI (Sinvula et al., 2017), which is the *Secretariat* form of the *Policy Maker*. For the South African SDI, for example, the *Secretariat* has delegated such a function to what are known as *Base Data Set Coordinators*, so they are agents for the *Secretariat*. It is not clear that *agency*, *contracting* or *representation* roles or functions should be deemed to be separate stakeholders in the model.

- Having only two types of End User, namely the Naïve User and an Advanced User, is limited (as was noted in (Cooper et al., 2011)). Further refinement could be based on how data are used (eg: view, manipulate or transform), the purpose for using the data (eg: mapping, visualization or analysis) and/or on whether the End User is an organisation or an individual. However, to identify such roles will require in-depth analysis and comparison of the users in several SDIs that are functioning fully.
- A *Decision Maker* is not necessarily a *Policy Maker* (Sinvula et al., 2017). However, this comment is probably a misunderstanding of a *Policy Maker*, so that definition needs improvement.

The anonymous referees who reviewed (Sinvula et al., 2017) for the International Journal of Spatial Data Infrastructures Research (IJSIDIR) also made some suggestions on improving the stakeholder model, such as including SDI-financiers (donors), SDI-researchers, SDI-educators and relevant non-government organisations (NGOs). They also asked about dealing with the shifts in the roles and characteristics of SDI stakeholders over time.

3.4 Improvements suggested by Oliveira et al (2015)

(Oliveira and Lisboa-Filho, 2015) unified the stakeholders in the ICA SDI model (Hjelmager et al., 2008, Cooper et al., 2011) with the actors proposed by (Béjar et al., 2012), see Section 3.1 above. They noted the following about the ICA SDI stakeholder model in (Hjelmager et al., 2008, Cooper et al., 2011):

- There is no subtype of the *Producer* for services and no mention of a *Producer* removing or updating data in the SDI.
- There is no explicit provision for updating or removing policies in the SDI, nor for liaising with other organisations.
- Some of the roles of the *Operational Body* (Béjar et al., 2012) are missing, or were not mentioned explicitly, such as systems administration, technical support, quality assurance and managing the catalogue gateway (see (Nebert, 2004)).
- A *Contact* and an *Educator* (Béjar et al., 2012) have not been included, as discussed above in Section 3.1.

They then identified seven main actor roles for SDI participants or *Members* (Oliveira and Lisboa-Filho, 2015):

User: the same as the *User* in the ICA model.

Producer: the same as the *Producer*, but with the *Submitter of Revision Notice* and the *Data Base Administrator* moved to the *Operational Body*.

Provider: the same as the *Provider*.

Broker: the same as the *Broker*.

Value-Added Reseller: the same as the *VAR*.

Operational Body: this is essentially a combination of the *Secretariat*, the *Data Base Administrator* and the *Cataloguer*.

Governing Body: the same as the *Decision Maker* (Oliveira and Lisboa-Filho, 2015).

3.5 Possible attributes, adapted from Cooper (2016)

There are attributes that could be common across all six types of stakeholders in an SDI, such as their motivation for contributing to, or using, any particular SDI. There are other attributes that could be common across the five types of stakeholders that contribute to the SDI, namely the *Policy Maker*, *Producer*, *Provider*, *Broker* and *Value-added Reseller*. These attributes could relate to the stakeholder or to the contribution, such as data, products, services, software, metadata, policies, leadership, resources or technologies. (Cooper, 2016) identified the following attributes as being useful for classifying user-generated content, but they could also be attributes of stakeholders in an SDI:

- The *authority* or *ability* of the stakeholder to make the contribution and whether or not they are *liable* for the contribution and any consequences thereof;
- The *ownership* or *authorship* of the contribution and any issues related to any *intellectual property* in the contribution;
- The nature of any *funding* for the contribution, which could be a factor because the funding could be benevolent, or to promote some vested interest or agenda;
- The *ethics* related to the contribution, including invasion of privacy, arbitrary restrictions, constraining other resources or mischief;
- The *personality* of the contribution, which could be impersonal, subjective, pseudo-objective or objective;
- The *nature*, *size*, *intelligibility*, *quality*, *value*, *relevance*, *utility* or *reliability* of the contribution; and
- The documentation of the contribution, that is, the *metadata* (Cooper, 2016).

3.6 Suggestions from the ICA Commission in Dresden

The ICA Commission on SDI & Standards (known then as the Commission on Geoinformation Infrastructures and Standards) met in Dresden, Germany, in August 2013, just before the 26th International Cartographic Conference there. The Commission worked on the ICA SDI stakeholder model and realized that ‘subtype’ was not necessarily a relevant label for refining the types of stakeholders. However, labels such as ‘specialization’, ‘activity’, ‘perspective’, ‘dimension’, ‘viewpoint’ or ‘role’ also do not by themselves and individually describe all the refinements adequately. Hence, it might be useful to use modelling terms such as *sub-class*, or *parent* and *child* class?

It should be possible to use the ICA models of an SDI without being experts on the model itself, or on UML or RM ODP. Similarly, it should not be necessary to have to explain the SDI concepts and issues, so all the concepts should be defined and illustrated properly. It also raises the question of whether or not the models are too difficult or too abstract to use in practice — though they have been used successfully by (Oliveira et al., 2016a, Oliveira et al., 2016b, Oliveira et al., 2017, Torres et al., 2017a, Torres et al., 2017b), for example, to model and establish a corporate SDI.

The SDI stakeholder model needs to cater for both the top-down and the bottom-up approaches to an SDI. For example, the implementation of INSPIRE at the member state level is primarily top-down, but it does cater for bottom up participation as a legally mandated organisation (LMO) or a spatial data interest community (SDIC), and such participation is not restricted to Europeans (Dufourmont et al., 2004, European Parliament, 2007). There are probably many local authorities across Europe with the skills, capacity and vision to shape and direct any SDI, and hence could be involved explicitly and directly in the decision making for INSPIRE. Some European countries provided models that INSPIRE followed to varying extents and other European countries took on various aspects of the INSPIRE-type model — with the key enabler or inhibitor being money, unsurprisingly. Other countries around the world have similar situations.

During the meeting in Dresden, the Commission observed that the *Secretariat* for an SDI is not necessarily organised optimally nor housed in the appropriate organisation, as it depends on politics, funding, etc. Then, what is the significance of a particular sub-type or specialization not existing within any particular SDI? Finally, the Commission sketched out a rough and revised version of the ICA model of stakeholders in an SDI, which is included here in Table 2.

3.7 Improvements suggested by Coetzee et al (2017)

Subsequently, the ICA Commission on SDI & Standards examined academic SDIs, that is SDIs for research and education, and how they differ from ‘regular’ SDIs (Coetzee et al., 2017). The Commission applied the high-level model with six stakeholders (Hjelmager et al., 2008) to seven universities and research organisations around the world. The Commission then suggested further additions to the ICA SDI stakeholder model, without defining these roles (Coetzee et al., 2017).

- *Funder, Organisation and External Legislator* should be added as roles of the *Policy Maker*.
- *Researcher User, Educator User, Student User and External User* should be added as roles of the *End User*. This emphasizes that as well as being based on their expertise, users can be differentiated based on their relationships to the SDI.
- A *Researcher* should be added as a role of a *VAR*.
- *Researcher, External Producer, Educator and Student* should be added as roles of the *Producer*. Then, *Class Participant* and *Research Student* should be added as roles of the *Student*; and *Class Lecturer* and *Research Supervisor* should be added as roles of the *Educator*.

In practice for UML modelling, these *Researcher* roles will need to be separated from one another by adding a prefix or suffix to the name of the role. The Commission also suggested adding attributes to two of the stakeholders:

- Adding to the *Producer* an attribute specifying whether or not they produce *data*, and another for *services*;
- Also adding to the *Provider* an attribute specifying whether or not they provide *data*, and another for *services*, and a third attribute specifying if the *Provider* is from a different SDI.

4. Summary of the suggested changes to the model

*** *Is it feasible to produce a diagram of the whole SDI value chain, including all the stakeholders and sub-types in it?* ***

Based on the above review of the literature that has used the ICA model of stakeholders in an SDI (Hjelmager et al., 2008, Cooper et al., 2012, Cooper et al., 2011) and our own examination of the model, the following is the suggested expanded model:

*** *Should any of these definitions be improved?*

Policy maker: A stakeholder who sets the policy pursued by an SDI and all its stakeholders.

???

Producer: A stakeholder who produces SDI data or services.

???

Provider: A stakeholder who provides data or services to users throughout SDI.

???

Broker: A stakeholder who brings users and providers together and assists in the negotiation of contracts between them. They are specialised publishers and can maintain metadata records on behalf of an owner of a product. Their functions include harvesting metadata from producers and providers, creating catalogues and providing services based on these catalogues. *** *Need a better definition of Broker.*

???

Value-added reseller (VAR): A stakeholder who adds some new feature to an existing product or group of products, and then makes it available as a new product.

???

End user: A stakeholder who uses the SDI for its intended purpose (Hjelmager et al., 2008).

???

5. So what?

One possibility might be to adapt the model of *producers* (Coleman et al., 2009), providing something like: Ignoramus, Neophyte, Interested Amateur, Expert Amateur, Expert Professional, Expert Authority. It might also be useful to consider the motivations of the End User, be they benevolent or malevolent,

communities, NGOs, CBOs, etc?

SC: Maybe what's missing is a way forward at the end?

AC: Is it just a review paper, or should the Dresden table be included and if so, how? Should the table be completed? And the way forward.

SC: Suggestion: summarize/list improvements in conclusion; way forward: if and how all the improvements can be worked into next version of the ICA's model. I would include the Dresden table as supplement (otherwise too long)

...

AC: Or perhaps just an extract, as it is far from complete?

6. Conclusions

????

A preliminary version of this paper was presented at the 29th International Cartographic Conference (ICC 2019) in Tokyo, Japan, on 18 July 2019 (Cooper et al., 2019).

7. Acknowledgements

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We would also like to thank our employers for allowing us to participate in this research.

*** *This table is probably not relevant for this paper because it is not examined in this paper, but it is included for the moment to make it accessible.* ***

Table 1: Actors and activities in an SDI

UML Classes	Activity	Stakeholder (Actor)					
		Policy Maker	Producer	Provider	Broker	VAR	End User
Policies	Make policy	A	P	P	P	P	P
	Apply policy	A	A	A	A	A	P
	Make business plan	–	A	A	A	A	–
	Use business plan	–	A	A	A	A	–
Product specifications	Consult users	A	A	A	–	A	P
	Stipulate requirements	P	A	P	P	A	A
	Translate into product specifications	–	A	A	A	A	P
	Obtain and implement product specifications	–	A	A	A	A	P
Product	Capture/create data (from source)	–	A	–	–	A	–
	Produce product	–	A	A	A	A	–
	Assure quality (production process)	–	A	A	A	A	–
	Assure quality (certification of product)	–	A	A	A	A	P
	Provide product	–	–	A	A	A	P
	Use products	–	–	–	–	A	A
	Maintain product	–	A	A	A	A	–
Metadata (incl Service capability)	Produce metadata	–	A	A	A	A	–
	Assure quality of metadata	–	A	A	A	A	–
	Provide metadata	–	–	A	A	A	P
	Harvest metadata	–	–	P	A	P	–
	Search through metadata	–	–	–	A	A	A
	Analyse metadata	–	–	–	A	A	A
	Maintain metadata	–	A	A	A	A	–
Catalogue	Produce catalogue	–	A	A	A	A	–
	Provide catalogue	–	–	A	A	A	P
	Search for catalogue (incl chaining)	–	–	–	A	A	A
	Search through catalogue	–	–	–	A	A	A
	Maintain catalogue	–	A	A	A	A	–

In this table:

A Active-Maker

P Passive-Receivers

– Not Applicable (Hjelmager et al., 2008).

*** *This table is probably too messy and too sparse to be included in the paper. So, it should either only an extract should be used here as illustration of what we did in Dresden, or the table be completed. Unfortunately, it will need a lot of effort to complete the table, which would need to be done at a Commission meeting over a few days.* ***

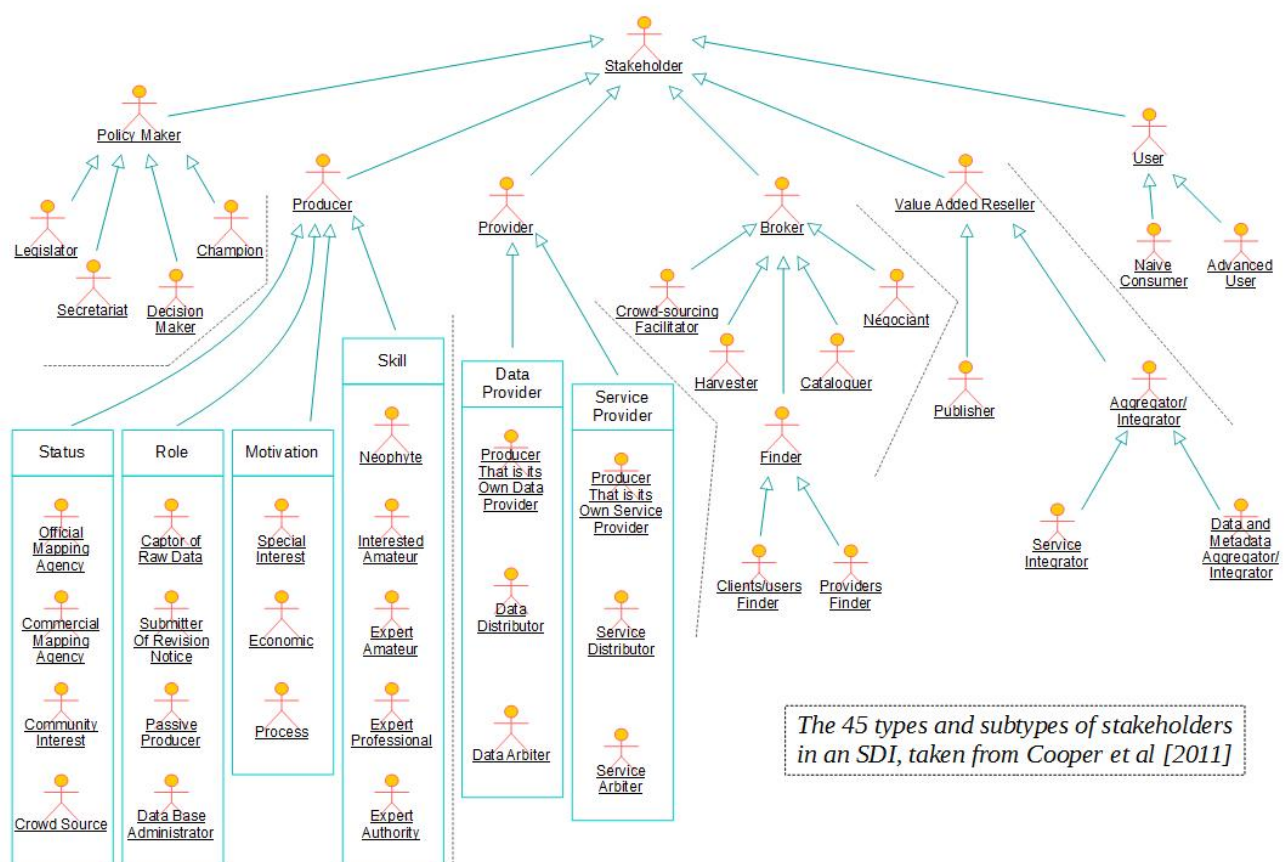


Figure 3: SDI stakeholder types and subtypes (Cooper et al., 2011).

Table 2: Expanded SDI stakeholder model

	Stakeholders					
Characteristics	Policy maker	Producer	Provider	VAR	Broker	End user
Status	Legislator (could be the executive management of a company for that company's SDI)	Official mapping agency (not just national, but also local, etc)	Official provider ???	Government organisation functioning as a VAR, whether or not it is explicitly part of their mandate	Government organisation functioning as a broker, whether or not it is explicitly part of their mandate	Government user
	Decision maker	Other government organisation (do we need to keep this distinction?)	Government organisation	Commercial VAR	Commercial broker	Commercial user
	Secretariat	Commercial mapping agency	Commercial organisation	Community interest VAR (such as a VAR doing crowd sourcing)	Community interest broker	Individual (citizen) user
		Community interest	Community interest			NGO user
		Crowd source	Crowd source			Community interest or community-based organisation (CBO) user
Human and/or information system (data base, search engine, web crawler, harvester, etc)	Automated translation of normative documents, which could create ambiguities	Human and/or information system	Human and/or information system	Human and/or information system	Human and/or information system	Human and/or information system
External stakeholders (any party that influences or is influenced by the SDI, but is outside the 'normal' domain of the SDI) ???		External producer, such as the owner of a remote sensing satellite	External provider (such as VGI repositories that span borders)	External VAR (such as VGI repositories that span borders)	External broker, such as an aid agency	External user
Scope of products or offerings	Data, services or both?	Data, services or both?	Data, services or both?	Data, services or both?	Data, services or both?	Data, services or both?
Role	Enable SDI (provide or facilitate funding, appropriate policies, etc)	Captor of raw data / Developer of services	A producer that is its own data and/or services provider	Publisher	Crowd sourcing facilitator	Nave consumer (might not even realise they are using geodata or geoservices)

	Stakeholders					
Characteristics	Policy maker	Producer	Provider	VAR	Broker	End user
	Hinder SDI (limit or withdraw funding, inappropriate policies, etc)	Submitter of revision notice (for data/services)	Data and/or services distributor	Data and/or Services Aggregator/Integrator	Client/users finder	Informed user
	Neutral (do nothing, keep out of the way of those who are making the SDI happen without the need for grandiose policies, etc)	Passive producer	Data and/or services arbiter		Providers finder	Experienced or educated user
	Pretend to do many wonderful things	Data base administrator / services administrator			Harvester	Expert
	Promote the SDI and participation in the SDI				Cataloguer	
					Négociant (We should probably have different definitions for broker and négociant)	
Who implements the role? Is this described by the status?						
Skill	Rookie legislator	Neophyte	Neophyte	Neophyte	Neophyte	Neophyte
		Interested amateur	Interested amateur	Interested amateur	Interested amateur	Interested amateur
		Expert amateur	Expert amateur	Expert amateur	Expert amateur	Expert amateur
		Expert professional	Expert professional	Expert professional	Expert professional	Expert professional
		Expert authority	Expert authority	Expert authority	Expert authority	Expert authority
Impact	Nonenity (easily ignored)	Nonenity (easily ignored)	Nonenity (easily ignored)	Nonenity (easily ignored)	Nonenity (easily ignored)	Nonenity (easily ignored)
	Influential (charismatic)	Influential (charismatic)	Influential (charismatic)	Influential (charismatic)	Influential (charismatic)	Influential (charismatic)
Motivation	Personal gain	Special interest	Special interest	Special interest	Special interest	Special interest
	Professional gain — achieving specified objectives	Economic	Economic	Economic	Economic	Economic
	Party political platform	Process	Process	Process	Process	Process

	Stakeholders					
Characteristics	Policy maker	Producer	Provider	VAR	Broker	End user
Secure funding	Secure funding for SDI	Secure funding for the producers data production and SDI involvement	Secure funding for the providers SDI involvement	Secure funding for the VARs value-add and SDI involvement	Secure funding for the brokers broking and SDI involvement	Secure funding for end users (education? Promotional data sets? GISs and tools?)
Decision maker (individual, committee, organisation, etc)	Decision maker within the SDI, which sets the policy for the SDI	Decision maker within the organisation or community of practice, which sets the policy within the organisation or community of practice	Decision maker within the organisation or community of practice, which sets the policy within the organisation or community of practice	Decision maker within the organisation or community of practice, which sets the policy within the organisation or community of practice	Decision maker within the organisation or community of practice, which sets the policy within the organisation or community of practice	Decision maker within the organisation or community of practice, which sets the policy within the organisation or community of practice
Secretariat	Secretariat	Unlikely	Unlikely	Unlikely	Unlikely	Not
Promotor (are these ordered from least effective to most effective, or are these independent characteristics which might or might not occur together in the same person?)	Advocate	Advocate	Advocate	Advocate	Advocate	Advocate
	Motivator	Motivator	Motivator	Motivator	Motivator	Motivator
	Champion	Champion	Champion	Champion	Champion	Champion
		Gets the producer involved in the SDI	Gets the provider involved in the SDI	Gets the VAR involved in the SDI	Gets the broker involved in the SDI	
Anti-champion or antagonist	Anti-champion or antagonist	Anti-champion or antagonist	Anti-champion or antagonist	Anti-champion or antagonist	Anti-champion or antagonist	Anti-champion or antagonist
Data provider		A producer that is its own data provider				
Service provider		A producer that is its own service provider				
Crowd-sourcing facilitator		Crowd-sourcing facilitator			Crowd-sourcing facilitator	
Finder						
Harvester			Harvester			
Cataloguer			Cataloguer			
Négociant						
Publisher				Publisher		
Aggregator/integrator				Service integrator		

	Stakeholders					
Characteristics	Policy maker	Producer	Provider	VAR	Broker	End user
				Data and metadata aggregator/integrator		
Naïve consumer						
Intermediate ???						
Advanced user						
VGI ???						
SDI has an administrative focus while VGI has a business or social responsibility focus, so how can these different foci be merged? What about overlapping responsibilities and gaps between responsibilities?						
What about liability or responsibility?						
Should we differentiate between public- and private-sector VARs, providers, producers, etc?						
Governance						
Is the INSPIRE Invoke Service an Integrator or a Broker?						
Do we cater adequately for agents and contractors?						

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