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| [insert BUSINESS UNIT/FLAGSHIP NAME] |
| A Data Specification Framework  for the  Foundation Spatial Data Framework  Paul Box1, Bruce Simons1, Simon Cox1  Stephen Maguire 2, and Jonathan Yu1  1 CSIRO Land and Water Flagship  2 Zicomi Systems  Prepared for the Department of Communications |

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| [Insert partner or collaborator logos here, scale to fit, 3cm maximum height (delete if not required)] |

Digital Productivity Flagship and Land and Water Flagship

Citation

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INSPIRE for leading the way forward

Executive summary

[This executive summary should concisely describe the nature of the work, the principal results and conclusions. Normally, the executive summary would not exceed one page. It should be written so that a non-specialist can understand the nature of the research.]

# Introduction

## Purpose

The purpose of this document is to explain the rationale for geospatial data specification using a coherent information modelling approach. The case is made for information modelling from a system of system or [Spatial Data Infrastructure (SDI)](#SDI) perspective.

The document is aimed at a number of audiences:

* Senior executives –to explain the rationale and cost benefit of modelling, in the context of the development of a national information infrastructure - the Foundation Spatial Data Framework (sections 1, 2 and 5);
* For technical managers – to articulate the value and process of modelling from both an enterprise (i.e. single organisation) and system of system i.e. the Foundation Spatial Data Framework (FSDF) perspective (all sections);
* For modellers - to situate modelling activity in a broader context enabling a clearer understanding of the a rationale for and role of modelling (sections 3, 4 and 5); and
* Database, data product and service implementers – to understand the role of modelling to support the design and implementation of products and services (sections 3, 4 and 5).

This report is intended primarily for those engaged in the Foundation Spatial Data Framework (FSDF). However much of the content is relevant for the broader other spatial information community.

## Scope

* The document is intended to provide an overview of the proposed data specification framework.
* It does not provide the comprehensive design of the framework
* It describes the pieces of the framework that that are in place, and how these need to be built out and better supported by governance arrangements
* Has a focus on the modelling aspects of data specification
* More details will need to be articulated as specification framework is implemented in more detail.

## The Foundation Spatial Data Framework (FSDF)

### Overview

The Foundation Spatial Data Framework (FSDF)[[1]](#footnote-1) is an Australia and New Zealand Land Information Council (ANZLIC) initiative that aims to deliver national coverage (for Australia and New Zealand) of the best available, most current, authoritative source of foundation spatial data[[2]](#footnote-2). Foundation spatial data provides the basic data infrastructure within which richer applications take place. ANZLIC envisions that foundation spatial data will become a ubiquitous part of activities across all sectors of both the Australian and New Zealand economies.

The FSDF has been conceived as a coherent national approach to enable the access to and evolution of national foundation spatial data. It will provide a common reference for the assembly and maintenance of Australian and New Zealand foundation level spatial data in order to serve the widest possible variety of users. It will deliver national coverage of the best available, most current, authoritative source of foundation spatial data which is standardised and quality controlled. FSDF represents a data centric approach to developing national Spatial Data Infrastructure (SDI).

As noted by Drew Clark ANZLIC Chair, the key benefits to be realised through implementation of the FSDF are “improving supply chains, realising efficiencies and reducing the duplication of effort in the Australian, state and territory governments” ([ANZLIC—the Spatial Information Council 2014](#_ENREF_1))

The FSDF groups foundation spatial data into the following themes:

* Geocoded Addressing;
* Administrative Boundaries;
* Positioning;
* Place Names;
* Land Parcel and Property;
* Imagery;
* Transport;
* Water;
* Elevation and Depth; and
* Land Cover.

User consultations have identified priority datasets for each theme, and completed theme profiles that provide a description of each theme and identified data sets, together with use cases for the data. In parallel with the technical work, FSDF governance arrangements and a policy framework have been developed. Three year road maps have been developed for each theme, which identify future goals and plans to resolve gaps, evolve datasets and delivery mechanisms. Work plans are articulated around four areas of focus as shown in Figure 1. A work plan for a ‘cross cutting theme’ has also been developed. This work plan addresses data specification and harmonisation priorities.

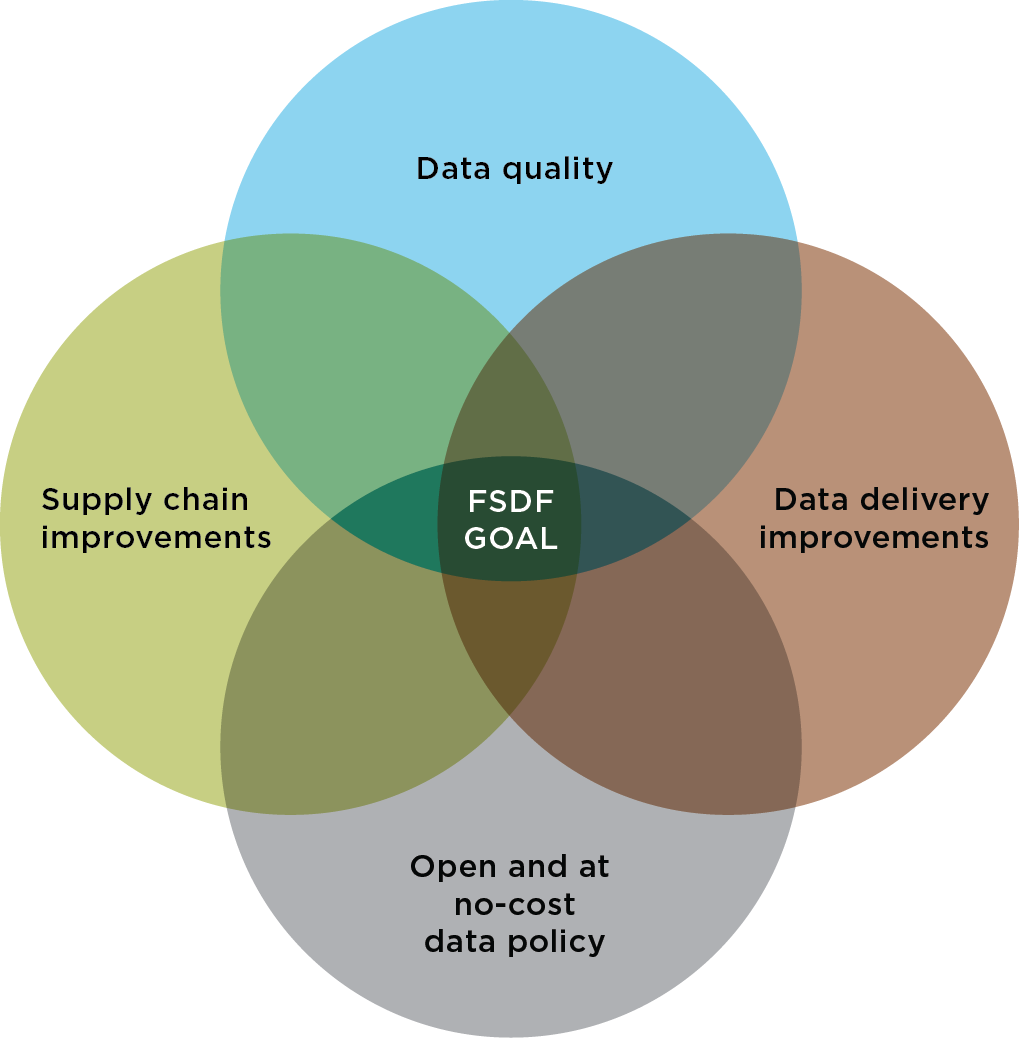


Figure Evolution of FSDF datasets: Areas of focus ([ANZLIC—the Spatial Information Council 2014](#_ENREF_1)).

### Key challenges

To achieve desired outcomes, the FSDF initiative must address a range of interwoven technical and social challenges caused by the fragmented and heterogeneous production, management, supply and governance of geospatial data across multiple levels of government.

The most critical challenge to be addressed across most of the FSDF Themes is the need to integrate a patchwork of data sources with different structures and semantics, developed under different business contexts, into coherent suite of maintainable national products. This challenge is largely a function of a federated government structures in which spatial data production and delivery takes place across all levels of government, and foundation data products are often merely a by-product of protocols related to local regulatory or business activities. INSPIRE is addressing a similar challenge in Europe, that of integrating Member States’ data to create seamless EU spatial data coverage.

Something about the Geofabric multiple linked representations as opposed to AusHydro that was a output odf topographic mapping process. . Contrasted with examples from gazetteer/ admin bnd space

Important dimensions of this challenge are:

* **Enabling policy settings** - addressing the heterogeneous and sometimes incompatible legislation, policies, licencing, governance and access arrangements to achieve open and no-cost data outcomes
* **Optimising supply chains** - reconciling heterogeneous information management and delivery frameworks across levels of governments in Australia and New Zealand to increase efficiency and address data quality issues at various stages of the information supply chain
* **Demand driven products** - If foundation data is to serve a wider range of functions, design of products must be demand driven to explicitly meet end user needs.

Many of these challenges are socio-technical in nature and require changes to work practices, collaboration arrangements, and organisational culture to support the adoption of technical solutions.

## Geospatial data interoperability

For most applications, users need to be able to integrate spatial data from multiple sources. For example, several disparate sources of data relating to the same object such as two road data sets that cover two adjacent areas, or disparate data sets that characterise different phenomena e.g. hydrology and land cover. However as spatial data is produced for different purposes at different scales, using different methods at different times, by different organisations using different systems, delivered in different formats, data integration and use is problematic.

To facilitate users to access and use spatial data we aim to make it interoperable. Interoperability is ‘the ability to transfer and use information in a uniform and efficient manner across multiple organisations and information technology systems’ ([Australian Government Information Management Office (AGIMO) 2006 p. 3](#_ENREF_2)).

The quest for interoperability has been characterised as a series of layers each of which addresses a set of concerns to achieve deeper interoperability. These encompass the use of communication protocols (such as http) to achieve technical interoperability, the use of common data formats the use of common models to achieve syntactic interoperability and the use of models and controlled vocabularies to achieve semantic interoperability.

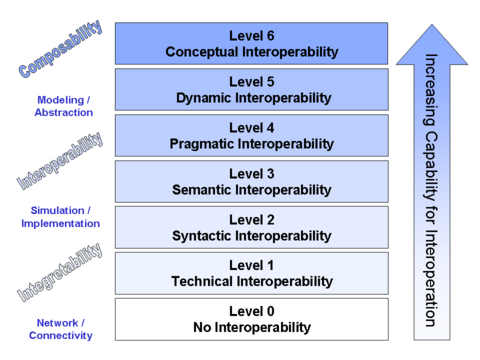
([OGC 2014](#_ENREF_9))

Figure 2 Levels of conceptual interoperability

(Levels of Conceptual Interoperability (published in Tolk A, Diallo SY, Turnitsa CD, Winters LS (2006) "Composable M&S Web Services for Net-centric Applications," Journal for Defense Modeling & Simulation (JDMS), Volume 3 Number 1, pp. 27-44, January 2006) [*Creative Commons*](http://en.wikipedia.org/wiki/Creative_Commons)[*Attribution-ShareAlike 3.0*](http://creativecommons.org/licenses/by-sa/3.0/)

### Data format

A wide variety of Geographic Information Systems (GIS) and associated technologies are used to produce manage deliver and work with geospatial data. These systems use a range of proprietary data formats. Moving data between systems, and integrating data from different systems to a common format, requires translation between data formats. Much of the software provides in-built translation tools, although some information cannot survive transformation (e.g. topology will be lost when transforming to a format that does not support topology).

Standard formats have emerged such as Geography Markup Language (GML) ([ISO 2007](#_ENREF_5)) that can be used as the basis for transmission of data and enable providers to more reliably translate from proprietary formats to a common delivery format. However…..

### Data structure and semantics

For users that need to integrate and use multiple sources of data relating to the same spatial object, having the data sets in the same format is not sufficient. Users need to be able to interpret and query data in a consistent manner and thus data needs to be integrated into a common structure with common semantics. The need to aggregate and integrate multiple data sets is a common requirement and is in fact the key challenge that the FSDF is addressing.

Geospatial data is an abstraction of reality, being (digital) *representations* of features in the world. Representations are created for various purposes, with different views of the same object, with different properties or aspects of the feature described, and often at different scales. For example, a local government area feature represented in a gazetteer (place names) data set will contain different information compared with the feature represented in an administrative boundary data set. Similarly, a topography and hydrology data sets will contain different information about the same rivers. Each representation of the same object, even in the same system, is likely to have a different identifier, which creates problems when attempting to link information from different themes to geographic locations. Furthermore, even in data prepared for applications of similar scope where the same view is required, the way in which the data is structured and the attributes and classification schemes used to characterise spatial object are typically implemented in different ways in different organisations. The variations are due to design choices made by the database/data product designers, based on interpretation of user needs, best practice, personal preference and the technology platforms being used. Finally, data from different themes that is supposed to fit together (e.g. administrative boundaries aligned with hydrology) frequently does not, because of different geometry scales, generalisations, other assumptions in the data preparation process, or simply that datasets originally derived from each other drift apart with time if there is no active synchronisation plan.

All of this variability imposes a cost for end users wishing to integrate and use multiple datasets representing the same spatial object. Although data can be brought into the same environment using a common data format, the datasets cannot be queried or processed together without further interpretation, and transformation to develop concepts and classifications that are compatible.

Furthermore the duplication of concepts relating to the same phenomena is confusing for end users and creates significant issues

### The role of standards

A standard is ‘a documented agreement between providers and consumers, established by consensus, that provides rules, guidelines, or characteristics ensuring materials, products, and services are fit for purpose’. ([OGC 2014 p. 5](#_ENREF_9)).

Standards play a key role in achieving interoperability at a number of levels from standardised communication protocols such as http to standard formats such as Geography Markup Language (GML), and through standardised community application schema such as GeosciML and semantics such as AGIFT GCMD. The adoption of standards is driven an organisation’s desire to share integrate and use geospatial data with a broader community.

Two sets of standards play an important role achieving interoperability of geospatial information namely, ISO TC211 and the Open Geospatial Consortium (OGC)

Firstly, the ISO TC211 191xx series of International Standards provides a standardised conceptual modelling framework for geospatial information. This suite of standards provides a set of constructs that define how aspects of spatial information should be modelled. For example, ISO 19107 – Geographic Information – Spatial schema specifies how to describe the spatial characteristics of geographic features. Together these standards provide a framework within which information models can be developed in different domains in a consistent manner. This in ensure that structural or syntactic interoperability can be achieved between domains. For example the INSPIRE data specifications[[3]](#footnote-3) are developed using the these standards as a framework. Domain content standards can themselves be promulgated as standards for a specific community. This will be the case for the model developed under the remit of the FSDF as they willa ct as standards for data product development and data exchange.

Content versus tech standards

Standards harmonisation

* cross domain context
* current data versus future needs

## The role of information modelling in geospatial data production

Information modelling is a key element of the data specification process. Formal modelling provides some significant advantages when developing inter-related spatial data products.

FSDF is developing information models, expressed in Unified Modelling Language (UML) for the foundation spatial data themes, that will enable the production and maintenance of suites of interoperable, standards based foundation spatial datasets. This approach follows global best practice developed in the European INSPIRE initiative. The goal of INSPIRE is to facilitate exchange of geospatial data between EU Member States by defining data exchange standards. The exchange standards are based on agreed information models, together with technology standards for data discovery visualisation and access. The development and evolution of the ten FSDF themes is supported by INSPIRE-based modelling approaches, together with CSIRO modelling tools, methods and experience gained through the development of significant national and global data standards[[4]](#footnote-4).

Data specification provides an opportunity to achieve:

* Interoperability – achieve interoperability by specifying the things that need to be same across the whole of the FSDF as well as within each theme;
* Harmonisation - improve coherence between data sets within and across themes;
* User demand driven - update existing products to better meet articulated end users needs in the context of emerging technology paradigms; and
* Efficiency– improve supply chains and address common challenges collectively these problems are ubiquitous across FSDF and so the solutions.

Figure The role of modelling to reconcile supply and demand, current and future state

### Information modelling and data modelling

Information modelling refers to the process used to represent concepts and relationships for a particular ‘domain of discourse’. Formal information models (i.e. those which are expressed using a formally defined modelling language) such as UML (Unified Modelling Language) are used to define agreed concepts and relationships. For example, we can specify that a road has a centre-line, a pavement geometry, a classification that may vary along its length, and is connected to other roads at junctions.

Expressing standards in UML – separation of concerns and - between business needs and technology implementations.

Data modelling is a form of information modelling which is concerned with design the physical structures of databases. For the purposes of this document the term information modelling includes data modelling. Information modelling should be conducted before data modelling so that structure and semantics can be agreed in technology neutral way. These agreed constructs can then be implemented in technology specific ways in multiple flavours of data model e.g. for for Oracle or SQL.

Ontologies are a kind of information model, though there are distinctively different assumptions and use-cases compared with more conventional data models. Information and data models are typically concerned with database design, and supporting assessment of completeness and validity, while ontologies are more focussed on enabling inference of additional information by considering the assertions in the data together with the axioms in the ontology.

## Towards a National Spatial information Infrastructure

* SDI are web based data sharing initiatives enabling large scale shgarig oand access of spatial data on the web.
* FSDF is data centric approach to developing national SDI
* Significant efforts in the past and present at a variety of scales. For example…..
* FSDF information modelling aims to leverage these efforts . It aims to provide coherent well design data delivered as a key element of a national Spatial Data infrastructure.

# Context and the need for data specifications

## Overview

* This section provides a description of supply chains in Australia and how models and data sepcs are used in supply chains
* main issue is reconciling different models and semantics used by authoritative data providers within Australian Governments - at Commonwealth, State and Territoriy and local government levels.

## Geospatial data production and delivery patterns

To understand the role of information models we must place them in the context of the geospatial information supply chains. A number of key patterns can be identified. These are:

* Anarchic / Point-to-point;
* Centralised supply;
* Aggregated;
* Brokered; and
* Federated.

These patterns are distinguished primarily by the location and timing of the transformation of data from the storage format and structure to the product schema, and thus the actor who bears the cost of performing the transformation. Three primary actors are involved in the supply chains:

* Provider;
* Intermediary (aggregator or broker); and
* User.

These play different roles in design, integration, delivery and use of geospatial data in each of the patterns. Supply chains commence with data held by providers that is processed into spatial data products and delivered to end users. We may compare of the relative costs for various stakeholders, as well as the aggregate cost of operations, associated with each pattern.

Note that in the characterisation of supply chains presented in this document, the focus is on production and delivery of spatial data rather than its collection. Data collection is therefore excluded from the analysis.

Figure 4 Geospatial information production and delivery patterns

##### Pattern 0 – Anarchy/point-to-point - direct producer user interaction with no mediation

##### Each user must find, negotiate access to, interpret, extract, transform, load, interpret, transform and then harmonise each source dataset to create a coherent product with national coverage. This was the traditional pattern for GIS users – get the dataset then inspect the table and infer the meaning from column headings in order to use it in a local environment, which assumes that the tags or column headings are in fact comprehensible to consumers. This pattern imposes no costs to providers. However, as each user must perform the process independently;

##### each user may end up with a different final end product; and

* each user bears the costs of production.

The total cost of producing a particular product is multiplied by the number of users. This is a very inefficient supply chain model in aggregate, though it is appealing to providers if they are given no specific incentive to assist users.

##### Pattern 1 – Centralised production – tightly coupled, application-specific

##### A single organisation is responsible for all the data that is required to produce a national product to meet a specialized internal or external user need. This organization is either responsible for generating or collecting all the data itself, or has private arrangements with the collectors. There is no other source of the data within Australia, and users have to accept the structure and format provided, even if it does not conform to international norms. There is no intermediary.

Examples of this pattern include - ABS ASGS (core structures), Bureau of Meteorology (weather and climate data).

##### Pattern 2 – Centralised aggregation and integration pattern

##### An intermediary aggregates heterogeneous data from multiple providers, each of which publishes data according to a different structure and format, and publication method. The intermediary processes the data to create a coherent national product. Processing the data entails access extraction, interpretation, transformation, loading, integration, harmonisation and the production and delivery of the final product. The cost of data transformation falls only on the intermediary, who is required to maintain knowledge of all provider’s structures and formats. A user could obtain the data directly from each provider, and this can satisfy requirements if, for example, both providers and the application are geographically limited, but the intermediary is the only source of a uniform national product, and can therefore charge users a premium for it in an unregulated market. A monopoly provider also has little incentive to improve quality or coverage. The size and type of user-base is severely affected by the pricing approach.

Examples of this pattern are the national gazetteer (GA), National addressing (PSMA).

##### Pattern 3 – Centralised broker – centralized on-the-fly mediation pattern

A centralised broker service transforms heterogeneous data supplied by data providers as services to a common structure based on an agreed model. This entails mapping of the individual supply data models to the common model, whose cost is proportional to the number of suppliers. There is no additional impost on data providers in terms of data supply requirements, although there may be small effort required to assist the broker to map supplied data model to the common model.

Examples of this pattern include - Canadian ‘Groundwater Information Network’ mediator; EuroGEOSS broker

##### Pattern 4 – Federated data supply using community models

In this pattern the data providers provide a view of their data according to a community agreed model. Mapping of the storage data structure to the community schema is performed in a feature service hosted by each provider. End users access services from multiple data providers, with conforming to the standard (community) structure and semantics. This is helpful to users, who can use common software to process multiple sources. However, the cost falls primarily on the providers, who maintain the mapping from the local schema to the community schema (arguably they are best positioned to do this), and are responsible and the service performing the transformation. If the market they supply is purely external, then there may be little direct incentive or perceived payoff to the provider.

Examples of this , INSPIRE pattern include Geoscience community data ….. .

### web services

The broker and federated models rely on data delivery using WFS (or potentially other online delivery mechanisms). They differ in that the broker pattern takes on the task of transforming data from suppliers, whereas the federated model requires the supplier to provide a view of their data using the agreed community model.

### Private versus community schema

The production patterns use application schema in different ways and at different stages in the supply chain. The schema for the product is designed by the user in pattern 0, the provider in pattern 1 and the aggregator in pattern 2. In patterns 3 and 4 a community product schema is used. The product schema in patterns 0, 1, 2 is ‘private’ and developed by the actor responsible for data production. This contrasts with a community schema that is developed and agreed to by a community. It enables a third party to transform their data (pattern 3) or enables them to supply a view of their data (pattern 4).

### costs of production and use

In geospatial supply chains there is a total cost for data production, from data collection through to product design and delivery, and use. However, with the different supply chain patterns these costs are borne by different users. For each of the patterns the locus and total costs of production and use of data is different. Figure 5, provides an indication of approximate costs of production (product design, data integration and production) borne by each of the three supply chain actors for each pattern[[5]](#footnote-5).

Figure 5 Proportion of data production costs by actor type

When considering the total costs of production shown in Figure 5, for each additional data provider there is an increase in costs for users and intermediaries in patterns zero, two and three as additional effort is required to deal with additional data sets. More importantly, it should be noted that the total cost of production and use for pattern 0 increases linearly as the number of users, whereas the marginal cost per additional user is close to zero for patterns 3 and 4. In pattern 2 there is a single transformation at a fixed cost per revision, so if notionally shared amongst all users, the cost per participant reduces with each additional user, though this depends on the business model of the aggregator.

## Drivers for change

### Horses for course

* SO what?
* Point-to-point pattern creates maximum cost and least transparency all round.
* Aggregator/broker pattern creates a monopoly provider with limited transparency, whose interests are not (necessarily) aligned with users, but with no competition there is limited responsiveness to market.
* What are the users demands? By **classes of user**
  + VARs
  + Consumers
  + Commonwealth
  + Businesses
  + Others
* For multiple data sets that needs to be aggregated to create a national view
* The aim is to move to more efficient production patterns 3 and 4. This means investing in modelling upfront and moving the modelling as close to the source of data as possible.
* Patterns 3&4 are more efficient in aggregate, but the immediate costs are shifted from user to provider/broker, who need to be compensated or otherwise incentivised.

### value proposition

* Systems of systems
* Persistence layer creaking under pressure to service increasing user demands
* Shifting the costs profile of geospatial supply chains
* Building capacity
* improved design

#### Interoperability

* Capturing the universe of discourse, Community engagement
* Agreeing on common semantics ( concepts and relationship) within information community/ domain
* Standard way
* Explicit and formal UML + OWL
  + Is this ‘documentation’ or ‘code’?
* Reduced costs of app dev as data predictable

#### Improved products

* Transparency - process / semantics provenance machine readability
* Developing community of practice
* Driving future change

#### System scale coherence

* Although there are significant benefits of modelling individual products based on well articulated use cases, the real value if realised is not improved individual products but coherenet suites of products e.g. geofabric
* Reusable design patterns
* Cross domain harmonisation
* No one community can model everything that community requires (e.g. spatial, time or coordinate ref systems) - reusable component
* Complex arrangement of intersecting overlapping communities and subsets thereof
* Shared common concepts across info communities /domains
* Reuse of agreed FSDF scoped patterns
* Re-use of software developed for systems based on the same stack (e.g. INSPIRE)

#### Increased efficiency

* Different depending on time-frame, particularly number of dev/review cycles and scale of the initiative
* Consistent process is costly to set up, but cheap to repeat.
* first one is expensive, subsequent modelling activities are cheaper
* update and maintenance is incremental, rather than by replacement
* new products are transparently related to existing products
* Shifting the costs profile of geospatial supply chains
* Building capacity
* improved design, transparency, community engagement
* maintenance, migration
* Efficiency and costs are dependent on role

##### individual agency

* modelling process helps data owners understand and audit own data to understand how their data and systems need to change
* provide opportunity to desing products to meet use case
* reuse of concepts

##### Community

* How domain needs to change - road maps
* Re-use of concepts

##### Cross community

* Common concepts and approaches – time and referece
* Design patterns – handling topoliogy
* Learning
* Resue of concepts

FSDF stakeholders and data specification benefit matrix

#### model derived documentation

* Auto gen of doc
* Feature type catalog
* HTML Views of the model
* Linked data definitions - emerging semantic web

### Blockers

* Classic infrastructure dilemma – costs are born by the party who has least incentive, but who wants a society where everyone has a private army?
* ‘tragedy of cost-benefit allocation’
* Costs
* Change
* Lack of skills
* Economy of scale in Australia - fragmentation

## Experiences from countries that are not Australia ☺

### INSPIRE

* worth reflecting on INSPIRE and its approach to modelling
* section 4.5 Estimated costs and benefits of midterm review
* from INSPIRE mid term evaluation section 4.5 of INSPIRE report

“There is little doubt that the [data spec] measures put in place by INSPIRE are complex, but no alternative could be identified in order to achieve the interoperability objective. Whilst the actions related to interoperability are appropriate, further modifications might be taken into consideration in order to enable further benefits. The high complexity of this field of action is additionally identified as an issue by the ongoing maintenance process (INSPIRE MIF). Possible modifications — as suggested by the public consultation — are improved communication and secondly reflections about possible reduction of the technical complexity. One area where additional measures may be needed is to ensure that the Member States deposit and share the data models (including underlying use cases) they are detailing for individual applications. In this way they can be reused across Europe, ensuring that the interoperability achieved at the general level is not lost at the detailed one. Furthermore, European funding could represent powerful levers to ensure cross-border data interoperability, which implies that this topic is included”

### GEOSS

Broker solution appears to be sustainable because of limited # suppliers

But also seen as ‘bootstrapping’ – i.e. create a unified supply to trigger development of clients, which will then stimulate providers to feed the clients directly. At which stage the broker can fade away.

### oneGeology

Existing, highly coherent community (geology)

Common technology (WMS, WFS)

Primarily successful at WMS – with standard colour schemes.

WFS much less so – GeoSciML complexity

Would not have succeeded without long-term commitment from a small number of agencies (NRCan, GA, AzGS, BRGM, BGS) and highly committed inidivuals (Geologist are such dags!)

### NEIM

# FSDF modelling process

## Setting the scene (aka modelling jargon buster)

Perhaps the most critical aspect of data specification is data modelling. This section provides an overview of the FSDF modelling process. A more detailed description of the modelling methodology has been provided in a separate document.

* Multiple levels - abstraction
* Balancing supply and demand
* Concurrent activity
* Multiple roles in modelling – levels of skill and engagement points

Figure Modelling levels of abstraction and types of models

## The modelling process

reference - Geospatial Information Modelling for Interoperable Data Exchange - Application Schema Modelling: From Concept to Implementation <http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=5693905>

The following figure provides an overview of the modelling process

Figure Overview of the FSDF modelling process

### Requirements and use cases

* Critical step to ensure the right product is produced
* Often paid scant attention but the use cases directly determine the fitness of purpose of a dataset for use
* Assumptions need to be confirmed and new ways of solving challenges can be addressed if effort is put in to an analysis of what data product are actually required

### explore existing data provision and design

* Do not automatically reverse engineer unless the product is perfect.
* Recognise that existing products reflect authentic uses cases best practices and community agreement.

### Analysis: Modeller - Domain expert dialogue - resulting in true conceptual model

Generates a true conceptual model

### Develop a logical model

* From conceptual model to logical model and bring concepts and relationships into the ISO191xx framework
* ISO Identify components for reuse from across the ISO standard suite e.g. CRS , geometry
* ISO Identify reusable patterns e.g. feature have geometries
* Identify and review domain content models
* Need to document models reviewed and reasons for rejection or discounting.

### Test the logical model

* Test by creating a physical model and instances using existing data. Two options:
* Create a physical model representing the whole logical model
* Create physical model for subset of logical model for priority use case. This is a product model

### Test the physical models

* Can you generate a data document/file/table /graph (depending on the delivery environment) from the physical model
* Is it useful? - compare against use case. Both existing product implied use cases and new use cases.

### Developing the FSDF common model

## Data delivery/deployment

* Models are increasingly used to support the delivery of data via OGC web services
* Detailed description of the role of data models in data delivery is beyind the scope of this document
* However this section may articulate a few strategies for delivery

## Data model publication

* Publication – models as downloadable desing patterns
* FTC
* Linked data

# The data specification framework

## Overview

The preceding sections of this report have presented the rationale for modelling, together with a description of the modelling process as part of the broader data specification process. This section describes the requirements for an FSDF data specification framework (FSDF-S), together with the proposed framework. The following section provides recommendations for implementation of such a framework.

The FSDF data specification framework FSDF-S is intended to support the long term development and maintenance of a suite of foundation data products. Practically, it provides the ability to:

* Capture and model user requirements for data products;
* Document current data products;
* Unambiguously define and document concepts, relationship and classifications used within and across domains (FSDF themes);
* Design and implement new products meeting articulated requirements, using agreed concepts;
* Support gap analyses between ‘as is’ and future state for spatial products; and
* Support evolution of a suite of interrelated products.

The framework of models defines key standards for the FSDF. These include ISO TC211 standards (and parts thereof) used in the FSDF initiative; standardised concepts and relationships within domains (FSDF theme standards); and standardised application schema for FSDF products including data exchange schema. As such, it represents a critical component of a national spatial information infrastructure that can potentially be used to support communities and activities beyond the FSDF.

Modelling is a critical step in the data specification process, which incorporates product design,…….. Defining the data production process i.e. implementing models, is touched on lightly in this document as the document is primarily focussed on the modelling processes. Models developed through the framework are likely to be utilised in a variety of data production contexts. These may range from an ad hoc process for a data product developed by a single organisation, or a more formal process defined by the FSDF to meet the needs of an FSDF theme or other defined set of stakeholders.

### ISO 19135 - a Governance Model

Conceptually, the framework is based upon the ISO 19135 Standard - Procedures for Registration of Geographic Items ([ISO 2004](#_ENREF_4)). This standard articulates: the use of registers (or lists); registries (the systems that manage these lists); defined roles to establish and manage registers; and a registration process to manage the registration of items[[6]](#footnote-6). A register contains metadata about registered items such as their status, approval date and authority together with a reference to the artefact that has been registered. This metadata enables the objects being described to be managed, discovered and used to achieve common goals.

Each register is established and it’s are managed by a register owner. Optionally, the role of register manager can be delegated to another organisation. Submitting organisation (i.e. those able to submit content for inclusion in the register) are authorised by the register owner. The register owner can optionally appoint a control body to decide on submissions.

Figure ISO 19135 governance roles

Repositories are typically used to store registered items. Registers can reference the location of a registered item, or can provide both a registry and repository functions, enabling access to registration metadata and the registered items themselves.

### Key components

The framework comprises three inter-related components:

1. Interconnected suite of models – (information view point?) - interconnected suites of models that define foundational spatial data and the way in which it is used
2. Modelling tools and processes (technology computation and deployment viewpoints)– the tools, systems and components used to create, access and exploit models.
3. Model governance (enterprise view point?) – the roles, processes and rules and mechanism to govern models throughout their entire lifecycle from creation, publication, use and retirement.

Figure Overview of the FSDF model framework

These components are articulated in more detail in the next sections of the document

### Change and modularity

## Framework requirements

* **Open** - provide open access to FSDF models to enable modellers and other users to access and use models to support data product development, delivery and use
* **Efficient** - deliver improved efficiency in the geospatial supply chain, by enabling modellers to discover and reuse models to develop foundation products that meet user community needs.
* **Foundation –** support the development and delivery of foundation spatial data as a coherent suite of interoperable products
* **Federated** - enable the governance of modular interrelated models under federated governance
* **Flexible** -provide a flexible framework enabling different approaches to the development and governance of models.
* **Sustainable -** ….
* **Transparent and accountable governance**  of models through their entire life-cycle. Model governance should reflect and facilitate broader FSDF and spatial community governance arrangements and the federated governance of spatial information resources
* **Effective change management** toaddress continual change in inter-dependent models and drive the development of improved products that meet new requirements and exploit emerging technology paradigms.

## **Framework use cases**

A use case model for the model framework is presented in… below. The framework meets both modelling and model exploitation use cases (shown in blue) and supporting model governance use cases (shown in red).

In this diagram, use cases are presented in a logical sequence running from top to bottom.

Modelling and model governance are separate but inter-related process. A description of the modelling process is provided in section 4.5 and of the governance process in section 4.6



Figure FSDF model framework use cases

## The FSDF model suite

### structure and hierarchy

The FSDF model suite comprises a hierarchy of inter-dependent models. Independently governed models are inter-related within the FSDF framework to achieve interoperability (based on ISO TC211 standards) and harmonisation between foundation data within and across themes.

**Core Model**

**Role** – standardise FSDF wide concerns. These include, modelling process definition, the spatial and temporal coordinate systems and any other dimension of data to be standardised across the FSDF, and any metad models or design pattern that can be applied across theme.

**Structure** – core models are arranged in the following hierarchical package structure

* Context models
* Logical model – FSDF metamodel and reusable design pattern for foundation data
  + Key aspects
    - Identity foremost
    - Multiple versions
    - Topology
    - Associated geographies for each version
    - Flexible metamodel.
  + Has been tested and current data products including flat file structures such as shapefiles can be readily transformed into this structure
  + Provides important target for and potential to realise ambitions

**Current status** – to date thematic logical models have been developed for the administrative boundary theme and the place names theme.

**FSDF Thematic models**

**Role** - defines the user requirements and use cases, key concepts and relationships for the domain (FSDF Theme).

**Structure -**  thematic models are arranged in the following structure

* Requirements Model
  + Use cases and other requirements that guide the development of thematic models
  + provides an opportunity to revisit assumptions about what is actually required to meet use cases for theme data without jumping into product design. For example in the context of addressing understanding the real use cases for addressing beyond the delivery of mail.
* Conceptual Model – abstract definition of the key concepts in the language of the domain
* Logical Model The thematic model that defines the as well as individual data products. concepts and relationships

**Product models**

**Role** - models for foundation datasets within a theme. Both as is and future state models can be developed. data models are developed within a theme a

**Structure** – a data product package is located within the theme package. A separate package is used for each foundation product. Sub-packages package can be configured into sub-packages in accordance

* Contents - Currently product models have been developed for:
  + Administrative boundary theme topology product (future state) – Adminsitrative Bodunary Theme
  + National gazetteer product (as is) – Place Names theme
* alone based on different feature types with no reuse of feature types. In other case there may be reuse of feature types e.g. Admin boundaries implemented to support different use cases e.g. a product showing In other cases the

Application schema – developed from product models – stored where??

ISO models – Hollow World

### dependencies between models

Dependencies between models will be documented using – dependencies, imports

* ISO to core
* ISO to thematic logical models
* Thematic logical models to thematic logical model
* Thematic logical model to product model
* Product model to application schema

## Modelling process and tools

### Actors

**FSDF modeller** - modellers create, edit and (re)use FSDF models as part of the FSDF data specification process. Modellers include:

* FSDF core team modeller - responsible for developing core FSDF models; providing technical support, guidance and setting best practice for FSDF modelling efforts; providing review of FSDF models developed within FSDF themes.
* FSDF theme modellers - responsible for developing and maintaining models within an FSDF theme
* FSDF product modellers -responsible for developing FSDF product models in conformance with FSDF theme models

**FSDF data product developer** - product developers implement FSDF product models to develop and deliver products to end users. Product developers typically work within or contracted by organisations that are custodians of the FSDF product under development.

**FSDF data product user** - product users utilise documentation generated from models describing FSDF products.

A modelling guide being developed in conjunction with this report will provide a detailed description of the modelling process. The following sections provide an overview modelling environment and

### Use cases

**Create/edit FSDF model** – this use case is concerned with enabling the community of FSDF information modellers to create an federated, interdependent set of FSDF core, FSDF theme, and FSDF product models. This use case is further discussed in section….

**Use model** – model users access and use the published models to inform development of new and refinement of existing models. Use model use case includes the application schema and product documentation generation use cases.

**Generate application schema** – database and product developers use published models to generate application schema for FSDF products.

**Generate documentation** – FSDF product users access product documentation (feature type catalogue) generated directly from the model. Documentation will be provided in machine readable formats.

### the federated model development environment

Within the FSDF model framework, modelling occurs at three scales with differing operational and governance contexts:

* FSDF core modelling - models owned by the FSDF sponsor (ANZLIC) and developed by the core modelling team;
* FSDF theme modelling - models owned by FSDF theme sponsors[[7]](#footnote-7) and produced by designated theme modellers; and
* FSDF product models – models for specific products developed by or on behalf of FSDF data custodians.

The first two scales of modelling operate outside of individual organisational environments. ANZLIC governs the FSDF environment and thus sets rules and procedures for modelling. Theme sponsors are responsible for theme modelling. Although a number of organisations act as theme sponsors, it is anticipated that a common approach to developing thematic models will be developed under the auspices of ANZLIC.

FSDF product modelling will typically be performed within the operational the governance context of the organisation that acts as custodian for the data being modelled. Modelling may need to conform to architecture and standards set by the data custodian.

Given the federated, complex interrelated nature of the models and their governance, a registry is required to provide a means of publication of and access to models

### modelling tools

* Any tool can be used to support modelling process
* Any tool can be used. However EA is recommended as has connect with registry and models are under development

### Model registry

* Why and what

### Applciation scema generation tools

## Model governance

### Overview

* Complex inter-related overlapping governance contexts.
* Need to be addressed to enable a coherent apporacj Governance brings coherence
* Data specification governance leverages overarching FSDF governance

### Actors

**Register owner** -register owner is responsible for creating registers (and subregisters) and the management, dissemination and intellectual content of those registers. This includes, determining whether submitted content should be published in the register, authorisation of submitting organisations, appointing control bodies and delegating the register manager role to another organisation.

**Submitting organisation** – organisations authorised by the register owner to submit models for inclusion in the register.

**Control body** - optionally a register owner can appoint a control body to review submitted models and advise register owner to accept reject or request modification of the submitted model.

**Registry manager** – responsible for operation of the FSDF model registry and supporting the creation of registers.

### Use cases

**Manage registry** – this use case relates to the establishment and management of the model registry (and potentially other registries) to enable governance of and access to models. The entails deploying, operating and administering the registry.

**Create and manage register** - this use case relates to the creation and administration of registers by the register owner. It includes: establishing registers; assignment of roles and the management of permissions for submitting organisations and optionally control bodies for its registers; creating sub-registers and delegating responsibility to register owners.

**Submit model** – this use case is concerned with submitting to the register an FSDF draft model for review and eventual inclusion in the FSDF framework. The model is accessible only to register owner and control body at this stage. Register owners are responsible for identifying and authorising submitting organisations.

**Review and adjudicate** – register owner (optionally appointed control body) reviews submitted model and determine whether to accept, reject or request modification of the submitted models. Model is reviewed for conformance with ISOTC211 standards, coherence in relation to existing FSDF models (FSDF standards), and FSDF modelling guidelines and best practice

**Reject/request modification of model** – a submission is rejected or a modification requested based on review.

**Publish model** – register owner publishes approved model in the register as an FSDF standard, making it publically accessible.

### Register arrangments

Within the FSDF it is anticipated that there will be a core FSDF register, containing models that relate to the entire FSDF initiative, are owned by the FSDF sponsor, and a register for each FSDF theme.

Hierarchical registers…

# Model framework implementation

## Current status

## Recommendations

Shortened forms

Glossary

**Application schema** - A set of conceptual schema for data required by one or more applications. Application schemas are information models for a specific information community. ([Open Geospatial Consortium 2015](#_ENREF_10)). See also - information model

**Control body** - group of technical experts that makes decisions regarding the content of a register ([ISO 2004](#_ENREF_4))

**Data (product) specification** - detailed description of a data set or data set series together with additional information that will enable it to be created, supplied to and used by another party. ([ISO 2008](#_ENREF_6))

**Data specification framework** – a framework of governance, processes and tools that supports the development and management of data specifications for a suite of data products.

**Domain** - an area of knowledge or activity. In the governance context domain refers to extent of control of a governing authority([Merriam-Webster 2015](#_ENREF_7)) (e.g. ruler, government, decision authority).

**Domain of discourse** -…….. ISO

**Feature** - Abstraction of a real world phenomenon. "A digital representation of a real world entity or an abstraction of the real world. It has a spatial domain, a temporal domain, or a spatial/temporal domain as one of its attributes. ([Open Geospatial Consortium 2015](#_ENREF_10))

**Feature Type** - …([Open Geospatial Consortium 2015](#_ENREF_10))

**Feature (Type) Catalog** - Catalog containing definitions and descriptions of the feature types, feature attributes, and feature relationships occurring in one or more sets of geographic data, together with any feature operations that may be applied. ([Open Geospatial Consortium 2015](#_ENREF_10))

**Federated** – independent entities (organisations, political or territorial units) joined in an alliance (federation), ceding some powers and decision authority to the federation level while retaining control and decision authority for local matters (i.e. over its own territory or organisation operations).

**FSDF** – Foundation Spatial Data Framework

**Geospatial** - Referring to location relative to the Earth's surface. "Geospatial" is more precise in many GI contexts than "geographic," because geospatial information is often used in ways that do not involve a graphic representation, or map, of the information. ([Open Geospatial Consortium 2015](#_ENREF_10))

**Geography Markup Language (GML)** – OGC`s XML-based language for describing and encoding geospatial information. An application of XML, a specification developed by members of the Open GIS Consortium. http://www.opengis.org/techno/specs/00-029/GML.html ". GML is an XML encoding for spatial data. In a sense, it is a schema-writing language for spatial information.([Open Geospatial Consortium 2015](#_ENREF_10))

**Governance –** a framework of ‘authority structures’ and processes, by which communities manage their collective affairs through a continuous process of negotiation and decision making.The framework enables the creation and operation of mechanisms, processes and rules designed to reconcile the diverse needs and interests of a community, to steer individual and collective initiatives of stakeholders to achieve agreed, collective goals ([Box 2013](#_ENREF_3)).

**Harmonization** – of standards: activities undertaken by communities of experts to align standards. For example, to define common metadata and application schema from legacy sources, harmonization will consider: -- Architecture - multiple viewpoints that capture high level requirements, use cases, scenarios, information flows and computational flows. -- Data modelling - definition and UML encoding of feature type, attribute type, data type, coding, dependency mapping -- Schema modelling - UML mapping and encoding to GML, mapping of profiles to one another, and delineation to service types -- Iteration and development - build a little, see if it works, build more- -- Delivery to standards organizations for approval.([Open Geospatial Consortium 2015](#_ENREF_10))

**Information community** - A collection of people (a government agency or group of agencies, a profession, a group of researchers in the same discipline, corporate partners cooperating on a project, etc.) who, at least part of the time, share a common digital geographic information language and common spatial feature definitions. ([Open Geospatial Consortium 2015](#_ENREF_10))

**Information Infrastructure** – interconnected systems with interwoven social and-technical components including information supply chains, institutional arrangements, standards, and technology. See also: Spatial Data Infrastructure, System of Systems.

**Information model**  – a representation of the concepts and relationships for a particular ‘domain of discourse’.

**Interoperability**

1. - the capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units ISO 2382-1. "The ability for a system or components of a system to provide information portability and interapplication, cooperative process control. Interoperability, in the context of the OpenGIS Specification, is software components operating reciprocally (working with each other) to overcome tedious batch conversion tasks, import/export obstacles, and distributed resource access barriers imposed by heterogeneous processing environments and heterogeneous data." ([Open Geospatial Consortium 2015](#_ENREF_10))

2. - the ability to transfer and use information in a uniform and efficient manner across multiple organisations and information technology systems ([Australian Government Information Management Office (AGIMO) 2006 p. 3](#_ENREF_2)).

**Model Driven Architecture (MDA)** - an approach for deriving value from models and architecture in support of the full life cycle of physical, organizational and I.T. systems[[8]](#footnote-8). The MDA approach represents and supports everything from requirements to business modeling to technology implementations. ([Object Management Group 2014](#_ENREF_8))

**Ontology - …**

**Register** - set of files containing identifiers assigned to items with descriptions of the associated items. hierarchical register - a structured set of registers for a domain of register items, composed of a principal register (that contains a description of each of the subregisters) and a set of subregisters that contain items from a partition of a domain of information. ([ISO 2004](#_ENREF_4))

**Register manager** - organization to which management of a register has been delegated by the register owner. ([ISO 2004](#_ENREF_4))

**Register owner** - organization that establishes a register ([ISO 2004](#_ENREF_4))

**Registration** - assignment of a permanent, unique, and unambiguous identifier to an item ([ISO 2004](#_ENREF_4))  
Registry - information system on which a register is maintained ([ISO 2004](#_ENREF_4))

**Registry manager** – a person or an organization responsible for the day-to-day management of a registry ([ISO 2004](#_ENREF_4))

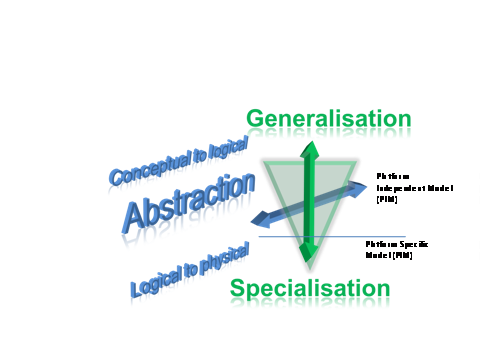
**(Geo)Spatial data infrastructure (SDI/GDI)** – a (geo)spatial data infrastructure *is a collaborative, approach to creating, maintaining, providing and using distributed geospatial resources under heterogeneous ownership and operation, to meet common information needs (*[*Box 2013*](#_ENREF_3)*)*

**Standard** - a documented agreement between providers and consumers, established by consensus, that provides rules, guidelines, or characteristics ensuring materials, products, and services are fit for purpose. ([OGC 2014 p. 5](#_ENREF_9)).

**Submitting organization** - organization authorised by a register owner to propose changes to the content of a register ([ISO 2004](#_ENREF_4))

# Modelling ontology

The following describes an inter-related set of terms related to modelling. They are presented below together with a diagram to explain their inter-relation



**Abstraction** - a conceptual process of reducing the information content of a concept or an observable phenomenon, typically to retain only information which is relevant for a particular purpose.  "An abstraction" is the product of this process—a concept that acts as a super-categorical noun for all subordinate concepts, and connects any related concepts as a group, field, or category.([Wikipedia 2015](#_ENREF_11)) . See also ‘level of abstraction’

**Level of abstraction** -

**Platform Specific Model (PSM)** -

**Platform independent model (PIM)** -

**Generalisation** -

**Specialisation** -

**Requirements model** -

**Conceptual model** –

**Logical model** -

**Physical model** -

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1. <http://www.anzlic.gov.au/foundation_spatial_data_framework> [↑](#footnote-ref-1)
2. The term ‘[geospatial](#Geospatial)’ is used throughout this document to refer to both geographic data i.e. data that relates to locations on the Earth’s surface and to ‘spatial data’ that describes the relative position of objects in space. [↑](#footnote-ref-2)
3. <http://www.isotc211.org/> [↑](#footnote-ref-3)
4. Australian Hydrological Geospatial Fabric (AHGF) and other modelling activities in the hydrology and geosciences domains and more broadly (e.g. OGC Observation and Measurements), [↑](#footnote-ref-4)
5. Costs of data collection are excluded from this analysis which only compares the costs of design, production and delivery of spatial products. [↑](#footnote-ref-5)
6. Although ISO 19135 refers to registration of geographic item it can and has been used as model for registering a range of different resources including such things as models and vocabularies. [↑](#footnote-ref-6)
7. At the time of writing this report Theme sponsors are Intergovernmental Committee on Surveying and Mapping (ICSM), Bureau of Meteorology, Australian Bureau of Statistics and the Department of Communications. [↑](#footnote-ref-7)
8. A “System”, in this context, is any arrangement of parts and their interrelationships, working together as a whole. This is inclusive of designs at all levels such as an entire enterprise, a process, information structures or I.T. systems. [↑](#footnote-ref-8)