APPENDICES

STRATEGIC PATHWAY 4: DATA

APPENDIX 4.1: Data Theme Description Template

The following template is an example of a Data Theme Description for the New South Wales (NSW) Data Framework Administrative Boundary Theme in Australia (NSW, 2013).

Name	Administrative Boundaries Theme
Description	The Administrative Boundaries theme is a collection of legislative, regulatory, political, maritime and general administrative boundaries sourced from local and state boundary datasets.
Datasets	Parish County Suburb Local Government Area State Electoral District State Border
Purpose	The Administrative Boundaries theme is used to visualize administrative areas that represent voting districts, redistributions, zoning, socio-economic analysis, regional planning, service distribution and local and state government boundaries. In addition, Administrative Boundaries can also be used to aggregate information for analytical purposes and geographically stable boundaries (over time) can be used to establish and analyze time series trends. Administrative boundary data in combination with geo-coded address data, demographic information and agency specific business information underpins the ability to perform high quality spatial analysis. The aggregation and analysis of data includes: Evidence-based development and assessment of government policy Providing the ability to undertake spatial accounting Regional analysis for government, health, education, business and a range of other purposes Support for emergency management Market catchment analysis, micromarketing, customer analysis and market segmentation Emergency management.
Status	Within the database, the position of feature instance will be within the feature's reported value for 90% of the well-defined points. The position of the feature instance will be within 0.5mm at map scale for 90% of the well-defined points. That is, based on the scale of the source documents, the positional accuracy of the cadastral points will be 1:500 = 0.25m, 1:2000 = 1m, 1:4000 = 2m, 1:25000 = 12.5m, 1:50000 =25m and 1:100000 =50m. Quality assurance/conformance testing and reporting of the data accuracy, completeness and consistency to the defined specification is required. The datasets in this are updated daily as a component of the DCDB update process.
Standards	Metadata for the relevant LPI datasets complies with AS/NZS ISO 19115 ANZLIC Metadata Profile v1.1 and 19139 National Mapping Council of Australia, Standards of Map Accuracy (1975).
Version	Version 0.5

APPENDIX 4.2: Data Inventory Questionnaire

The following is an example of survey questions for a Data Inventory Questionnaire. It can also be used to conduct an inventory of Standards.

The survey aims to gather detailed information on datasets acquired [by organization]. (Duplicate this table for each dataset)

Dataset	
Dataset Name	
Name of Custodian	
What is the data used for?	
What other organizations use/rely on this dataset?	
Contact	
Point of Contact Name	
Point of Contact Position / Title	
Point of Contact Details (Email, Phone)	
Coverage	
What area does the data coverage?	
Is there an index of data coverage [Yes/No]?	
What is the coordinate system for the Data?	
Data Resolution / Scale	
What is the resolution of the data (e.g. scale)?	
Data Accuracy	
What is the horizontal accuracy of the data?	
What is the vertical accuracy of the data?	
Data Lineage	
Describe the source(s) from which the data was derived and the method(s) used.	
Data Attribute Accuracy	
What is the accuracy of the attribute values within the data?	
Data Logical Consistency	
How is data logical consistency managed (e.g. topology rules)	

Data Currency	
How current is the data (e.g. date of production or last maintenance?	
How frequently is the data updated?	
Data Quality Assurance/Control	
Processes used to validate the data e.g. field check, accuracy evaluation)	
Data Format	
Is the dataset paper or digital?	
If digital, what format is the data in (tabular form, CAD, GIS or Other)?	
Provide more information about the format type (i.e. Spreadsheet, Access Database, AutoCAD, ESRI, Design file, etc.)	
Are there any standards the data complies with [Yes/No]? If Yes, name the standards.	
Data Dictionary	
Do you have a data dictionary [Yes/No]?	
Data Storage	
How is the data stored (e.g. sheets (individual files) or seamless database]?	
What type of storage systems is used?	
Estimate the size of the data (in Megabytes).	
Metadata	
Is there metadata at the dataset level (Yes or No)?	
If Yes, is the Metadata (digital or paper based)?	
If Yes, does the metadata comply with a standard (e.g. ISO 19115, ISO 19115-2)?	
Do you have metadata at the feature level (Yes or No)?	
If Yes, describe what metadata is stored.	

Data Accessibility	
Do you have the Intellectual Property rights for your data (Yes or No)?	
If No, who / what organization holds the rights?	
If No, is the data restricted from access in any way?	
How is data shared internally, and what standards are used (e.g. web services - WMS, WFS, file-transfer)?	
If the data is not restricted are you willing to share the data with others (i.e. externally) (Yes or No)?	
If Yes, how is data shared/transferred and what standards are used (e.g. web services - WMS, WFS, file-transfer)?	
If Yes, is the sharing for free or at cost?	
If at Cost, what is the fee?	
Policy and Legislation	
Is there policies/legislation addressing the collection or sharing of this data (Yes or No)?	
If Yes, list and describe the Policy / Legislation.	
Data Sensitivity	
Open access takes precedence over restricted access unless there are specific, compelling reasons to restrict access (True or False)?.	
Is the dataset considered Sensitive (Yes or No)?	
If the dataset is considered sensitive, which best defines its sensitive nature (multiple choices allowed): 1. Privacy issues 2. Commercial sensitivity 3. National security 4. Environmental sensitivity 5. Sensitivity explicitly defined in a policy, legislation or regulations	

If the dataset is considered sensitive, how is the sensitivity best managed (multiple choices allowed): 1. Sensitive data is generalized/aggregated so as not to compromise any sensitive issues. 2. Controlled access guidelines are used in cases where sensitive information is in the public interest 3. Access restrictions are documented in metadata records	
Alternative / Duplicate Datasets	
Are you aware of any other organization that produces a similar dataset (Yes or No)? If yes, please provide the Organization name/Contact Person	

APPENDIX 4.3: Dataset Profile Template

The following is an example of a Dataset Profile Template for the NSW Data Framework Administrative Boundary Theme - Parish dataset (NSW, 2013).

Description	Parish depicts the boundaries of 7383 areas formed by the division of 141 counties. It is a polygon feature class within the NSW Digital Cadastral Database (DCDB). Parishes are divided into separately disposable parcels called 'portions', these being the common basic units of land disposed of by the Crown. Other basic units are allotments in government towns and villages.
Datasets Uses	Land and Property data underpins the economic, social and environmental fabric of NSW and is used, amongst other things, to: • Secure tenure for access to capital • Define allowable use of land • Manage Native Title, Nature Conservation, Heritage Protection, Defence, and Disaster Management • Improve infrastructure and property development planning.
Current Status	The Parish is a historical layer and the information was gathered from original paper maps which were held by LPI. They can however be updated (if necessary) after a manual title inspection. The Parish dataset is up to-date and complete state wide. Coincidence with the cadastral fabric is maintained where required and the spatial accuracy of the Parish dataset reflects that of the cadastral fabric. The attributes 'create date' and 'modified date' provide information on the features' temporal accuracy. There is no overall accuracy reported in the database. Any changes that occur to the dataset should have a reference in the authority of reference feature class in the DCDB.
Standards and Specifications	Metadata for the relevant LPI datasets complies with AS/NZS ISO 19115 ANZLIC Metadata Profile v1.1, ISO 19115-2 and ISO 19139. AS/NZS ISO 4819:2011 National Mapping Council of Australia, Standards of Map Accuracy (1975).
Access and Licensing	Land and Property Information (LPI), a division of the Department of Finance and Services creates and manages intellectual property (IP) for the Crown in right of New South Wales. Shared IP rights may reside in the data and in this circumstance specific terms and conditions will be included in the data. LPI has placed its copyright notice on the data and appears in the following manner: 'Land and Property Information (a division of the Department of Finance and Services) year'. Acquisition of this data is subject to the customer entering into an appropriate license agreement. Unless stated in the license, the data always remains the property of the Crown in right of New South Wales as managed by Land Property Information (LPI). Unless otherwise stated in the license agreement, the data is licensed for the internal business use only, excluding any commercial exploitation, by the Licensee and its employees and agents.
Data Theme	**Parish**
Update Strategy	The dataset is complete, modifications are rare.
Custodian Agency and Contact	Land and Property Information, Manager, Spatial Data Services, 346 Panorama Ave Bathurst NSW 2795
Data Curator i.e. Aggregator(s)	Land and Property Information
Distributor(s)	Same as Custodian

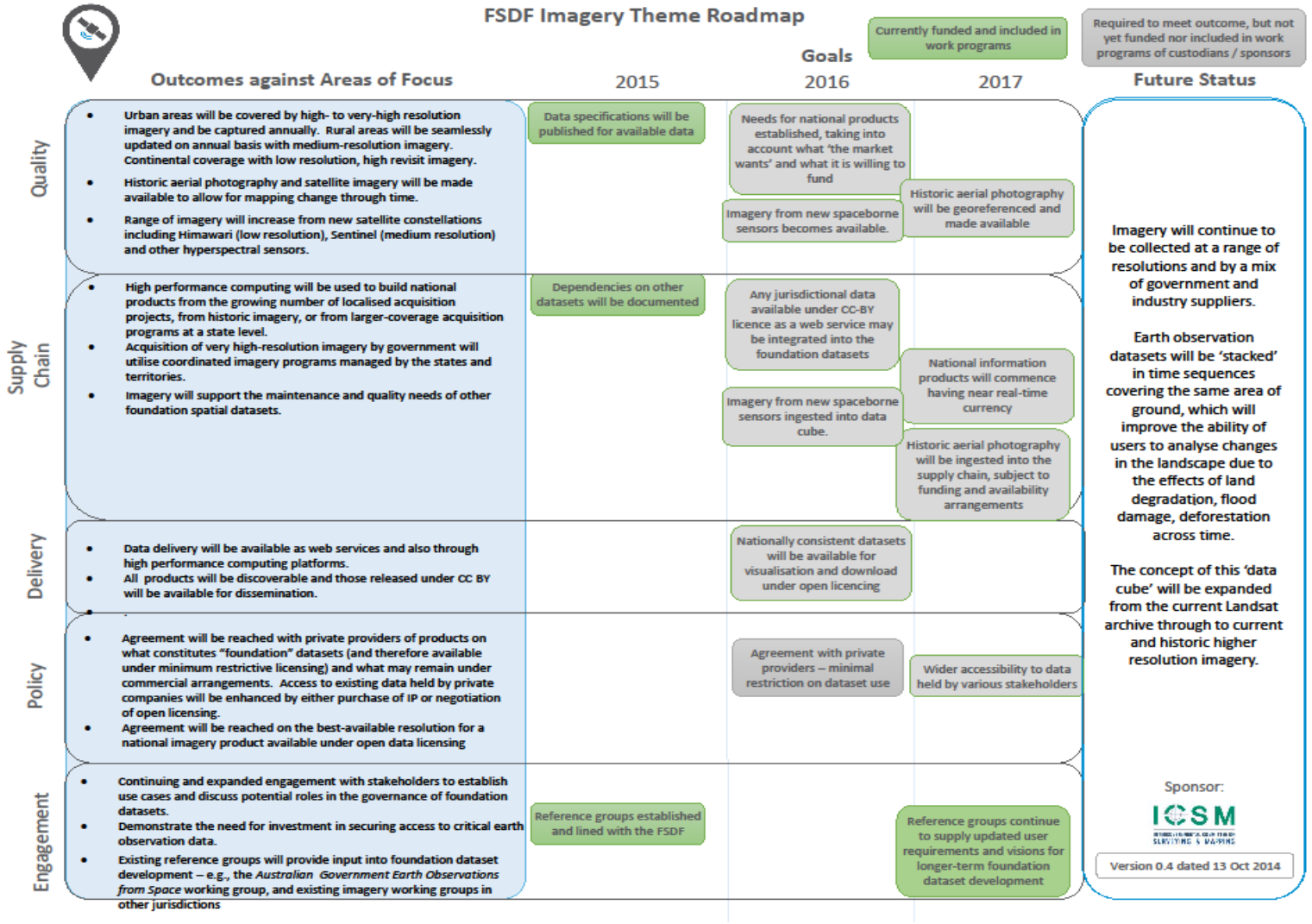
APPENDIX 4.4: Gap Analysis Matrix

The following table is an example of a Gap Analysis Matrix.

Current Situation	Desired Future State	Gaps in Capability (Challenges)	List of Actionable Strategies
Example: The nation has significant data holdings that are adequately maintained but there is a lack of information on urban infrastructures, particularly dwellings.	Example: A high-quality representation of the landscape.	Example: A building footprints dataset that can be used to understand potential economic loss from exposure to natural hazards.	Example: Investigate cost effective automated image interpretation and change detection methods to capture the location of existing buildings and identify new buildings as they are constructed.

APPENDIX 4.5: Data Theme Road Map Template

The following is an example of a Data Theme Road Map Template produced by the Intergovernmental Committee on Surveying and Mapping for the Australian and New Zealand Location Information Council (ANZLIC). The example is for the Imagery Theme.



APPENDIX 4.6: Principles of a Data Custodianship Policy

Principle 1: Trusteeship

Custodians do not 'own' data but hold it in trusteeship on behalf of the community.

Under this principle, custodian agencies become the trustee not the owner of the information held in their databases. This results in an emphasis upon cooperation in sharing information amongst agencies rather than competition.

Principle 2 - Standard setting

Custodians are responsible for defining appropriate standards and proposing them for national ratification.

The setting of standards to determine how the information will be collected, described and used is the most important commitment that an agency makes when agreeing to become a custodian. Custodians must seek input from users to assist in defining appropriate standards for information in their custody, and propose standards for national ratification. These include standards for access, collection, classification, description, accuracy, quality, format and structure of the information.

Principle 3 - Maintenance of information

Custodian agencies must maintain plans for information collection, conversion and maintenance, and these plans should be developed in consultation with users.

Custodians should liaise with the SDI Steering Committee, SDI sub-committees, SDI Office, users and any other affected parties, such as national sponsor, when making any significant information management or dataset changes, so that the impact upon users can be assessed.

The custodian agency is also responsible for negotiating the terms and conditions under which other agencies collect and maintain the geospatial information on its behalf.

Principle 4 - Authoritative source

The custodian becomes the authoritative source for the fundamental or thematic dataset in its care.

In acting as the authoritative source, the custodian agency becomes the preferred supplier of this information. This lessens confusion for users and overcomes the accuracy and reliability problems that may be encountered when supposedly identical information is held separately by several agencies, where several agencies contribute information to a common database, or where information provided by different agencies is combined.

By virtue of its development and maintenance plans the custodian is also likely to have more current information than other agencies.

As the agency responsible for setting the standards, the custodian is also in the position of being able to advise users on the source, currency and completeness of the information.

Principle 5 - Accountability

The custodian is accountable for the integrity of the data in its care.

A custodian may delegate any or all of its responsibilities for a dataset in its care to another agency. It will, however, still remain accountable for the integrity of the dataset.

Principle 6 - Information Collection

Collection and/or conversion of information is to be justified in terms of a custodian's business needs.

Custodians are not expected to collect or convert information for which they have no business requirement. Collection must be justified in terms of their own needs. These will generally reflect either the agency's strategic priorities or statutory responsibilities.

If other agencies require further information to be collected, they can either;

wait until the custodian can justify the collection/conversion;

contribute the required resources to the collection/conversion of the information by the custodian;

contribute to a submission by the custodian for more funds for the collection/conversion of the required information; or,

collect/convert data themselves.

If an agency collects or undertakes work on any geospatial information which is under the custodianship of another agency, it must do this according to the custodian's standards and provide the custodian agency with a copy free of charge and according to an agreed transfer standard. The custodian will then be responsible for future maintenance of the data.

Principle 7 - Maintain Access

A custodian must maintain access to the fundamental or thematic datasets in its care at the highest level for all users.

A custodian must support end user access to the datasets for which they are responsible. This includes access to updated information at an agreed interval.

APPENDIX 4.7: Data Governance Roles and Responsibilities

The following roles and responsibilities are typically included in an organization's Data Governance Framework.

Role	Responsibility
Executive Sponsor	• Sets strategic direction and delegates data governance responsibilities. • Provides overarching governance for the Data Program. • Has ultimate accountability for the data and compliance with regulations, policies and standards. • Advocates on behalf of internal teams and stakeholders and funds the Data Program.
IT Steward	• Responsible for communication of data across systems, standardised data definitions, formats, profiles, data structures and system architecture and maintenance. • Implements system security – e.g. locks down data, secures data from unauthorised access and/or use.
Data Steward	• Delivers strategic goals and enforces data governance policy. • Responsible for end-to-end data lifecycle management and oversight, and seeks value from data. • Is responsible for stakeholder engagement and recommends quality and process improvements in line with operational and customer needs. • Is responsible for risk management and escalates issues.
Data Custodian	• Manages data release according to classification and guidelines. • Responsible for master data management, metadata management, data integration, curation and data validation. • Responsible for data model designs. • Manages corporate data stores and implements data security and secures data from unauthorised access/use. • Puts data governance policy into practise and implements business rules. • Conducts solution and issues management.
Subject Matter Expert (SME)	• SME with authority over a particular domain of knowledge. • Creates and enforces standards, technical specifications and regulatory compliance. • Uses data to perform a job or create a product. • Defines data release classification and documents descriptive metadata. • Validates drawings, design, reports according to standard/technical specification. • Develops training materials. • Archives data in document management system.
Data Producer	• Is an internal officer or external consultant that produces information. • Creates, updates and acquires data according to a standard/specification. • Verifies content, and stores data in a staging area.

APPENDIX 4.8: Data Management Plan Elements

The following elements are typically included in a Data Management Plan for the collection and production (and coordination of the collection and production) of geospatial information and related statistics.

KNOWLEDGE

Data Description- A description of key data sources and the nature and scale of data that will be generated or collected in the future

Formats – Explanation of how data will be generated, maintained and made available, including procedural and archival appropriateness of those formats.

Standards – A description of existing standards and a discussion on the alignment of data standards across systems where required.

Intellectual Property Rights Management - Entities or persons who will hold the intellectual property rights to the data, and how IP will be protected if necessary. Any copyright constraints (e.g., copyrighted data collection instruments) to be noted.

Metadata - A description of the metadata to be provided along with the generated data, and a discussion of the metadata standards used.

SECURITY

Storage and Backup - Storage methods and backup procedures for the data, including the physical and cyber resources and facilities that will be used for the effective preservation and storage of the research data.

Archiving – The Information Security and Privacy Policy and Procedures, decisions regarding retention of data collections to be met by data custodians.

Security - A description of technical and procedural protections for information, including confidential information, and how permissions, restrictions, and embargoes will be enforced.

CUSTODIANSHIP

Responsibility - Names of the individuals responsible for data management and their role. Data custodianship guidelines to support roles and responsibilities.

Maintenance – Specification of data update frequency in line with quality standards and end-user needs.

Data Curation – A model for effective data lifecycle management describing the collection, maintenance, preservation of data in a way that adds value to the department's digital resources.

QUALITY

Data Quality – The guidelines that maximize the currency and quality of data, the assignment of quality ratings to ensure that it is used appropriately, and data quality reporting processes.

Data Validation – A system that facilitates data providers to check and validate their data against a set of validation rules to ensure data of the highest quality possible**.**

ACCESSIBILITY

Access and Sharing - A description of how data will be shared, including access procedures, embargo periods, technical mechanisms for dissemination and whether access will be open or granted only to specific user groups. A timeframe for data sharing and publishing.

Data Release – A classification system for the release of information usually specifying access, licensing, pricing and conditions related to use.

APPENDIX 4.9: Checklist for Creating Metadata

The following checklist can be used to help an organization identify what is needed to create compliant metadata. (Adapted from the Victorian Spatial Council Spatial Metadata Guidelines (Victorian Spatial Council, 2009)).

Decide who will create the metadata or 'catalogue' resource.

Decide whether its creation will be centralized or decentralized within the organization.

Ensure that appropriate metadata management systems and procedures are in place and are adequately resourced.

Make sure involved staff are adequately resourced and properly trained, and that they have access to the necessary standards and guidelines and "help" facilities.

Decide how the metadata is to be stored and how it is to be accessed and displayed.

Select a metadata entry tool that best meets the organization's needs.

Decide on the appropriate level for the individual documentation of resources. The resources should be documented with sufficient "granularity" to yield a useful result when a user discovers the metadata record via a searching mechanism. Too coarse a granularity will result in too generalized result, too fine a granularity is likely to overwhelm the user with too many choices.

For each resource, enter the minimum set of metadata elements (elements that are either mandatory or become mandatory under certain conditions). Completion of this minimum requirement will provide a baseline metadata record, referred to as core metadata (see below). Additional elements that will enhance the description of geographic data sets are particular for discovery. This set of metadata, comprising the minimum metadata for geographic

In addition to the core, the Profile encompasses a large number of other elements that may be used to describe resources in more detail. Completing these elements can aid a range of uses including evaluation of the resource's fitness for purpose, and enabling applications to discover and transact directly with a resource. ANZLIC encourages completion of as many metadata elements as possible in order to better describe the resource.

In general, the overall effort put into creating the metadata record for a resource should be consistent with the significance of the resource and with the stage of the resource's "life cycle".

Carry out agreed quality assurance processes and ensure proof of compliance to the Profile using the validation process specified in the Profile.

Place the metadata in the agreed store, and ensure that the metadata can be accessed and displayed.

On an ongoing basis, ensure that the metadata is adequately maintained and kept up to-date.

APPENDIX 4.10: Data Release Guidelines

The following is an example of Data Release Guidelines for an organisation.

1 Principles

Principle 1: Open by default

A. We accept that access to and re-use of geospatial information held by [Organisation] is of significant value to society and the economy.

B. We will orient our organization towards open data by default and have clear and ethical application and release processes.

C. We recognise that data and value added information are both important components of an open access environment.

D. We will respond to user expectations and will publish and provide data in an open way by default whilst recognizing that there are legitimate reasons why some data cannot be released or re-used.

E. We will be clear about which geospatial information can be supplied free and circumstances where a charge will be made.

Principle 2: Trusted and authoritative

A. Our values of excellent customer service and professionalism will be maintained as we progress towards open access.

B. We will select and prioritize information for release that is of a high quality and will consult to enable us to understand and respond to the needs of other users.

C. We will describe the geospatial information that is available to help consumers to understand its strengths, limitations and completeness.

D. Where possible the source of our geospatial information will be advised, and where multiple sources are involved, this will be disclosed.

E. We will respond in a timely way to requests and to an extent possible, provide comprehensive and accurate data that is in a usable format and in line with user needs.

Principle 3: Accessible and discoverable

A. When releasing geospatial data, we aim to do so in a responsible way that will increase the interoperability of data from different perspectives.

B. In order to improve its application geospatial information will be accompanied on release by documentation that includes an appropriate level of metadata that provides insight into the logic used to derive the product.

C. To avoid misuse, we will be clear about how geospatial information can be used and reused and whether or not rights can be transferred to third parties.

Principle 4: Responsible of respective rights

A. We acknowledge our responsibilities to our [Country] in ensuring our intellectual property rights are respected internally and externally.

B. We respect the rights of others that may involve individual privacy, intellectual property and copyrights.

C. We will provide for the security of confidential information.

D. We support the use of licenses or other release instruments that are not unnecessarily restrictive and promote the re-use of data for non-commercial or commercial purposes.

1 GUIDELINES

Guideline 4.1 Clearly defined roles and responsibilities

Within {Organization] there will be defined roles and responsibilities in relation to implementing and maintaining the Data Release Policy.

Guideline 4.2 Geospatial information is managed according to a standard

To the maximum extent possible, all data and metadata will adhere to agreed formats, conventions, and standards so that our information can be readily exchanged and easily analysed.

All geospatial information will be archived, preserved, stewarded, and accompanied by metadata that will ensure they will be fully usable and understandable in the future.

Guideline 4.3 Category assessment to be independent and impartial

Over time all types of our geospatial information will be categorized to facilitate the implementation of this policy.

These categories will form the Data Release Framework. At a strategic level, decisions will be made about the number and purpose of categories and how data will be assessed and assigned.

{Organisation] operates under various legislative provisions that impact on the way we deal with content. There may be conditions for restricting release of geospatial information such as that of a confidential nature. There may be provisions requiring that charges apply to information released.

Category assessment to be independent and impartial. Decisions about categorizing data for release will be made on the merits of each case and an assessment tool will be developed to ensure impartiality. The over-riding concern is to release data for community benefit.

Decisions about whether to release data under the Data Release Policy are not to consider the financial implications of the decision. Financial implications will be part of a separate decision that determines whether data is to be provided free of cost and establishes a schedule of fees and charges where these are to be applied.

Guideline 4.5 Fees and Charges will be publicised

A schedule of fees and charges under the Data Release Policy will be adopted annually and published.

Guideline 4.6 Data to be released under an approved licence

Data custodians will release content according to a license type approved under the Licensing Framework. The choice of license will consider external user needs, and Intellectual Property Rights.

Data custodians are encourage to adopt a Public Domain Licenses. However, specific licenses may be used for particular geospatial information, particularly where third party data are a component.

Guideline 4.7 Adopt Creative Commons Licensing Framework

We will move towards implementing a Creative Commons Open Access and Licensing Framework, which has been endorsed by our Government.

Guideline 4.8 Content to be released so it can be readily used

Geospatial information is to be released in a format that is usable and be accompanied by appropriate metadata.

Geospatial information will comply with [Organisation] specified quality standards and, where feasible, will be made available to external users online as the preferred delivery method. If online methods are not available then email, counter transactions, post/courier services will be used.

Guideline 4.9 The release of content to be traceable and staff accountable

Data release methods will function in a way that enables traceability in order to:

A. Emphasize the importance of governance in the data release process
B. Minimize the risk of a policy breach
C. Meet the [Organisations] obligations under the Privacy Act when dealing with Personal information.
D. Create a privacy and security aware culture within the workplace

Guideline 4.10 Data Release Process

The Data Release Process considers the release of geospatial information from the perspective of data custodians and is enacted once a ‘request’ for data and/or information is received.

When a request is received the Data Custodian considers if adequate metadata are available as this metadata is to accompany the geospatial information to be released.

The custodian then assigns a release category for the content and identifies if fees and charges apply.

If an appropriate creative commons license is not suitable, the Data Custodian consults with the Legal Office to develop a license to meet a specific need. The Legal Team considers or not there are intellectual property or privacy considerations that require explicit terms.

Once the license is determined, the content can be prepared for release to the end-user. All content should be accompanied by appropriate metadata.

External users must agree to the conditions or license under which the data are released before receipt of goods. This should be actioned by signature on a license or other traceable method.

APPENDIX 4.11: Guidance for Improving Geodetic Infrastructure

The following provides guidance for countries who are needing to determine and establish national geodetic infrastructure, and/or improve existing geodetic infrastructures.

The importance of the Global Geodetic Reference Frame (GGRF)

On 26 February 2015, the United Nations General Assembly adopted resolution 69/266 on 'A global geodetic reference frame for sustainable development'. Since then the UN-GGIM Sub-Committee on Geodesy (SCoG) has been established and has delivered a GGRF Roadmap[1] and Implementation Plan[2]. These documents set out five key focus areas – Geodetic Infrastructure; Policies, Standards and Conventions; and Education, Training and Capacity Building underpinned by Governance; and Outreach and Communication (Figure 4.11.1).

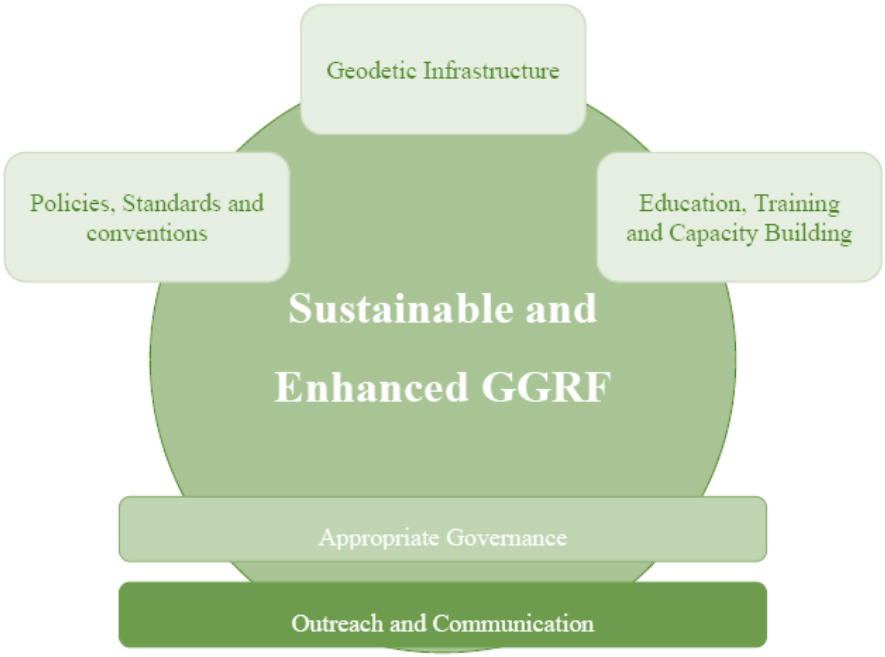


Figure 4.11.1: *GGRF Road Map (UN-GGIM, 2018)*

All of the above initiatives, to improve existing geodetic infrastructures, either leverage and/or support the strategic goals of the GGRF. It is recognised that the GGRF is a collaborative effort and no one country can achieve it alone. The GNSS CORS network is one component of the GGRF that can deliver considerable and tangible benefits, as it is not only plays a significant role in the derivation of the GGRF, it also provides the means of efficiently accessing the GGRF. The global GNSS CORS infrastructure is currently not evenly distributed and this means that the derivation of the GGRF is weakened in regions where the network is sparse.

[1] *http://ggim.un.org/meetings/GGIM-committee/documents/GGIM6/E-C20-2016-4%20Global%20Geodetic%20Reference%20Frame%20Report.pdf*
[2] *http://ggim.un.org/meetings/GGIM-committee/8th-Session/documents/Road-Map-Implementation-Plan.pdf*

GNSS CORS have demonstrated their importance in providing nations with a valuable tool to support natural disaster mitigation and recovery (climate change, earthquakes, flooding, tsunamis etc) and can provide additional impetus to the funding business case. Further value can be derived by nations with ocean boundaries when GNSS CORS are collocated with tide gauges to monitor and measure changes to the land mass adjacent to the tide gauge – i.e. is the sea level rising and/or is the land 'sinking'.

Another advantage of GNSS CORS is they are relatively low maintenance, when constructed with quality components and with a reliable source of power and communications. Once installed and configured they can operate autonomously.

There are well established data centres that can process the data for GGRF analysis and commercial real time positioning service providers that will potentially deliver a positioning service to users, thereby maximising the value and usage of the infrastructure. Only GNSS CORS constructed to a high standard with sound foundations can be multifaceted in supporting the GGRF, scientific studies and the user community.

Capacity building is another core aspect of the GGRF, and nations should strive to build and 'maintain' their expertise in all operations of their geodetic infrastructure. Whilst the processing of data from CORS may initially be outsourced to an established data and analysis centre, the long-term aim is to have more redundancy in the processing of data and as more sites are constructed, more processing capacity will be required.

The GGRF capacity building mandate means that there will be many more opportunities to participate in geodetic seminars and workshops. Nations need to nominate appropriate staff members to attend these sessions wherever possible and ensure that the knowledge gained is shared and able to be put into practice upon completion. These sessions will not only provide practical and operational skills, it will also build a collaborative network of specialists to support the ongoing knowledge journey.

Countries should also undertake a gap analysis to understand what skills, knowledge and resources are needed to progress their aspirations for a modern, functional and sustainable geodetic infrastructure to support and underpin their entire geospatial catalogue. This information should be fed back through to the SCoG to assist in the development of future training initiatives. The SCoG has already identified the need for regionally focused training strategies as the nature, size and variety of challenges differ regionally and may include linguistic, technological, economic and cultural impediments.[3]

Under the GGRF focus area of Policies, Standards and Conventions, data sharing is a key concern. In the context of the GGRF, data sharing in mainstream applications primarily relates to GNSS, gravity and tide gauge data. Data sharing needs to be undertaken in full consideration of licensing, quality, liability, authority, and security issues, while at the same time respecting local and national legal and policy frameworks[4]. The benefits of data sharing are wide ranging and include improvements in the GGRF at the global scale as well as improvements at a local scale based on the origin of the data.

[3] http://ggim.un.org/meetings/GGIM-committee/9th-Session/documents/E_C.20_2020_7_GGRF.pdf
[4] http://ggim.un.org/meetings/GGIM-committee/8th-Session/documents/Road-Map-Implementation-Plan.pdf

Adopting international standards ensures shared data can be used and consumed readily without modification. One simple task that can be undertaken to support data exchange is to register a country's coordinate reference system in the ISO Geodetic Registry[5]. This public database aims to catalogue details of international coordinate systems and transformations and over time will become a valuable resource for spatial data users.

The Communication and Outreach component of the GGRF is crucial in raising the profile and awareness of the importance and value of the GGRF in supporting sustainable development and policy making. As a fundamental infrastructure that underpins all spatial data, the GGRF and local geodetic systems are completely under-rated by the wider community. They do not understand the complexities and investment, in time and resources, that makes the spatial system work. The challenge is to enlighten the decision makers at every opportunity to encourage continued and sustainable investment in this significant and critical resource.

The SCoG has identified gaps in the GGRF infrastructure as well as needs in terms of capacity, education and training in delivering and maintaining geodetic infrastructure and has a mandate to deliver 'a GGRF for sustainable development'. Nations are encouraged to support this initiative in whatever form or capacity it takes to grow the global network of high-quality geodetic infrastructure and highly trained personnel to achieve this aim.

- **Develop a Geodetic Strategy:** To inform government and industry stakeholders as well as raising the profile to decision makers of the importance and value of a modern geodetic system, now more than ever, to support the new paradigm of positioning technology and the economic benefits it will bring.
- **Review and Update Legislation, Regulations, Standards and Guidelines**: To be reviewed in collaboration with industry and government stakeholders to support a modern geodetic and cadastral framework.
- **Establish and/or Densify and Maintain a CORS Network:** To support a higher level of positioning accuracy for both post processing and real time positioning. Such networks provide an improved understanding of earth dynamics, crustal deformation and tectonic motion and provides the vital link to the GGRF. Earth dynamics enable precise survey information to be shifted in time to account for movement of the earth with respect to the frame, a core requirement for legal surveys in some regions. Suitable CORS may potentially be included in either regional reference frames e.g. Asia Pacific Reference Frame (APREF), African Geodetic Reference Frame (AFREF) and/or the GGRF. It is important to consider Public/Private Partnership opportunities, such as commercial real time CORS networks where the user-pays for subscription-based services.
- **Digitize All Hardcopy Geodetic Records:** Protects historical records from loss and enables accessibility to a wider user base. Publish geodetic mark information online to ensure all users have access to this information.

[5] ISO Geodetic Registry is available at https://geodetic.isotc211.org/

- **Undertake an Audit of Current Geodetic Infrastructure:** Includes physical infrastructure, associated data and capacity (human resources) to fully understand current and future requirements. Analyze data by considering if it is correct, complete and current and has appropriate metadata. E.g. a coordinate or height without an accuracy statement and associated datum is of little value. Consider using crowd sourcing to gain information on the location and condition of geodetic marks – a form of geocaching, successfully used in the Australia, UK and USA. Understanding capacity in terms of suitably qualified and experienced personnel is critical to supporting a modern geodetic framework and future training needs. Crowd-sourcing may also be used to facilitate rapid positioning through sharing of local atmospheric information with others.
- **Improve Datum Infrastructure Management** – This requires a program of work to relate all marks at the local level to the highest accuracy network of CORS sites. The program involves a structured process of GNSS field campaigns, rigorous processing of observations and rigorous network adjustment. The hierarchy system of relating local level marks directly to CORS sites is represented in the Figure below that illustrates an Australian Case Study.

- **Achieve Legal Traceability for commercial GNSS service provision**: The advent of commercial GNSS real-time services in some nations has raised concerns about traceability of the resulting position information to the national datum. In Canada, a voluntary compliance program has been introduced to validate commercial network coordinates and to monitor station stability. Results of this

monitoring are shown on a publicly accessible government website. Some legislative actions have been implemented to require use of compliant services for land surveys.

- **Achieve Legal Traceability**: This requires the support of a legislative framework for legal metrology and a delegated authority to administer the Act, Regulations, Standards and Guidelines. It can be applied to measurements of length by electronic distance measurement instruments (EDMI)/total stations and for position by GNSS CORS. In some nations there is a well-established methodology for attaining legal traceability for length by establishing physical calibration baselines that are measured with EDMI that are certified against an established and legally traceable standard for length. Calibration of an EDMI is undertaken to prescribed standards and processes in order to achieve certification for legal traceability. The current trend to use GNSS for all measurements is making the establishment of EDMI calibration baselines obsolete, however it also complicates the legal traceability process as there are significant components of the GNSS measurement process that cannot be easily standardized. Legal traceability of position for GNSS CORS can be achieved by complying with a rigorous methodology to establish and maintain a reference standard for position with oversight and regular auditing by the delegated authority. This reference standard of position of GNSS CORS can then be used as the reference stations to define a datum.
- **Upgrade the Datum through Modernization:** With the advent of GNSS there is now a greater impetus to modernize geodetic datums and in this process there is an increasing trend to use a global reference frame and a geocentric ellipse that aligns with GNSS. This negates the need for complex transformations between localized datums and is in anticipation of centimeter accuracy real time GNSS positioning being available to the mass market on mobile devices. Given that existing geospatial data holdings often are in older datums, a thorough understanding, and an accurate transformation methodology are required to relate localized datums to the GGRF. Ultimately, to maximize the benefits of accurate positioning afforded by GNSS, a modern geodetic datum is required, but it is understood that transformation of existing data holdings is costly.
- **Height Modernization:** Datum Modernization also includes Height Modernization and whilst the GGRF can deliver three-dimensional coordinates, for practical management of water the height component needs to incorporate effects related to the Earth's gravity field rather than a mathematical ellipse. To achieve this, a thorough understanding of the current height datums and their origin is required. If there are multiple height datums (e.g. terrestrial and or hydrographic/chart datums) then a means of correlating them is highly desirable. Relating the height datum to chart datums and to a reference ellipse is facilitated by use of a geoid model. Geoid accuracy benefits from this relationship with sea-level and other information. Geoid modelling typically incorporates airborne and terrestrial gravity data, GNSS observations on ground marks with local height values, CORS stations collocated with tide gauges and other information. Ultimately, the GGRF will include the development of an International Height system at a defined geopotential value which will support transformations between local height datums and the IHRF.

APPENDIX 4.12: Guidance for Geospatial and Statistical Integration

The following provides guidance for countries who are needing to determine means to implement the Global Statistical Geospatial Framework and what steps may need to be undertaken. The steps typically undertaken to integrate geospatial and statistical data are as follows (Figure 4.12.1):

1. **Develop a Strategy:** Bring focus and provide clear direction to the Geospatial and Statistical Data Integration Initiative through a common vision, mission and goals. This will guide the development and achievement of targets as a whole.
2. **Establish a Working Group:** To direct, communicate and oversee the strategy and plan for integrating geospatial information and statistics data, as well as to formalize the relationships between participating agencies through agreements, and foster an institutional environment for collaboration and cooperation through the implementation of policy, guidelines, standards and common processes. The working group will typically report to the Geospatial Steering Committee (See SP1: Activity 1.6.1) and interact closely with the Geospatial Coordination Unit (See SP1: Activity 1.6.3).
3. **Identify the Key Stakeholders**: Data producers and users, decision makers etc. (See SP9: Activity 9.6.3).
4. **Identify the Available Resources:** Statistical and administrative data is typically available from National Statistics Organizations (statistical units, and social, economic, demographic, agricultural, environmental and census statistics etc.). Geospatial information is typically available from National Mapping Organizations (administrative boundaries, addresses, transport, water networks, elevation data, satellite imagery and topographic data, etc.). (See Section 4.6.2 for how to conduct a data inventory).
5. **Specify Policy, Standards, Guidelines and Norms:** Policies, standards, guidelines and norms are required to support the utilization, access, analysis and visualization of integrated geospatial and statistical information including terms of use agreements, data release policies (See Section 4.6.15), privacy policies, data standards to enable interoperability and guidelines for the security of information. In addition, it is necessary to elaborate on the technical norms and regulatory agreements related to the standardization of the geographical elements to be represented. These policies, standards, guidelines and norms are best addressed and implemented at a national level and where possible, are to be compliant with international laws and common practices.
6. **Develop the methodology:** Develop the methodologies and procedures that standardize the collection, generation and maintenance of data, both geographic and tabular:
    - **Address**: Use a standard for the collection and assignment of addresses nationwide to effectively capture the address label and physical location.
    - **Coding**: Establish coding classifications for disaggregation into spatial entities, such as government administrative boundaries or census areas.
    - **Verification:** Implement address verification at point of address data entry (for computer-based capture/mobile applications) to better manage and maintain data quality and reduce time spent on data cleansing.
    - **Georeferencing**: Align geographic data to a known coordinate system so it can be analyzed, viewed and queried with other data.
    - **Geocoding**: Adopt common geocoding practices at the national level.

- **Quality**: Specify a quality model and measures for both geospatial and statistical data.
- **Retrieval**: Establish an effective method for storing and managing integrated geospatial and statistical data files so that they can be automatically updated and retrieved without the need for reprocessing.
- **Linking**: Evaluate open source, bespoke and COTS services for connecting data, with consideration to the OGC Table Joining Services standard[6].
- **Make data accessible -** Use standard services (WMS and WFS) to serve data and distribute results over the Web

Figure 4.12.1: *Steps for integrating geospatial and statistical data*

[6] A simple way to describe and exchange tabular data that contains information about geographic objects. See https://www.opengeospatial.org/standards/tjs