Fundamental Geospatial Data

May 2017

Title	Fundamental Geospatial Data	
Objective	Propose Fundamental Geospatial Data at Pan American level	
Abstract	The concept of Fundamental Geospatial Data relates to the common denominator of all the datasets of thematic geographic information. These datasets ares used to enhance most applications, to improve interoperability and thus to increase and make more efficient the use of spatially-referenced data.	
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Proposal for Fundamental Geospatial Data

(Working Document)

Introduction

In the year 2013, the Permanent Committee on the Spatial Data Infrastructure for the Americas (CP IDEA), as it was then, stated that framework data (sometimes known as "base cartography" or as "fundamental", "main" or "reference" data) are the sets of uninterrupted and completely integrated spatial data that provide a context and reference information in a Spatial Data Infrastructure (SDI). There is a tentative and flexible separation between the framework data and the thematic data (that is, data specific to particular applications), in which the framework data is sometimes used as a base for presenting the thematic data. Often, there are varying interpretations about what constitutes the framework or infrastructure layers, and sometimes the thematic layers become fundamental layers as demand from users shows that they are required generally. Classifying any kind of data as framework or fundamental data is normally subject to its availability in the major sectors where the SDI undergoes development, and to the consensus that exists between the main parties interested, about the importance of the data (Permanent Committee on the Spatial Data Infrastructure for the Americas, CP IDEA, 2013).

At the same time, it indicated that framework data functions as the main "anchors" for the development of integrated data sets used in the processes of compiling data, reports and analyses. The framework data provides an important part of the "interoperability" of systems on the Internet. One of the reasons that explains the importance of interoperability is the fact that it reduces the time required for converting the data, thus allowing more time for the important activities of analyzing and presenting information. Interoperability also enables organizations in various situations to more easily share and exchange information or, instead, it allows work to be done on joint projects. The use of shared framework data facilitates the breakup of the "information silos" which often impede the performance of spatial information projects that organizations put into effect and which are required for dealing with the challenges of ever-more complex horizontal policies (CP IDEA, 2013).

The fundamental reason for standardizing the layers of the framework consists of improving its usefulness and facilitating its interoperability. The adoption of shared standards applied to the framework data not only improves capabilities for integrating or analyzing data, it also reduces the potential for duplication in creating and maintaining data in the various organizations. The key aspects of the fundamental data may be expressed in the way that the Global Spatial Data Infrastructure - GSDI – declared in the year 2009:

- Layers defined in the digital spatial data with specifications for the content
- Procedures, technology and guidance that enable the integration, exchange and use of this data
- Institutional relations and practices at work which encourage the maintenance and use of the data.
- Definition of the layers of fundamental data
- Decisions about the content of the framework data.

Normally the framework data takes one of the following three forms:

- *Alignment layers*: visible features such as road intersections, the content of images and the control points required for adequately positioning the spatial information; here the layers are critical for the reliability and use of all the other layers.
- *Layers of relief and terrain features:* portrayals of natural or artificial and physical features, easily observable, clearly distinguishable and not susceptible to interpretation, including features that are visible on topographic maps and cartographic applications on the Internet, such as Google Maps. For example, roads, rivers, and major structures (which may serve as reference information for the conceptual layers); or
- *Conceptual layers:* frameworks that society develops and uses for describing and managing the country. Often these layers are derived from observation of the physical, economic or social factors, and include features such as municipal boundaries, federal electoral constituencies and ecological zones.

One may adopt one of several methods to decide which layers or themes will be included in the framework data of the SDI. In many countries, the SDI initiative is led by the National Cartographic Organization (OCN, its initials in Spanish) which historically has undertaken responsibility for developing the program of topographic cartography. In these cases, the OCN can determine the composition of the infrastructure data based on the experience of the respective country and on the creation and distribution of the data from the base maps base. The layers are integrated by the datasets from the digital base cartography or an associated subset. Alternatively, the OCN may seek a consensus with a wider community of parties involved in the SDI about the layers to include.

In other cases, the creation of framework data may be through a cooperative effort between the OCN and other important providers of the data (for example, cartographic organizations at the level of states, provinces and municipalities). In this case, a consensus is reached among the participants committed in relation to the data layers to include. Additionally, data from other reliable sources (for example, public services and data providers in the private sector) is sometimes integrated with that of the respective infrastructure. This method complies with the principle that data should be collected only once, very close to the source where it was created and shared with many people.

An important part of the definition of the framework data layers is the determination of the specifications to apply for creating and maintaining this data, as it has a highly significant impact on the suitability of the framework data to be the base for the thematic data within an SDI and on its interoperability. The publication of these specifications helps to assure a level of accuracy, identification of sources and authors and quality and documentation of the framework data. Moreover, it allows users to trust in the legitimacy of the data.

Standardization in the sphere of Fundamental Geospatial Data (FGD)

The fundamental reason for standardizing FGD is to improve its usefulness and to make its interoperability easier. Adopting shared standards applied to them not only improves capabilities for integrating or analyzing that data, it also reduces the possibilities for duplication in the creation and maintenance of the data in various organizations.

ISO TC 211 contributes to the global specification of models for content and to FGD models through the standards ISO 19109:2005 for "Geographic Information —Rules for application schema", ISO 19110:2016 – "Geographic Information — Methodology for feature cataloguing", and ISO 19131:2007Amd 1:2011 "Geographic Information — Data Product Specifications – Requirements related to the inclusion of an application schema and feature catalogue, and the treatment of coverages in an application schema".

- ISO 19109 provides rules for defining application schema - *a formal description of the structure and content of the data required by one or more applications*, including principles for classifying geographic objects and their relations with that schema.
- ISO 19110 provides a framework for organizing and classifying geographic features contained in the application schema and its operations, attributes and associations.
- ISO 19131:2007/Amd 1:2011, intended to be used by producers, suppliers and potential users of the FGD, provides practical aid in defining the requirements that a data product should fulfill in terms of the application schema for which it was conceived. The 1:2011 amendment strengthens it by adding to its content the application schema and its corresponding catalogue of geographic objects.

These standards are especially critical for the FGD because they provide a basis for the SDI. Moreover, the adoption of shared data models helps to facilitate the interoperability of the data.

Essential aspects of the FGD

- As one of the foundations for SDI, the FGD fulfill an important function in their contribution to ensuring interoperability in the respective infrastructure. Key considerations include: the data layers to be chosen, the procedures, technology and guidance information that enable the integration of the data, the shared access and use of data, also the institutional relations and practices at work and in the business that encourage the maintenance of data.
- The choice of the FGD layers depends on the circumstances; nevertheless, normally the national cartographic organization manages this task alone or in conjunction with other producers of key data, on the basis of assessments of the needs of users.
- The publication of product specifications for the FGD is understood to be a precise technical description of the data product in terms of the requirements and scope that it should or can fulfill: level of accuracy, quality, documentation and identification of sources and authors. Nevertheless, the data product specification only defines how it should be; the metadata performs the task of describing how the product really is, once it is materially set up.
- Continual maintenance of the FGD is a major consideration. The way to handle this depends on the circumstances and on the way in which responsibilities for the custody of the data are assigned. Both the centralized and the decentralized models have advantages and disadvantages.

- Those responsible for managing the FGD are exploring the potential for taking advantage of the trend for voluntarily offered geographic information in order to aid in keeping data up to date; however, analyses should be carried out for establishing the credibility, quality and availability at the right time of this data.
- Data models constitute an important means for facilitating interoperability.

Concept of Fundamental Geospatial Data proposed by the PAIGH

The concept of FGD relates to the common denominator for all datasets of thematic geographic information. It is used to enhance most applications to improve interoperability and thus to enable the use of spatial data to grow and become more efficient. It constitutes a shared, basic and essential structure for all types of applications and geographic contexts, and for the most varied fields of application. This concept has as its goal sharing datasets between users, with the objective of facilitating the development of applications. Each item of data may be provided by different suppliers which produce the information in their daily business, including for example managing highways, urban planning, land administration, tax collection, natural resources, environmental management, etc. Although there are many suppliers of data, the datasets provided should be integrated with the purpose of making them into fundamental datasets. Once these datasets are shared among the users, each one of them does not need to be developed, thus avoiding the duplication of efforts.

Thus one can say that the fundamental geospatial data is the geographic data produced for the purpose of serving to geo-reference any other thematic dataset. It provides a neutral and abstract model of reality that serves as a basis for setting up thematic models or models specific to various fields of application. It therefore fulfils the same function as that of basic cartography and is for general purposes. Examples of this type of data are: the system of coordinates, administrative boundaries, transport networks, hydrography, relief, orthophotos, etc. (Sánchez Maganto, 2012).

Uses for Fundamental Geospatial Data:

- Georreferencing thematic data or creating it new, based on an already geo-referenced structure for data.
- Add a geographic context as a background to any dataset, and make it more comprehensible and intelligible.
- Mix or combine several thematic datasets which fit together and are consistent through being based on the same fundamental data.

Moreover, the benefits of the FGD concept will appear more when the time comes to update FGD than when it is created, because it is created by those who produce it through their regular work tasks and updated more frequently. Moreover, the data creators will be able to develop their respective data with much more detail and greater quality, based on the thematic requirements specific to their specialisation; at the same time, this facilitates the process of sharing geospatial data with other users. At national scale, the shared fundamental geospatial data is defined by means of legal agreements within communities, about their content. A variable number of data strata may be considered for shared use and of national and transnational importance as fundamental data.

As a complement to these, one can state that the thematic data are those which are created on the basis of reference data, or, over the basic data is added other data that describes specific and concrete themes that occur on the territory, such as for example geology, tourism, the environment, climatology, etc. (Sánchez Maganto, 2012).

The difference between fundamental data and thematic data can be seen in Figure N° 1.

Fundamental Data

Thematic Data

Figure N° 1: Fundamental and thematic geospatial data
(Source: www.geosur.info)

In accordance with that stated so far, one can deduce the main properties that the FGD should have in order to better fulfill its function and tasks:

- Be unique.
- Be consistent within itself, in such a way that if the fundamental themes of a country or region are overlaid on each other, they fit exactly together and keep to a geometric and topological coherence.
- Be available at various scales, in order to serve as fundamental data for projects of high, medium and low resolution.
- Have the greatest quality possible within the logical and reasonable boundaries of its scale.
- Be updated at logical intervals of time and in a way compatible with its resolution and cost.
- Be aligned with standards, so as to be interoperable and to attain maximum versatility.
- Be sustainable, in such a way that keeping its features and properties stable is guaranteed while producing it.
- Be open data, to increase its possibilities for distribution and for it to fulfill its role very satisfactorily.

Examples of the FGD in the Americas

The data considered to be fundamental in most of the PAIGH Member States and in other environments and projects, such as the INSPIRE Directive in Europe, and in the working groups of the UN-GGIM (which have already produced some lists of themes considered to be fundamental data), has been analyzed for setting up this proposal,.

Country	Geodesic reference framework	Bound-aries	Relief	Topogra-phy	Cadastral	Geographic names	Natural resources and climate
Argentina	x	x	x	X	x	X	
Belize		x		X			
Bolivia		x		X			
Brazil	x	x	x	X		X	x
Colombia	x	x	x	X	x		
Costa Rica					x		
Chile	x			X			
Ecuador	x	x	x	X	x	X	
El Salvador	x		x	X	x	X	
Guatemala	x	x	x	X		X	X
Mexico	x	x	x	X	x	X	X
Panama	x	x	x	X			
Uruguay	x	x	x	X	x	X	

Table N°1: Fundamental data held by PAIGH Member countries
Results of the questionnaire about the status of the national SDI. "*Fundamentos de las IDE"*, 2012
(Source: Permanent Committee on the Spatial Data Infrastructure of the Americas CP IDEA, 2009).

Data included in the integrated maps of the American continent

Also of use as guidance, there is the work performed in the projects for the Integrated Map of Central America (Panama, Costa Rica, Nicaragua, Honduras, El Salvador, Guatemala, Belize and southern Mexico) and the Integrated North Andean Map (Panama, Colombia, Ecuador, Peru and Bolivia) also serve as guidance. This background will also be used in the Integrated Map of South America (Argentina, Chile, Uruguay, Brazil, Paraguay, Bolivia, Peru, Ecuador, Colombia, Venezuela, Guyana, Surinam and French Guinea). The Integrated Maps relate to official geographic datasets that are digital, in vector structure, standardized, continuous and fundamental (or for reference) at a resolution of 1: 250,000 or even larger scale, and cover the countries involved.

Six themes are covered (Administrative boundaries, Hydrography, populated zones, Transport networks, Terrain morphology and Miscellaneous) that contain, in turn, 15 geographic features. Their full description is included in the *Catalogue of geographic objects*. It should be noted that the edges of the geographic object «Country» are approximate, for reference and guidance only and have no official validity, nor value as evidence, in accordance with Chapter I, article 1 of the Organic Statutes of the PAIGH.

The purpose of the Integrated Maps is to provide a fundamental cartography for all kinds of users and all types of applications. This cartography covers the spatial aspects defined by the respective countries, but it is intended to complement and to give continuity to an Integrated Map of the pan-american region.

As a general philosophy, the family of ISO 19100 standards is intended to be used as a reference, always moving towards compliance with the applicable standards. The OGC standards should also be taken into account, as the publication through WMS services has been planned for.

It is considered that these should also be available in the form of a WMS service at the GeoSUR Portal (www.geosur.info) under a CC BY 4.0 licence stated as:

CC BY 4.0 CAF, PAIGH, GeoSUR Program, (participating Geographic Institutes)

These projects have had for themselves the sponsorship of the Latin American Development Bank (CAF), the PAIGH and the GeoSUR program; additionally they have had the technical support of the National Centre for Geographic Information (CNIG) of Spain and of the Geological Survey of the United States (USGS). At the same time, there have been contributions from the PAIGH National Section of the United States through the Department of the Interior (DOI) and the United States Agency for International Development (USAID). This concerns a project that has been a model in terms of institutional cooperation, because the Geographic Institutes of the countries involved have participated in the productive process, in a very positive teamwork environment, based on a methodology of technical workshops, which gives validity to the proposal.

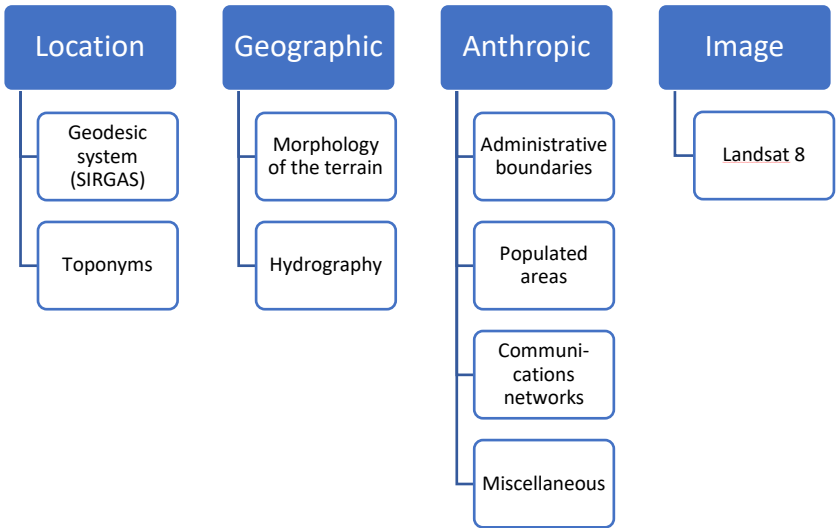

Figure N° 2 Fundamental data in the Integrated Map projects
(Note: the images used in the Project for integrated maps coordinated by the PAIGH have been Landsat 8)

Structure and content

The language of the data is Spanish or castilian (esp) and the character set is utf8.

UML Model

The UML v2.0 model can be seen in Figure Nº 3, which covers the following geometric primitives in accordance with the ISO 19107: 2003 standard:

- GM_Point
- GM_Curve
- GM_Surface

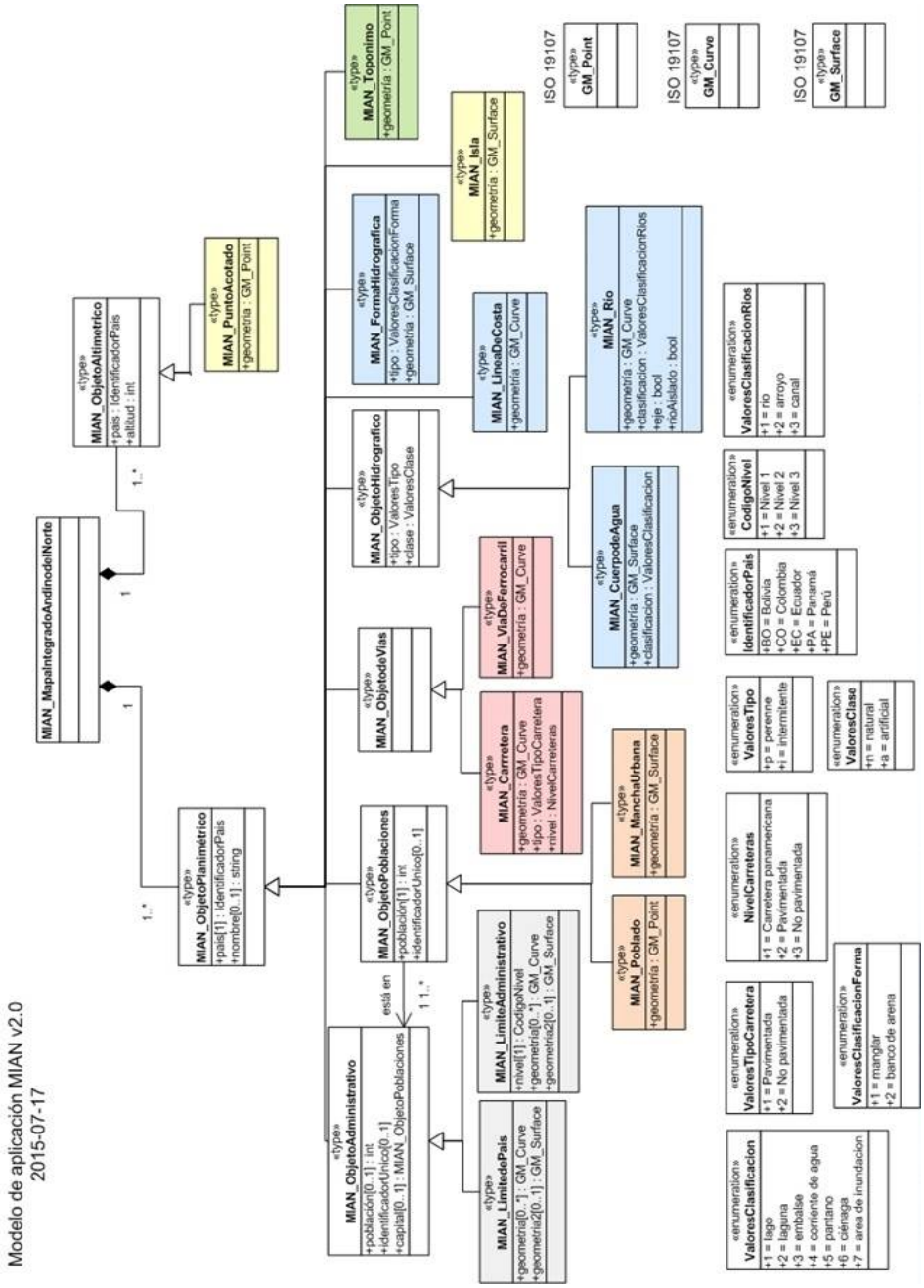

Figure N° 3 UML Model corresponding to the Integrated North Andean Map
(Source: MIAM specifications, available at
https://www.geosur.info/geosur/contents/20160729EspecificacionesMIANv2016.pdf)

Catalogue of Geographic Objects

The *Catalogue of geographic objects* is structured into six themes and 15 objects, just as is shown in Table 2.

Theme	Geographic object
Administrative boundaries	Country, Level 1, Level 2 and Level 3
Hydrography	River, Coast-line, Body of water, Hydrographic forms
Populated zones	Settlement, urbanized zone
Transport networks	Railway, Highway
Morphology	Labeled site, Island
Miscellaneous	Toponyms

Table Nº 2 Summary of the Catalogue of Geographic Objects
(Source: MIAM Specifications, available at
https://www.geosur.info/geosur/contents/20160729EspecificacionesMIANv2016.pdf)

It should be noted that the edges of the geographic object «Country» are for reference and guidance only and have no official validity, nor value as evidence, in accordance with Chapter I, article 1 of the Organic Statutes of the PAIGH.[1] Their purpose is not to portray the official boundaries of each country but to serve as an outline cartographic reference at large scale so that the user can spatially find a location approximately.

Proposal for the Fundamental Geospatial Data of the PAIGH

This proposal takes into account, as inputs, the following:

- The themes considered to be fundamental data in the countries of the American continent.
- The data involved in the PAIGH Americas Global Map initiative (MGA), linked to its counterpart at world level.
- The experience derived from the projects of the Integrated Maps of the Americas
- The conceptual definition by the PAIGH included in this document, which conceives fundamental data as an instrumental resource; so one can say that it has no practical application by itself, rather it serves as a basis for developing all kinds of thematic applications and is conceived to function in geo-referencing data from other themes.

[1] Article 1. The PAN AMERICAN INSTITUTE FOR GEOGRAPHY AND HISTORY is a Specialized Organization of the ORGANIZATION OF AMERICAN STATES, which has the objective of:
1) Encouraging, coordinating and distributing studies in cartography, geophysics, geography and history, also those about related sciences of interest to America.
2) Encourage and perform studies, work projects and training in those disciplines.
3) Encourage cooperation between the institutes for these disciplines in America and with related international organizations.
The Pan American Institute for Geography and History will use the initials "IPGH" (PAIGH).
It will not undertake any task of a political or sectarian nature. On issues that are controversial for the Member States, studies from the PAIGH will not in any case be of value as proof or evidence. The activities of the PAIGH will be, preferably, of multinational interest. The PAIGH will not carry out any task that affects a State.

We consider that the themes making up FGD in a traditional and *de facto* way, as a consequence of the habitual practice of professionals who produce geographic data, are the following:

Name of theme	Comment
Geodesic Reference framework	This is for geo-referencing the rest of the themes; thus one can say that it is the fundamental data for fundamental data.
Relief	Digital Elevation Models (DTM and/or DEM) include under-water relief or at depths, also contours and labeled spot heights, etc.
Administrative units	At various levels and with the hierarchical structure unique to each country, this often (not always) constitutes the geographic foundation upon which a large quantity of thematic data is referenced.
Hydrography	Includes seas, oceans, the coastline[1] and associated features, also related objects made by humans (dams, dykes, containing walls, canals, etc.
Communications networks	Includes all means of transport (by highway, railway, air, sea, cable-car, etc.) and all associated installations
Population	Cities, towns, villages, residential zones and any built features where people live permanently (barracks, hospitals, prisons…)
Cadastral records	Geographic dataset that describes relations concerning rights and obligations between persons and real estate properties. On some occasions, this includes the record of real estate property, depending on the country
Addresses	Including post codes
Geographic names	Although geographic features frequently have their name as an attribute, it is useful to have available a catalogue of geographic names, especially for those features without a clear geometry associated (mountain ranges, sites along a route...)
Images	Ideally as satellite and/or aerial orthoimages.
Land cover	Although this is less useful for acting to geo-reference other data, it can serve as a cartographic backdrop to give context or as surfaces upon which other attributes can be placed.

Table Nº 3 Proposal for themes to be considered as fundamental data

[1] The coast line, in hydrography, serves to indicate the land-sea boundary and the boundary where rivers come to an end. It is shown at various scales and is a physical, imprecise line; it is different from the coastline as a national boundary, which has a precise definition. The latter is used in jurisprudence, consists of a doublé line (lines of extreme low tide and high tide), it is set at a specific scale and is used for creating a series of marine boundaries (200 miles, exclusive zone and others).

All and each one of these themes comply with the two requirements necessary to be considered as FGD:

- They are included in the lists of fundamental data managed in various countries, organizations and projects.
- They are used on a de facto basis to geo-reference other thematic data.

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