

Australian/New Zealand Standard™

Geographic information—Reference model

Part 2: Imagery



AS/NZS ISO 19101.2:2011

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Australian/New Zealand Standard™

Geographic information—Reference model

Part 2: Imagery

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PREFACE

This document was prepared by the Joint Standards Australia/Standards New Zealand Committee IT-004, Geographical Information/Geomatics.

The objective of this document is to provide a reference model for processing of geographic imagery which is frequently done in open distributed manners.

This document is identical with, and has been reproduced from ISO/TS 19101-2:2008, *Geographic information—Reference model—Part 2: Imagery*.

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References to International Standards should be replaced by references to Australian or Australian/New Zealand Standards, as follows:

<i>Reference to International Standard</i>		<i>Australian/New Zealand Standard</i>	
ISO		AS/NZS ISO	
19115	Geographic information—Metadata	19115	Geographic information—Metadata
19119	Geographic information—Services	19119	Geographic information—Services
19123	Geographic information—Schema for coverage geometry and functions	19123	Geographic information—Schema for coverage geometry and functions

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the annex to which they apply. A ‘normative’ annex is an integral part of a Standard, whereas an ‘informative’ annex is only for information and guidance.

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INTRODUCTION

This Technical Specification provides a reference model for processing of geographic imagery which is frequently done in open distributed manners. The motivating themes addressed in this reference model are given below.

In terms of volume, imagery is the dominant form of geographic information.

- Stored geographic imagery volume will grow to the order of an exabyte.
- National imagery archives are multiple petabytes in size; ingesting a terabyte per day.
- Individual application data centers are archiving hundreds of terabytes of imagery.
- Tens of thousands of datasets have been catalogued but are not yet online.

Large volumes of geographic imagery will not be portrayed directly by humans. Human attention is the scarce resource, and is insufficient to view petabytes of data. Semantic processing will be required: for example, automatic detection of features; data mining based on geographic concepts.

Information technology allows the sharing of geographic information products through processing of geographic imagery. Standards are needed to increase creation of products. A number of existing standards are used for the exchange of geographic imagery.

Examples of technical, legal, and administrative hurdles to moving imagery online include

- technical issues of accessibility – geocoding, geographic access standards,
- maintenance of intellectual property rights,
- maintenance of individual privacy rights as resolution increases, and
- technical issues of compatibility requiring standards.

Governments have been the predominant suppliers of remotely sensed data in the past. This is changing with the commercialization of remotely sensed data acquisition. Geographic imagery is a key input to decision support for policy makers.

The ultimate challenge is to enable the geographic imagery collected from different sources to become an integrated digital representation of the Earth widely accessible for humanity's critical decisions.

Currently a large number of standards exist that describe imagery data. The processing of imagery across multiple organizations and information technologies (IT) is hampered by the lack of a common abstract architecture. The establishment of a common framework will foster convergence at the framework level. In the future, multiple implementation standards are needed for data format and service interoperability to carry out the architecture defined in this Technical Specification.

The objective of this Technical Specification is the coordinated development of standards that allow the benefits of distributed geographic image processing to be realized in an environment of heterogeneous IT resources and multiple organizational domains. An underlying assumption is that uncoordinated standardization activities made without a plan cannot be united under the necessary framework.

This Technical Specification provides a reference model for the processing of geographic imagery which is frequently done in open distributed manners. The basis for defining an information system in this

Technical Specification is the Reference Model for Open Distributed Processing (RM-ODP) [78]. A brief description of RM-ODP can be referenced in Annex B. The basis for defining geographic information in this specification is the ISO 19100 family of standards.

The RM-ODP [78] viewpoints are used in the following fashion:

- Typical users and their business activities, and policies to carry out those activities, are addressed in the Enterprise Viewpoint.
- Data structures and the progressive addition of value to the resulting products are found in the schemas of the Information Viewpoint.
- Individual processing services and the chaining of services are addressed in the Computational Viewpoint.

Approaches to deploy the components of the Information and Computational viewpoints to distributed physical locations are addressed in the Engineering Viewpoint.

AUSTRALIAN/NEW ZEALAND STANDARD

Geographic information—Reference model**Part 2:
Imagery****1 Scope**

This part of ISO 19101 defines a reference model for standardization in the field of geographic imagery processing. This reference model identifies the scope of the standardization activity being undertaken and the context in which it takes place. The reference model includes gridded data with an emphasis on imagery. Although structured in the context of information technology and information technology standards, this Technical Specification is independent of any application development method or technology implementation approach.

2 Conformance**2.1 General**

To conform to this Technical Specification, all of the conditions specified for at least one of the conformance classes described below shall be satisfied.

2.2 Enterprise conformance

Any enterprise that claims conformance to this Technical Specification shall satisfy all of the conditions specified in the Test module in A.1.

2.3 Sensor conformance

Any sensor for which conformance to this Technical Specification is claimed shall satisfy all of the conditions specified in the Test module in A.2.

2.4 Imagery data conformance

Any enterprise for which conformance to this Technical Specification is claimed shall satisfy all of the conditions specified in the Test module in A.3.

2.5 Imagery services conformance

Any enterprise for which conformance to this Technical Specification is claimed shall satisfy all of the conditions specified in the Test module in A.4.

2.6 Image processing system conformance

Any image processing system for which conformance to this Technical Specification is claimed shall satisfy all of the conditions specified in the Test module in A.5.

3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 19115, *Geographic information — Metadata*

ISO 19119:2005, *Geographic information — Services*

ISO 19123, *Geographic information — Schema for coverage geometry and functions*

4 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

4.1

band

range of wavelengths of electromagnetic radiation that produce a single response by a sensing device

4.2

calibration

process of quantitatively defining a system's responses to known, controlled signal inputs

[CEOS WGCV]

4.3

computational viewpoint

viewpoint on an ODP system and its environment that enables distribution through functional decomposition of the system into objects which interact at **interfaces**

[ISO/IEC 10746-3]

4.4

coverage

feature that acts as a function to return values from its range for any direct position within its spatial, temporal, or spatiotemporal domain

[ISO 19123]

4.5

digital elevation model

dataset of elevation values that are assigned algorithmically to 2-dimensional coordinates

4.6

digital number

DN

integer value representing a measurement as detected by a **sensor**

4.7

engineering viewpoint

viewpoint on an ODP system and its environment that focuses on the mechanisms and functions required to support distributed interaction between objects in the system

[ISO/IEC 10746-3]

4.8**enterprise viewpoint**

viewpoint on an ODP system and its environment that focuses on the purpose, scope and policies for that system

[ISO/IEC 10746-3]

4.9**feature**

abstraction of real world phenomena

[ISO 19101]

4.10**geographic feature**

representation of real world phenomenon associated with a location relative to the Earth

4.11**geographic imagery**

imagery associated with a location relative to the Earth

4.12**geographic imagery scene**

geographic imagery whose data consists of measurements or simulated measurements of the natural world produced relative to a specified vantage point and at a specified time

[Derived from ISO 22028-1]

NOTE A geographic imagery scene is a representation of an environmental landscape; it may correspond to a remotely sensed view of the natural world or to a computer-generated virtual scene simulating such a view.

4.13**grid**

network composed of two or more sets of curves in which the members of each set intersect the members of the other sets in an algorithmic way

[ISO 19123]

4.14**imagery**

representation of phenomena as images produced by electronic and/or optical techniques

NOTE In this Technical Specification, it is assumed that the phenomena have been sensed or detected by one or more devices such as radar, cameras, photometers, and infrared and multispectral scanners.

4.15**information viewpoint**

viewpoint on an ODP system and its environment that focuses on the semantics of information and information processing

[ISO/IEC 10746-3]

4.16**interface**

named set of **operations** that characterizes the behaviour of an entity

[ISO 19119]

4.17**interoperability**

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]

4.18**knowledge base**

data base of knowledge about a particular subject

NOTE The data base contains facts, inferences, and procedures needed for problem solution [Webster Computer].

4.19**measurable quantity**

attribute of a phenomenon, body or substance that may be distinguished qualitatively and determined quantitatively

[VIM]

4.20**measurement**

set of operations having the object of determining the value of a quantity

[VIM]

4.21**measurand**

particular quantity subject to measurement

[VIM]

EXAMPLE Vapour pressure of a given sample of water at 20 °C.

NOTE The specification of a measurand may require statements about quantities such as time, temperature and pressure.

4.22**metadata**

data about data

[ISO 19115]

4.23**metric traceability**

property of the result of a measurement or the value of a standard whereby it can be related to stated references, usually national or international standards, through an unbroken chain of comparisons all having stated uncertainties

[derived from VIM]

4.24**operation**

specification of a transformation or query that an object may be called to execute

[ISO 19119]

NOTE An operation has a name and a list of parameters.

4.25**orthoimage**

image in which by orthogonal projection to a reference surface, displacement of image points due to sensor orientation and terrain relief has been removed

NOTE The amount of displacement depends on the resolution and the level of detail of the elevation information and on the software implementation.

4.26**picture original**

representation of a two-dimensional hardcopy or softcopy input image in terms of the colour-space coordinates (or an approximation thereof)

NOTE Picture originals could be obtained from printed maps, printed pictures of a geographic imagery scene, or drawings of geographic information, etc.

4.27**picture portrayal**

representations of image data in terms of the colour-space coordinates that are appropriate for, and tightly coupled to, the characteristics of a specified real or virtual output device and viewing

NOTE Picture portrayals are geared for visual display whether in hardcopy or softcopy.

4.28**pixel**

smallest element of a digital image to which attributes are assigned

NOTE 1 This term originated as a contraction of "picture element".

NOTE 2 Related to the concept of a grid cell.

4.29**policy**

set of rules related to a particular purpose

[ISO/IEC 10746-2]

4.30**radiance**

at a point on a surface and in a given direction, the radiant intensity of an element of the surface, divided by the area of the orthogonal projection of this element on a plane perpendicular to the given direction

[ISO 31-6]

4.31**radiant energy**

energy emitted, transferred or received as radiation

[ISO 31-6]

4.32**record**

finite, named collection of related items (objects or values)

4.33**remote sensing**

collection and interpretation of information about an object without being in physical contact with the object

4.34**resolution (of a sensor)**

smallest difference between indications of a sensor that can be meaningfully distinguished

NOTE For imagery, resolution refers to radiometric, spectral, spatial and temporal resolutions.

4.35**scene**

spectral radiances of a view of the natural world as measured from a specified vantage point in space and at a specified time

[derived from ISO 22028-1]

NOTE A scene may correspond to a remotely sensed view of the natural world or to a computer-generated virtual scene simulating such a view.

4.36**sensor**

element of a measuring instrument or measuring chain that is directly affected by the **measurand**

[VIM]

4.37**sensor model**

description of the radiometric and geometric characteristics of a **sensor**

4.38**service**

distinct part of the functionality that is provided by an entity through **interfaces**

[ISO/IEC TR 14252]

4.39**technology viewpoint**

viewpoint on an ODP system and its environment that focuses on the choice of technology in that system

[ISO/IEC 10746-2]

4.40**uncertainty**

parameter, associated with the result of measurement, that characterizes the dispersion of values that could reasonably be attributed to the **measurand**

[ISO 19116]

NOTE 1 The parameter may be, for example, a standard deviation (or a given multiple of it), or the half-width of an interval having a stated level of confidence.

NOTE 2 Uncertainty of measurement comprises, in general, many components. Some of these components may be evaluated from the statistical distribution of the results of series of measurements and can be characterized by experimental standard deviations. The other components, which can also be characterized by standard deviations, are evaluated from assumed probability distributions based on experience or other information.

NOTE 3 It is understood that the result of the measurement is the best estimate of the value of the measurand, and that all components of uncertainty, including those arising from systematic effects, such as components associated with corrections and reference standards, contribute to the dispersion.

4.41**validation**

process of assessing, by independent means, the quality of the data products derived from the system outputs

[CEOS WGCV]

4.42**viewpoint (on a system)**

form of abstraction achieved using a selected set of architectural concepts and structuring rules, in order to focus on particular concerns within a system

[ISO/IEC 10746-2]

5 Abbreviated terms and symbols**5.1 Abbreviated terms**

BIIF	Basic Image Interchange Format
CEOS	Committee on Earth Observation Satellites
CIE	International Commission on Illumination
CRS	Coordinate Reference System
CRT	Cathode Ray Tube
CMYK	Non-linear Cyan, Magenta, Yellow, Black
CW	Continuous Wavelength
DCP	Distributed Computing Platform
DEM	Digital Elevation Model
DIAL	Differential Absorption LIDAR
DN	Digital Number
DSS	Decision Support Service
EOS	Earth Observation Satellite
EOSDIS	Earth Observing System Data and Information System
FIFO	First In, First Out
FOV	Field of View
G	Gravity
GEO	Geosynchronous Earth Orbit
GEOTIFF	Tagged Image File Format for Geographic Imagery
GHz	Gigahertz

GIS	Geographic Information System
GLONASS	Global Navigation Satellite System
GPS	Global Positioning System
GSD	Ground Sample Distance
GSI	Ground Sample Interval
HDF	Hierarchical Data Format
HSB	Hue, Saturation, Brightness
HSV	Hue, Saturation, Value
HTTP	Hypertext Transfer Protocol
IEC	International Electrotechnical Commission
IfSAR	Interferometric Synthetic Aperture Radar
IGFOV	Instantaneous Geometric Field of View
IHO	International Hydrographic Organization
IUS	Image Understanding System
SI	International System
ISR	Intelligence, Surveillance, and Reconnaissance
ISAR	Inverse Synthetic Aperture Radar
ISPRS	International Society for Photogrammetry and Remote Sensing
IHO	International Hydrographic Organization
IT	Information Technology
ITU-R	International Telecommunication Union Radiocommunication Sector
JPEG	Joint Photographic Experts Group
LEO	Low Earth Orbit
LIFO	Last In, First Out
NASA	National Aeronautical and Space Administration
NATO	North Atlantic Treaty Organization
NCSA	National Center for Supercomputing Applications
NEXRAD	Next Generation Radar
NIIA	NATO ISR Interoperability Architecture

NSIF	NATO Secondary Imagery Format
NSILI	NATO Standard Image Library Interface
ODP	Open Distributed Processing (see RM-ODP)
OGC	OpenGeospatial® Consortium
OLAP	Online Analytical Processing
RCS	Radar Cross Section
RGB	Red, Green, Blue
RGBI	Red, Green, Blue, Intensity
RM-ODP	Reference Model for Open Distributed Processing
RMSE	Root Mean Squared Error
SAR	Synthetic Aperture Radar
STANAG	Standardization Agreement
SPCS	State Plane Coordinate System
SQL	Standard Query Language
TIFF	Tagged Image File Format
UML	Unified Modelling Language
UTM	Universal Transverse Mercator
VIM	International Vocabulary of Basic and General Terms in Metrology
WMO	World Meteorological Organization
YCrCb	Luminance and Chrominance

5.2 Symbols

λ	wavelength
σ^0	radar backscatter
η_v	volume backscatter coefficient
σ	radar target reflective strength

6 Notation

The conceptual schema specified in this Technical Specification is described using the Unified Modelling Language (UML), following the guidance of ISO/TS 19103 [84]. Several model elements used in this schema are defined in other ISO geographic information standards. Names of UML classes, with the exception of basic data type classes, include a two-letter prefix that identifies the standard and the UML package in which the class is defined. Table 1 lists the other standards and packages in which UML classes used in this Technical Specification have been defined.

Table 1 — Sources of defined UML classes

Prefix	Standard	Package
CV	ISO 19123	Coverages
FC	ISO 19110	Feature cataloguing
GF	ISO 19109	Rules for Application Schema
IG	ISO/TS 19101-2	Reference model — Imagery
LI	ISO 19115	Metadata

7 Enterprise viewpoint – community objectives and policies

7.1 General

The enterprise viewpoint on a geographic imagery processing system and its environment focuses on the purpose, scope and policies as is done in ODP systems [78]. The purpose is provided as the objective of the geographic imagery community. The scope is defined through a high-level scenario in 7.3 and through use cases in Annex C. Policies are discussed in 7.4 through a set of criteria for developing policies for geographic imagery systems as well as several example international policies relating to geographic imagery. The enterprise viewpoint provides a context for the development of standards in the other viewpoints.

7.2 Geographic imagery community objective

The central concept of the enterprise viewpoint is how the geographic imagery community interacts to enable imagery collected from different sources to become an integrated digital representation of the Earth widely accessible for humanity's critical decisions. The enterprise viewpoint provides the metric traceability between this objective and the system design for distributed geographic imagery processing systems.

The fundamental goal of the geographic imagery community is to advance and protect interests of humanity by development of imaging capabilities, and by sustaining and enhancing the geographic imagery industry. Doing so will also foster economic growth, contribute to environmental stewardship, and enable scientific and technological excellence.

7.3 Geographic imagery scenario

Figure 1 provides an example of a geographic imagery scenario. The context is that a customer requests geographic imagery information to be used with other information, including other geographic information, in support of a decision. The analyst is key in the role of decision support.

The customer's request for geographic imagery information is assessed in the planning step. The customer's desired information may be readily available from an archive or a model, or may be processed from information in an archive or available from a model. In this scenario, a model is a simulation of some portion of the geographic environment able to produce geographic imagery. Some additional processing may be needed on the archive or model outputs in order to meet the customer's request.

The customer's request for geographic imagery may require collection of new imagery. Tasking determines the available sensors and platforms and develops an imagery acquisition request. The sensor is tasked to acquire the raw data and the acquisition is performed. Acquisition of the imagery data is done in accordance with the acquisition policies.

Whether the customer's request is to be satisfied from an archive holding, a model output, or a data acquisition, typically some type of additional processing is needed. This could range from changing the encoding format of the imagery to creating derived imagery or image knowledge products. The resulting imagery information may be applied with additional information to form a response that meets the customer's needs. Distribution of the imagery information response is done in accordance with the distribution policies.

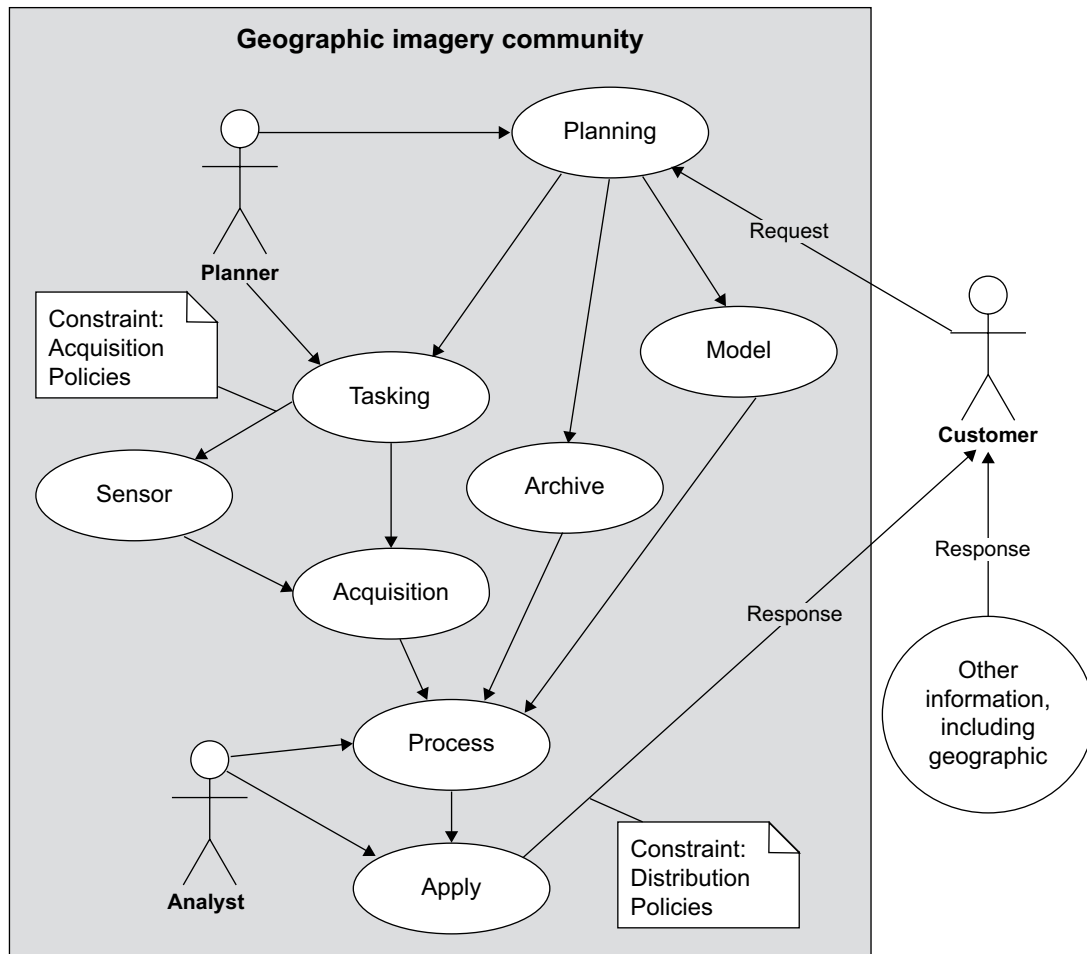


Figure 1 — Geographic imagery scenario

7.4 Geographic imagery policies

7.4.1 Introduction to policies

A policy, as defined in ISO/IEC 10746-2 [78], is a set of rules related to a particular purpose. A rule can be expressed as an obligation, a permission or a prohibition. Not every policy is a constraint. Some policies represent an empowerment.

Some geographic imagery policies promulgated by international organizations are included in 7.4.2 and 7.4.3. They may apply to particular geographic imagery systems.

Organizations involved in imagery work should develop policies consistent with the guidelines in Table 2.

7.4.2 Policy development guidelines

Guidelines for development of policies for geographic imagery systems are listed in Table 2. In this Technical Specification, “policy” refers primarily to issues of ownership, terms and conditions of use and charging for geographic imagery.

Table 2 — Policy development guidelines

Stability	Stability of data and services over time is essential so that investment decisions can be made with a correct understanding of the conditions of the future marketplace. Specific policies include continuity in data collection, consistency in format, frequency of observations, and access to comparable data over time.
Simplicity	Access to geographic imagery is subject to many interpretations driven by the variety of people and organizations with informed opinions about the subject. Simple policies that avoid the pitfalls of becoming too deeply entrenched in implementation are necessary.
Fair treatment	Given that much geographic imagery is publicly funded, there is a concern for fair treatment to be applied and to be seen to be applied. This means explicit conditions of access that do not arbitrarily favour one group or penalize another group.
Growth	Growth in the types, extent and volume of geographic imagery is desired. Policies that support growth are critical.
Maximum access	There is widespread interest in maximizing the use of geographic imagery. Image access should follow open standards to allow the integrated use of imagery from multiple sources.
Sustainability	A combination of high investment costs plus a high potential value of the data in the long-term means that the value of a sustainable geographic imagery sector should not disappear shortly after applications have been brought to a mature stage.

7.4.3 Policies

7.4.3.1 Imagery acquisition policies

The United Nations resolution “Principles Relating to Remote Sensing of the Earth from Space” [36] (see also Annex D) was adopted by the United Nations as part of the progression of formulating international rules to enhance opportunities for international cooperation in space.

The International Telecommunication Union – Radiocommunication (ITU-R) has drafted a handbook [21] that identifies radio frequencies that are critical to meteorological measurements and which should not be used for radio transmission as a matter of policy. These measurements would be degraded by radio transmission from non-meteorological sources.

7.4.3.2 Imagery distribution policies

The World Meteorological Organization (WMO) has promulgated a resolution [22] that identifies radio frequencies that are critical to meteorological measurements and their distribution.

7.4.3.3 Enterprise development policies

A policy of standardization for data and interfaces is one of the essential building blocks of the Information Society. There should be particular emphasis on the development and adoption of International Standards. The development and use of open, interoperable, non-discriminatory and demand-driven standards that take into account needs of users and consumers is a basic element for the development and greater diffusion of information and communication technologies and more affordable access to them [37].

8 Information Viewpoint – knowledge-based decisions

8.1 Introduction to Information Viewpoint

8.1.1 Introduction to types of geographic imagery

The term “image” is not explicitly defined or addressed in this reference model since there are many meanings of image within various user contexts. Geographic imagery however is defined in this Technical Specification. Geographic imagery is imagery whose data is associated with a location relative to the Earth. To view geographic imagery, a presentation process is required.

To place geographic imagery in the larger context of imagery, various types of “images” are shown in Figure 2, which is derived from the image state diagram of ISO 22028-1:2004 [27]. ISO 22028-1 categorizes image encodings into scene-referred or picture-referred image states. Those image encodings have been refined further within this Technical Specification in the manner described below.

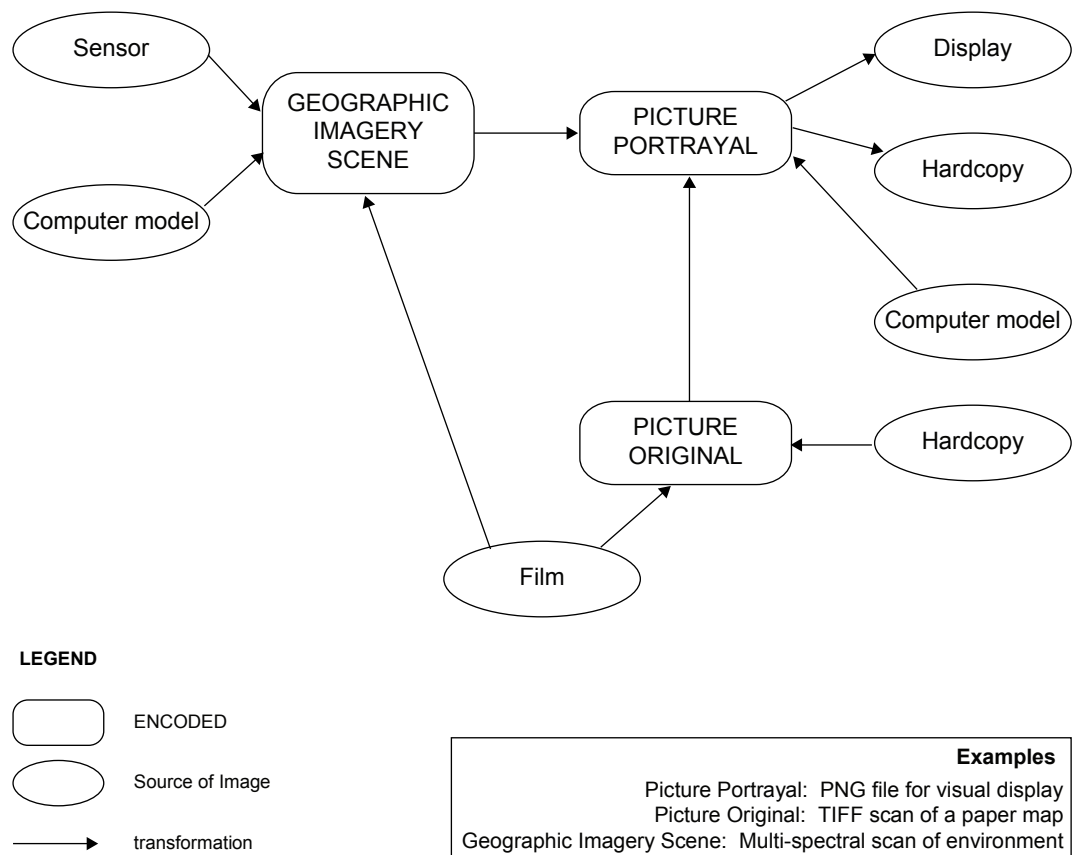


Figure 2 — Image state diagram with modifications for geographic imagery

A “Scene” is defined as spectral radiances of a view of the natural world as measured from a specified vantage point in space and at a specified time. A Scene may correspond to a remotely sensed view of the natural world or to a computer-generated virtual scene simulating such a view. This Technical Specification applies the approach of feature modelling of the 19100 series of International Standards to “Geographic Imagery Scenes”.

A feature is an abstraction of real world phenomena [83]. A geographic feature has implicit or explicit reference to a location relative to the Earth. A coverage is a feature that acts as a function to return values from its range for any direct position within its spatiotemporal domain. Examples of coverages include an image, a polygon overlay, or a digital elevation matrix. Consistent with the ISO 19100 series approach of feature modelling, a

Geographic Imagery Scene (Figure 2) is a type of coverage. A Geographic Imagery Scene is a coverage whose range values quantitatively describe physical phenomena.

This Technical Specification emphasizes scene-referred imagery, such as derivations of geophysical values based on sensor measurements. This derived imagery is also considered to be a type of Geographic Imagery Scene.

Physical quantities and units as defined in ISO 31-0 [81] should be used in a Geographic Imagery Scene for the quantitative description of physical phenomena as far as possible. Conventional scales may be used in other types of geographic coverages. The physical quantities of a Geographic Imagery Scene may be the result of a measurement by a sensor or from a prediction by a physical model (denoted as ovals labelled “Sensor” and “Computer Model” in Figure 2).

A Geographic Imagery Scene is a representation of an environmental landscape, i.e. a measurement of the natural world at a specified vantage point in space and at a specified time. It may correspond to a remotely sensed view of the natural world or to a computer-generated virtual scene simulating such a view. To accommodate geographic imagery, this Technical Specification has modified the image state diagram of ISO 22028-1 by changing from “Scene-referred colour encoding” to “Geographic Imagery Scene.” Geographic Imagery Scenes make use of a much broader spectrum than the colours addressed by ISO 22028-1. Also, Geographic Imagery Scenes may be measurements other than radiances, i.e. they may correspond to a computer-generated virtual scene simulating a remotely sensed view of radiances.

“Picture Portrayals” (Figure 2) are representations of image data in terms of the colour-space coordinates that are appropriate for, and tightly coupled to, the characteristics of specified real or virtual output device and viewing. They use colour coding for the representation of pixel values and are geared for visual displays suited for human readability, whether in hardcopy or softcopy (denoted as “Hardcopy” and “Display” ovals in Figure 2). The portrayal of geographic information is addressed in ISO 19117 [89].

“Picture Originals” (Figure 2) are representations of a two-dimensional hardcopy or softcopy input image in terms of the colour-space coordinates (or an approximation thereof). For geographic information, Picture Originals could be obtained from printed maps, printed pictures of geographic imagery, drawings of geographic information, etc. (denoted as the oval labelled “Hardcopy” in Figure 2). Although a Picture Original may be a picture of a Geographic Imagery Scene, it is not a Scene as defined in 4.35 because the picture was previously colour-rendered for printing.

Both Picture Portrayals and Picture Originals are colour encodings of any type of geographic information including, but not limited to, geographic imagery. Issues such as false-colour rendering shall be addressed to transform the broader spectrum of geographic imagery into colour imagery.

8.3 to 8.5 present a detailed conceptual schema for geographic imagery scenes.

8.1.2 Creating knowledge from imagery

The Information Viewpoint in this Technical Specification identifies various types of geographic information characterizing Geographic Imagery Scenes. The Information Viewpoint is structured following an integrated approach to geographic imagery showing relationships of raw sensed data to higher semantic content information and knowledge. As defined in ISO/IEC 10746-1 [77], an Information Viewpoint specification of an ODP system focuses on the semantics of information and information processing. The resulting structure of the Information Viewpoint is reflected in the UML packages identified in Figure 3. The contents of these packages are addressed in 8.2 – 8.5 of this Information Viewpoint.

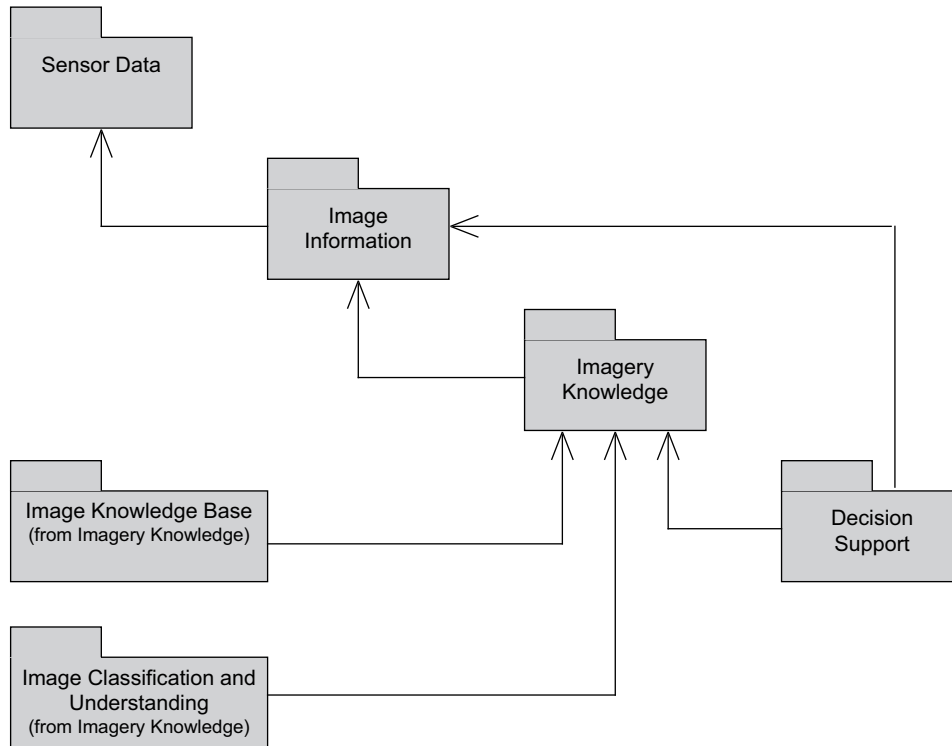


Figure 3 — Information Viewpoint packages

Geographic imagery is used to signify something about the environment. Figure 4 presents the structure for the Information Viewpoint [47].

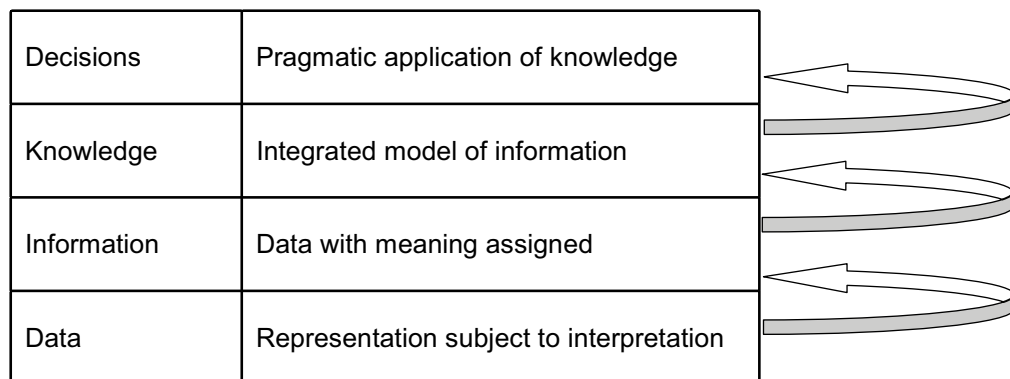


Figure 4 — Structure of the Information Viewpoint

Data (Figure 4, bottom layer) is a reinterpretable representation of information in a formalised manner suitable for communication, interpretation, or processing [25]. For imagery, data consists of the results of measurement by a sensor.

Meaning is assigned to data by applying conventions or agreed-upon codes so that it becomes information [13]. Structuring the sensor data in a standard syntax allows for transmission of the data to entities in the open distributed processing system.

As information is gathered, observed regularities are generalized and models are developed forming the transition to knowledge. Knowledge is an organized, integrated collection of facts and generalizations.

The knowledge base is used in the formation of pragmatic decisions that address the goals of multiple stakeholders. A key to effective decisions is identifying the context in which the decision applies. The context determines what information is relevant to the decision.

Geographic imagery is a type of geographic information. The ISO 19100 series of International Standards defines a conceptual modelling approach for geographic information. ISO 19101^[83] defines Conceptual Modelling and the Domain Reference Model that this Technical Specification extends for geographic imagery. ISO 19109^[95] defines the General Feature Model that is used in the ISO 19100 series wherever application schemas are dealt with.

The definitions of the feature types and their properties, as perceived in the context of an application field, are derived from the universe of discourse. A feature catalogue documents the feature types. An application schema defines the logical structure of data and may define operations that can be performed on or with the data.



Figure 5 shows the process of directly sensing or otherwise producing a representation of reality in a data set that can be processed to provide measurements of physical quantities or to be interpreted as a set of discrete features. The physical quantities and their properties, as perceived in the context of an application field, are derived from the universe of discourse. An attribute catalogue documents the physical quantities as attribute types.

Elements in the parallelograms of Figure 5 are defined in this clause. Sensors and the resulting data are described in 8.2, as are the physical quantities in an attribute catalogue. Derived Image is described in 8.3.2. Interpreted Image is described in 8.4.

8.1.4 Topics relevant across data, information, and knowledge

8.1.4.1 Resolution

The resolution of a sensor is distinct from the resolution of an image. The resolution of a sensor is the smallest difference that can be detected by a sensor. Sensor resolution is a measure of the ability of a sensor to detect differences between sensed objects and it may be expressed in many ways depending on the sensor (see 8.2).

For imagery, resolution refers to radiometric, spectral, spatial and temporal resolutions. Radiometric resolution is the amount of energy required to increase a pixel value by one quantization level or “count”. Radiometric resolution measures sensitivity by discriminating between intensity levels.

Spectral resolution measures sensitivity in discriminating between wavelengths. It is proportional to the number of bands recorded in an image and inversely proportional to their width.

The spatial resolution of an image is the minimum separation between two objects that can be distinguished as separate objects in the image. Pixel ground resolution defines the area on the ground represented by each pixel. This is often expressed as the distance between the centers of the areas represented by two adjacent pixels, called ground sample distance (GSD) or ground sample interval (GSI).

Related to the spatial resolution is the Instantaneous Geometric Field of View (IGFOV). IGFOV is the geometric size of the image projected by the detector on the ground through the optical system. IGFOV is also called pixel footprint. ISO 19123 defines the related concept of CV_Footprint. A CV_Footprint is the sample space of a grid in an external coordinate reference system, e.g. a geographic CRS or a map projection CRS.

Temporal resolution is an issue when successive images are used for change detection or for tracking moving objects. It is expressed as the frequency with which successive images are obtained or as the interval between successive images.

8.1.4.2 Uncertainty in imagery

Understanding and estimating the uncertainty in image data is important for absolute measurements of phenomena as well as for data integration. Sources of error are found across the many elements of geographic image processing. Table 3 provides examples.

Table 3 — Aspects of imagery within which errors may arise

Acquisition	Geometric aspects Sensor systems Platforms Ground Control Geographic Imagery Scene Considerations
Data Processing	Geometric Rectification Radiometric Rectification Data Conversion
Data Analysis	Quantitative Analysis Classification system Data Generalization
Data Conversion	Raster to Vector Vector to Raster
Aspects of Error Assessment	
Error Assessment	Sampling Spatial Autocorrelation Locational Accuracy Error Matrix Discrete Multivariate Statistics Reporting Standards

8.1.4.3 Imagery Fusion

Imagery fusion is the combining of imagery and other sources of geospatial information to improve the understanding of a specific phenomenon. Fusion may be performed at several levels: pixel (8.3.3.6), feature (8.4.4.4), and decision (8.5.5). Standards that enable fusion of measurements from different sensors should be suited to these levels of pixel, feature and decision fusion.

8.2 Sensor data package

8.2.1 General

Subclause 8.2 describes the concepts that should be modelled in the Sensor Data package which appears in Figure 3. Some of these concepts will be modelled in ISO 19130 and the remainder may be modelled in other standards.

8.2.2 Sensors and platforms

The attribute values of an image are numerical representations of the values of a physical parameter. The value for a physical parameter at a given time and place is obtained by conducting a measurement using a sensor. An imaging sensor typically performs multiple measurements to populate a grid of values. The raw imagery data described in 8.2 focuses on sensors, the data they produce (e.g. Digital Numbers (DN) and radiances at the sensor inputs), the methods for creating a grid of values, and the uncertainty of the sensor data.

Most geographic imagery data is obtained by remote sensing which aims to measure attributes of a real world phenomenon without being in mechanical contact with the phenomenon. The main type of remote sensing is radiometry – the measurement of the quantities associated with radiant energy, i.e. electromagnetic radiation.

Electromagnetic radiation is commonly classified as a function of wavelength across the electromagnetic spectrum (Figure 6). Sensors are designed to be sensitive to particular bands of the spectrum, e.g. visible band. A band is a range of wavelengths of electromagnetic radiation that produces a single response from a sensing device. Multispectral radiometers measure radiance in several wavelength bands over a given spectral region. Hyperspectral radiometers detect hundreds of very narrow spectral bands throughout the visible and infrared portions of the electromagnetic spectrum.

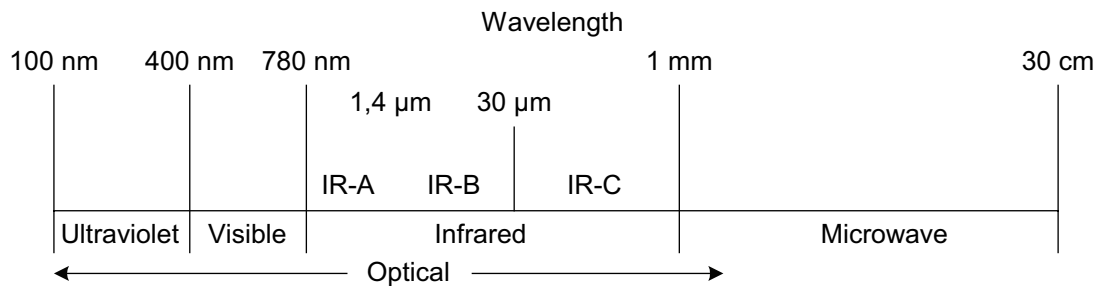


Figure 6 — Portion of the electromagnetic spectrum relevant for geographic imagery

The immediate output of a digital sensor are DNs. Prior to deployment, a sensor is calibrated in a laboratory using standard radiation sources. Using a calibration curve, DNs are mathematically converted to sensor input radiances.

The resolution of a sensor is defined by several quantities. The band structure for a sensor determines its spectral resolution. The radiometric sensitivity of a sensor for a specific band is the radiance increment for a single bit change in the DN. The spatial resolution of the sensor is the solid angle for which the sensor measures radiances.

An interferometer is an apparatus used to produce and measure interference from two or more coherent wave trains from the same source. An interferometer is an instrument used to measure distance. It does so by producing and measuring the interference between two or more coherent wave trains from the same source.

Sensor descriptions are organized by the type of energy sensed by the sensor. Firstly, the electromagnetic energy sensors are described: optical, microwave, and light detection and ranging (LIDAR). Secondly, the various mechanical wave energy sensors are described, such as sonar for example. Passive and active sensors are differentiated as necessary within this Technical Specification.

Schemas for describing some of these sensors and platforms are detailed in ISO 19130 [93].

8.2.3 Optical sensing

8.2.3.1 General description

Optical radiation is electromagnetic radiation at wavelengths between the region of transition to X-rays ($\lambda \sim 1$ nm) and the region of transition to radio waves ($\lambda \sim 1$ mm) [23]. Optical radiation includes infrared, visible and ultraviolet radiation (Table 4). Table 4 is derived from the International Lighting Vocabulary [23].

Visible radiation is any optical radiation capable of causing a visual sensation directly [23]. There are no precise limits for the spectral range of visible radiation since they depend upon the amount of radiant power reaching the retina and the responsivity of the observer. The lower limit is generally taken to be between 360 nm and 400 nm and the upper limit between 760 nm and 830 nm.