Extensions to ISO/TC 211 – 19115.3
Metadata to support Imagery and Gridded Data

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1. Introduction

In the Imagery and Gridded Data Report 19121 the work required for extending the TC211 suite of standards to support imagery and gridded data is identified. Imagery and gridded data consists primarily of spatially distributed attribute (pixel) data, georeferencing information, metadata, and encoding information. Some of the metadata information required for supporting imagery and gridded data is common to other geographic information and is addressed in the current 19115 Metadata CD3. In addition the Metadata CD3 contains some additional metadata information that partially addresses imagery and gridded data.

The initial version of this document resulted from an action raised in the ISO/TC 211 WG1 meeting held in Herndon (Washington DC) on 13-14 December 1999, where it was agreed that one of the "Potential areas for new work" for imagery and gridded data is Metadata. The action was:

Metadata needs to be reviewed both from the perspective of whether the current CD 19115.2 addresses the Imagery and Gridded Data requirements, and whether the existing sources (from the white papers) are addressed. A review of the existing 19115.2 should be expedited, and forwarded … by Jan 30, 2000.

During that meeting, the authors of each of the "white papers" documenting the existing imagery and gridded data standards recommended and defined components (Metadata *per se*) of their subject format. It was decided that the ISO document 19115.2 should be compared to the following standards and formats:

1) DIGEST A/D (version 2.0),
2) NITF 2.1 = STANAG 4545 = BIIF,
3) TC 130 TIFF/IT,
4) CEOS,
5) HDF-EOS (version 4),
6) FGDC Remote Sensing metadata (version 0.2),
7) ISPRS, and
8) SDS.

The other standards and formats, such as SQL/MM, T.4/T.6, and SC 29 do not need any additional work in TC 211 with respect to Metadata, since SQL/MM is a database standard that could support any of the TC211 metadata, and T.4/T.6, and the work from ISO JTC1 SC 29 are bit level encoding standards that don't directly relate to metadata. The work in OGC is separately being aligned with the TC 211 metadata standard.

In the TC211 WG1 Imagery and Gridded Data meeting June 22-23 it was requested that this paper be revised to reflect the latest metadata standard 19115 CD 3. The action was:

To submit a revised metadata paper to 19115 (July 25th 2000). A potential part 2 of 19115 .. [is] to be proposed (date to be determined).

1.1 Metadata related to Imagery and Gridded Data Addressed and Not Addressed

The current metadata standard 19115 CD 3 addresses many aspects of general metadata relating to all types of geographic information, that also apply to imagery, gridded and coverage data. The general areas related to imagery and gridded data that are not covered in the metadata document (19115.3) are: Platform Information (mission identification, platform orientation, etc.), and Sensor calibration (Geometric and radiometric

calibration), which might be an extensions to Remote Sensing data. This document endeavours to compare the metadata requirements from the referenced existing imagery and gridded data standards and indicate whether the existing 19115 document is adequate to support these requirements or whether additional metadata fields will be required in 19115.

It is also proposed that a new part (Part 2) of 19115 be developed to address new requirements for imagery and gridded data, since this would minimise the impact on the metadata stadnard.

2. ISO/TC 211 19115.3 – Raster classes and elements

The metadata sections/entities in ISO/TC 211 19115.3 are as follow:

Metadata entity set information
Identification information
Constraint information
Data quality (from ISO 19113)
Maintenance information
Spatial representation information
Reference system information
Content information
Portrayal catalogue information
Distribution information
Metadata extension information
Application schema information
Extent information
Citation and responsible party information
Metadata application information

The metadata entity set information is a set of both mandatory and optional metadata elements (UML attributes). It is an aggregate of the rest of the sections. The metadata elements in 19115.3 can be defined as whether:

1) ACCEPTABLE - that is they do not conflict with the Image and Gridded Data needs, and

2) ADEQUATE - that is, whether additional metadata elements will be required when the work of 19124 (and 19123, and any new work items) is complete.

The identification information contains information to uniquely identify the data. It includes information about the citation for the resource, an abstract, the purpose, credit, status, etc. Raster elements are within “Data Identification” specified class:

- Raster, image, matrix, TIN, and stereo model in “Spatial representation type code” class;
- Pass sequence identifier (Integer number that uniquely identifies the pass performed by a platform);
- Image orbit identifier (Character string unique identifier for the orbital path of a platform and the row along an orbital path of a platform); and
- Orbit number (Integer number of the orbit in which the image was taken).

2.1 Review of the sections of 19115

The **identification information** is ACCEPTABLE for the citation for the resource, the abstract, the ACCEPTABLE for some elements. In particular: “Spatial representation type code” includes the types "Raster,

image, matrix, TIN, and stereo model", since 19124 has not yet defined some of these types, and some of these types are super types of other of these types, these is a potential for future incompatibility.

The identification information is NOT ADEQUATE with respect to the identification of the sensor, since it only identifies some orbital parameters. There are many other types of sensors than satellite imagery. There is a new work item proposal under development to address sensor models.

The **constraint information** contains information concerning the restrictions placed on data. It is ACCEPTABLE and ADEQUATE.

The **data quality information** is a general assessment of the quality of the dataset. It contains information about the sources and production processes used in producing a dataset. It could be expanded to include lineage information on raster data, such as radiometric correction, radiometric data transformation tables, radiometric compensation, or geo-parameter calculation. The information on Quality in 19115.3 is ACCEPTABLE, but not ADEQUATE since it will need extension.

The **maintenance information** is about the scope and frequency of updating data. It is an important section to forecast Remote sensing imagery change detection. It is ACCEPTABLE and ADEQUATE.

The **spatial representation information** contains information regarding the mechanisms used to represent spatial information in a dataset. It does include raster spatial representation, a new class within this section. It is classified according to raster spatial, while raster attribute shall also be included. Raster spatial is based on the form of its cell's distribution in geographic map projection coordinate system. In the other hand, raster attribute is based on the nature of the attribute values assigned to its cells. Matrix and pixel elements in "Cell geometry/Raster spatial information" could be defined as "tile/pixel. In fact, current databases store data in pyramids and tiles, where each tile is a record, fully indexed. A compression option element (i.e. lossy, lossless) can also be added to this class. Raster spatial representation may include "Georectified" and "Georeferenceable" dataset. Extensions to "Georeferenceable" (if any) shall include remote sensing and photogrammetric elements. The spatial representation information is ACCEPTABLE, but NOT ADEQUATE.

The **reference system information** is a description of the spatial and temporal reference system(s) used in a dataset. It is ACCEPTABE, but NOT ADEQUATE. In fact, there is a new work item under development to cover sensor coordinates systems.

The **content information** is identifying the feature catalogue used for vector dataset, and/or information describing the content of raster dataset (i.e. raster and image description). The elements of raster and image description classes could be expanded to include other element related to grid description. The "Image condition code/Image description" indicates conditions, which may affect the quality of the image, and therefore could be included in the quality information section. The content information is ACCEPTABLE, but NOT ADEQUATE and that there are elements that should be moved to the Quality section.

The **portrayal catalogue information** contains information on the portrayal catalogued being used. It is ACCEPTABLE and ADEQUATE.

The **distribution information** contains information about the distributor, the format of distribution (encoding related), the digital transfer options, and other information for obtaining, a resource. It is ACCEPTABLE and ADEQUATE.

The **metadata extension information** is about user specified extensions. For Imagery and Gridded Data purpose, the metadata extension information is how Image and Gridded data information that is not included in the current 19115.3 will be added in the future. This mechanism is itself ACCEPTABLE and ADEQUATE.

The **application schema information** contains information about the application schema used to build a dataset. It is ACCEPTABLE and ADEQUATE.

The **extent information and citation and responsible party information** are both metadata data types. The extent information contains the metadata elements, which describe the spatial and temporal extent of the referring entity. The citation and responsible party provides a standardized method for citing a resource and information about the party responsible for a resource. There are both ACCEPTABLE and ADEQUATE.

The **metadata application information** is related to a dataset that must have one or more related metadata entity sets. Metadata may optionally related to aggregations of datasets. Dataset aggregations may be specified as a general association, dataset series, or a special activity. It includes "Platform", "Production series", "Sensor", and "stereo mate" if "Data identification/Spatial representation type code" equals "image". The metadata application may generate some confusion within the perspective of Imagery and Gridded Data, and hence it is not ACCEPTABLE, nor ADEQUATE.

The following table stresses the requirements for each metadata section.

METADATA SECTION	ACCEPTABLE	ADEQUATE
Metadata entity set information	YES	YES
Identification information	YES ◆	NO ✣
Constraint information	YES	YES
Data quality (from ISO 19113)	YES	NO
Maintenance information	YES	YES
Spatial representation information	YES	NO ★
Reference system information	YES	NO ✈
Content information	YES	NO
Portrayal catalogue information	YES	YES
Distribution information	YES	YES
Metadata extension information	YES	YES
Application schema information	YES	YES
Extent information	YES	YES
Citation and responsible party information	YES	YES
Metadata application information	NO	NO

◆ Terminology regarding "Spatial representation type code" has not yet been resolved.

✜ Orbital parameter type code (i.e. Image Orbit Identifier, Orbit number, etc.) shall be delayed since there are so many other types of imagery and gridded data (i.e. eccentricity, focal length, etc.).
★ Need additional Remote sensing and photogrammetric elements
✈ Need sensor coodinates systems elements

3. Conclusions

The current version of I SO/TC 211 19115 Metadata (CD3) is largely ACCEPTABLE with respect to Imagery and Gridded data. There is some confusion with respect to " Metadata application information" which needs to be resolved before the current Metadata document is completed.

The current metadata standard is INADEQUATE with respect to several areas of metadata related to imagery and gridded data. Rather than delay the current work on the metadata standard it is proposed to develop a part 2 to the metadata standard that addresses these additional areas.

Appendix 1: ISO/TC 211 19115.3 and other formats

1. FGDC Content Standard and ISO/TC 211 document 19115.3

The following table lists the Metadata levels (sections) from FGDC Content Standard and ISO/TC211 19115.3 document for comparison.

FGDC Content Standard	ISO/TC211 (ISO 19115.3)
	Metadata entity set
Identification	Identification
	Constraint
	Maintenance
Spatial Organization	Spatial Representation
Spatial Reference	Reference System
Entity/Attributes	Content
	Portrayal Catalogue
Distribution	Distribution
	Metadata Extension
	Application Schema
	Extent
Citation	Citation and Responsible Party
Data Quality	Data quality
	Metadata application
Contact	
Time	
Metadata Reference	

The CD 19115.3 Metadata document has been pushed up against other Metadata standards such as FGDC content standard or FGDC Remote Sensing Extensions by adding one level/section called Metadata entity set information (A.2). This level/section contains elements such as “Contact”, which is equivalent to ‘Metadata

contact", element in FGDC content standard/Metadata Information, and "Date", equivalent to "Metadata date" element in FGDC content standard/Metadata information.

The "Distribution information" is clearly described with details, from format information to standard order process information, passing by media information.

The "Metadata extension information" level is an empty "Object". It does define some new elements, which are not found in ISO 19115, required to describe geographic data. But its main goal is to describe how to define new, extended elements.

Some elements in "Content information" level have different means, such as "Language", used for documenting metadata, which might be different from the "Language(s)" element, which is the language used within the data set in "Metadata Identification" level.

The "Contact", "Date" and "Data quality info" elements in "Metadata entity set information" level shall be "Mandatory" and not "Optional".

A "Title" and "Data set type" elements, describing the type of the data set (i.e. satellite swath data, side-scan image data, etc.) should be added to "Identification information" level.

"Pass Sequence Identifier", "Image Orbital Identifier", and "Orbit Number" elements shall be moved within "Platform Identification" level (level to be created?).

"Image quality code" and "processing level code" elements in the "Image description/Raster description/Content information" section refer both to "MD_Identifier" <code list>. "MD_Identifier" code list has to be clearly described.

In overall this Metadata standard serves a wide variety of digital geo-spatial data. It does cover "Sensor Information" entities and elements, which are essential to describe Imagery and Gridded data. However, a Metadata Extension might be suitable for Remote Sensed data imagery in conformance with Annex C in order to cover other sections/elements, such as "Sensor calibration", "Platform Information", and "photogrammetric" perspective.

2. Comparison with DIGEST (version 2.0)

The DIgital Geographic Information Exchange STandard (DIGEST) is an international exchange standard designed to enable the transfer of Digital Geographic Information (DGI) between geographic information systems. It was prepared and issued under the authority of the Digital Geographic Information Working Group (DGIWG).

The DIGEST A is an ISO 8211, generally used for bulk transfer and for archival purposes. DIGEST B is intended for telecommunications applications, DIGEST C is a direct use Vector Relational Form for vector data products and DIGEST D is an Image Interchange Format (IIF) – for image, raster map, and matrix data. It is based on NATO Secondary Image Format (NSIF), and only implements the part of NSIF which handle raster (image) or matrix data structure.

The Metadata in DIGEST is organized in a hierarchical manner. In fact, there is different level in metadata content, namely "Transmittal Metadata", and "Data set [Library] and Layer [Coverage] Metadata subset". The "Transmittal Metadata" defines the contents of the transmittal and identified its parent database. It does include Metadata sections/elements such as "Database identification" or "Security and release". The "Data set [Library] and Layer [Coverage] Metadata subset" support information related to the Geo Data subset, which is contained in "Data set [Library] Metadata subset". Such Metadata elements as "projection", "quality" and "datums" are

included in this subset providing the information necessary to interpret all the Geo Data Layer(s) [Coverage(s)] composing the Geo Data subset. Metadata elements specific to each “Layer [Coverage]” is include in “Layer [Coverage]” Metadata subset.

The following table lists the Metadata levels (sections) from ISO/TC211 19115.3 Metadata document and DIGEST Dataset [Library] and Layer [Coverage] Metadata for comparison.

ISO/TC211 (ISO 19115.3)	DIGEST Dataset [Library] & Layer [Coverage] Metadata
Metadata entity set Identification Constraint Maintenance Spatial Representation Reference System Content Portrayal Catalogue Distribution Metadata Extension Application Schema Extent Citation and Responsible Party Data quality Metadata application	General Information Geo-reference description Quality description Graphic source description Sensor parameters description

The “Geo-reference description” section of DIGEST contains a “Sounding Datum”, which is not specified in ISO/TC 211 Metadata document.

“Encapsulation” element in “General Information” section of DIGEST Identify the encapsulation primarily used for the transmission of Dataset [Library] and Layer [Coverage], namely A (ISO 8211 or DIGEST A), or D (IIF or DIGEST D). The equivalent of this encapsulation element does not exist in ISO/TC 211 Metadata document.

The “WGS84 MBR” DIGEST entity, which provides the approximate location of Dataset using the WGS84 reference system, is equivalent to “Geographic box” in ISO/TC 211 Metadata document, Extent Information section. It is Mandatory in both DIGEST and ISO/TC 211 19115.3.

The “Security classification” element in “Security and Release” DIGEST section has no equivalent in Distribution section of ISO/TC 211 Metadata document. However, in the Constraint information section, one constraint list is Security constraints, which includes a classification element with codes such as “unclassified”, “confidential”, “secret”, and “top secret”.

The “Source description” section in DIGEST may be either a “Graphic source description” or a ‘Sensor parameters description”. The graphic source description provides the description of a map or chart used as a source of the data. The sensor parameter description provides sensor parameters elements for imagery data.

The “Platform Information” section is missing in DIGEST and ISO/TC 211 Metadata document standards. However, DIGEST covers some elements dealing with Platform Information, such as “Attitude speed and angle at image centre”.

3. Comparison with NITF, Version 2.1 = STANAG 4545 = BIIF

NITF is a standard file format for imagery and imagery-related products to be used by the US Department of Defence and Intelligence Communities. The NITF provides a common basis for storage and interchange of images and associated data among existing and future systems.

The following table lists the Metadata levels (sections) from ISO/TC211 19115.3 Metadata document and NITF (2.1) for comparison. The NITF is a digital interchange format (as an implementation of BIIF) for transmission of imagery and all related data in a file.

ISO/TC211 (ISO 19115.3)	NITF (2.1) = STANAG 4545 = BIIF
Metadata entity set Identification Constraint Maintenance Spatial Representation Reference System Content Portrayal Catalogue Distribution Metadata Extension Application Schema Extent Citation and Responsible Party Data quality Metadata application	Identification Security

In NITF, a header/sub-header carries information about identification, security, structure, content, and size of data segment. The followings are relevant elements (fields) for defining Metadata in Imagery and Gridded Data. NITF image sub-header carries:

IID1 - Image Identifier 1 (contain a valid alphanumeric identification code associated with the image. The valid codes are determined by the application)
IID2 - Image Identifier 2 (contain the identification of additional information about the image)
NROWS - Number of significant rows in Image
NCOLS - Number of significant columns in Image
PVTYPE - pixel value type (i.e. integer, bi-level, real, etc.)
IREP – Image Representation (i.e. monochrome, RGB, multi-band imagery, etc.)
ICAT – Image Category (i.e. visible, side-looking radar, optical, XRay, etc.)
ICORDS – Image Coordinate Representation (i.e. UTM Northern Hemisphere, Geographic, Decimal degrees, etc.)
NBANDS – Number of Bands (i.e. 1 to 9, multi, RGB/LUT, etc.)
IMODE – Image Mode (i.e. uncompressed, BIP, BS, BIR, etc.)

4. Comparison with TC 130 – TIFF/IT

TC 130 is an ISO Technical Committee dealing with Graphic Technology. TC 130 has 14 and 21 participating and observer countries, respectively. It is formed by six Working Groups, which are:

WG 1 - Terminology;
WG 2 - Prepress data exchange;
WG 3 - Process control and related metrology;
WG 4 - Media and materials;
WG 5 - Ergonomics – Safety;
WG 6 - Density measurements (Revision of ISO 5 series).

WG2 – Prepress data exchange developed TIFF/IT, an ISO 12639:1998 Graphic technology -- Prepress digital data exchange -- Tag image file format for image technology (TIFF/IT). TIFF/IT is an extension of TIFF 6.0.

TIFF/IT is based on American National Standard IT 8.8 – 1993 Graphic Technology. It is also implemented by a variety of pre-press manufacturers such as Crosfield, Linotype-Hell, Scitex, 3M, Ultimate Technologies and several others.

This International Standard (IS) specifies a media-independent means for prepress electronic data exchange. This IS defines image file formats for encoding colour continuous tone picture images, colour line art images, high resolution continuous tone images, monochrome continuous tone picture images, binary picture images, and binary line art images. The technical content of this IS enables the interchange of various types of rasterized colour and monochrome image data files among electronic, digital systems used in prepress image processing, graphic art design and related document creation and production operations.

TIFF/IT has two levels of conformance: TIFF/IT (also referred to as full TIFF/IT) conformance and TIFF/IT – P1 conformance. Both conformance levels are intended to support a media-independent means for the exchange of various images used in the prepress, printing, graphic arts, and information processing fields. TIFF/IT – P1 conformance provides a minimized set of options to permit simpler implementation and compatibility, where possible (for CT, BP, and MP files), with commonly available TIFF 6.0 readers and writers. TIFF/IT – P1 is intended for use where the full set of TIFF/IT options is not required.

A TIFF/IT file conveys image data for a single image or a set of related images. The TIFF/IT structure includes a short header, one or more Image File Directories (IFD), and the image data associated with the IFDs. Image parameters are encoded in tagged fields in the IFD. Fields that are not used to describe an image are omitted from its position in the directory entry.

The following tables' stress the traditional TIFF fields and the additional TIFF/IT fields, extracted from ISO 12639:1998(E) document.

Traditional TIFF fields

Tag No.	Field name	Data type
254	NewSubfileType	Long
256	ImageWidth	Long or Short
257	ImageLength	Long or Short
258	BitsPerSample	Short
259	Compression	Short
262	PhotometricInterpretation	Short

269	DocumentName	ASCII
270	ImageDescription	ASCII
271	Make	ASCII
272	Model	ASCII
273	StripOffsets	Long or Short
274	Orientation	Short
277	SamplesPerPixel	Short
278	RowsPerStrip	Long or Short
279	StripByteCounts	Long or Short
282	Xresolution	Rational
283	Yresolution	Rational
284	PlanarConfiguration	Short
285	PageName	ASCII
296	ResolutionUnit	Short
305	Software	ASCII
306	DateTime	ASCII
315	Artist	ASCII
316	HostComputer	ASCII
332	InkSet	Short
334	NumberOfInks	Short
336	DotRange	Byte or Short
33432	Copyright	ASCII

Additional TIFF/IT fields

Tag No.	Field name	Data type
34016	Site	ASCII
34017	ColorSequence	ASCII
34018	IT8Header	ASCII
34019	RasterPadding	Short
34020	BitsPerRunLength	Short
34021	BitsPerExtendedRunLength	Short
34022	ColorTable	Byte
34023	ImageColorIndicator	Byte
34024	BackgroundColorIndicator	Byte
34025	ImageColorValue	Byte
34026	BackgroundColorValue	Byte
34027	PixelIntensityRange	Byte
34028	TransparencyIndicator	Byte
34029	ColorCharacterization	ASCII
34030	HCUsage	Long
34031	Reserved for future TIFF/IT use	
34032	Reserved for future TIFF/IT use	
34033	Reserved for future TIFF/IT use	
34034	Reserved for future TIFF/IT use	
34035	Reserved for future TIFF/IT use	

5. Comparison with GeoTIFF

GeoTIFF development began under the leadership of Ed Grissom at Intergraph, and others in the early 1990's. In 1994 a formal GeoTIFF mail list was created and maintained by Niles Ritter at JPL. In a conference in March of 1995 hosted by SPOT Image, with representatives from USGS, Intergraph, ESRI, ERDAS, SoftDesk, MapInfo, NASA/JPL, and others, a working proposal for GeoTIFF was outlined. The outline was condensed into a prerelease GeoTIFF specification document by Niles Ritter, and Mike Ruth of SPOT Image. Following discussions with Dr. Roger Lott of the European Petroleum Survey Group (EPSG), the GeoTIFF projection parameterization method was extensively modified, and brought into compatibility with both the Petrotechnical Open Software Corporation (POSC) Epicenter model, and the Federal Geographic Data Committee (FGDC) metadata approaches.

The GeoTIFF format is completely open, public domain, non-proprietary. There is no restriction on licensing, implementation, promulgation, or any uses of the format. The format is entirely open, and available to all. The specifications are public; there are abundant free software source libraries, toolkits, data samples, and technical support through the email forum.

GeoTIFF is mainly a metadata extension of the TIFF format. The metadata extension is related to encoding the geolocation information associated with georeferenced regular grid data. It supports an extensive list of map projections. The GeoTIFF spec defines a set of TIFF tags provided to describe all "Cartographic" information associated with TIFF imagery that originates from satellite imaging systems, scanned aerial photography, scanned maps, digital elevation models, or as a result of geographic analyses. Its aim is to allow means for tying a raster image to a known model space or map projection, and for describing those projections.

The following table lists the Metadata levels (sections) from ISO/TC211 19115.3 Metadata document and GeoTIFF for comparison.

ISO/TC211 (ISO 19115.3)	GeoTIFF (TIFF 6.0)
Metadata entity set Identification Constraint Maintenance Spatial Representation Reference System Content Portrayal Catalogue Distribution Metadata Extension Application Schema Extent Citation and Responsible Party Data quality Metadata application	Ellipsoid/Datum

GeoTIFF uses a "MetaTag" (GeoKey) approach to encode dozens of information elements into just 6 tags, within TIFF format. GeoTIFF uses numerical codes to describe projection types, coordinate systems, datums, ellipsoids, etc.

List of tags, which relate raster space R with device space D (i.e. monitor, scanner, and printer):

Resolution Unit (296)

X Resolution (282)
Y Resolution (283)
Orientation (274)
X Position (286)
Y Position (287)

6. Comparison with CEOS Format

The aim of the Committee on Earth Observation Satellite (CEOS) superstructure format usually referred to, as simply CEOS format is to minimise the effort to read and write data products from similar Earth observation sensors. This is achieved by establishing a standard for a family of formats, and then making further recommendations for specific sensor classes (i.e. optical and SAR sensors).

The handling of data description information is very poor in CEOS files. When data is interchanged in CEOS files, there is a strong reliance on paper documentation to describe the parameters, especially in the Leader and Header files.

The following table lists the Metadata levels (sections) from ISO/TC211 19115.3 Metadata document and the ICS (Interoperable Catalogue System) - System Design Document (SDD) Data Model for comparison.

ISO/TC211 (ISO 19115.3)	CEOS/ICS/SDD
Metadata entity set	
Identification	Product/Collection
Constraint	
Maintenance	
Spatial Representation	
Reference System	Spatial Reference/Coverage
Content	Attributes
Portrayal Catalogue	
Distribution	Contact
Metadata Extension	
Application Schema	
Extent	
Citation and Responsible Party	
Data quality	Quality Product Stats
Metadata application	
	Order
	Query?
	Platform Information
	Sensor Information

Additional metadata information shall be added to address the data fields from the following CEOS data records or fields. The radar parameters may be appropriate for a future version of the metadata standard.

7. Comparison with HDF-EOS (version 4)

The Hierarchical Data Format (HDF) has been developed for facilitating data access in heterogeneous computing environments by the National Center for Supercomputing Applications (NCSA), University of Illinois at Urbana-Champaign (NCSA, 1994) since the late 1980s. NASA selected the Hierarchical Data Format (HDF) as the basis for developing the standard format for Earth Observation System Data Information System (EOSDIS).

There are two types of metadata in HDF-EOS -- structure metadata and the product metadata. Both, metadata are stored as attributes in the HDF-EOS files. The structure metadata define the relationship between data components. The product metadata describe the data product. Both product and structure metadata are encoded in text format by using Object Description Language (ODL) and stored as global attributes in HDF-EOS files. The content standard for the structure metadata is defined in the EOSDIS conceptual data models. The structure metadata are generated, encoded, and stored automatically by the HDF-EOS software library when an HDF-EOS data object is created. FGDC Extensions for Remote Sensing Metadata is based on HDF-EOS.

8. Comparison with the FGDC Extensions for Remote Sensing Metadata (version 0.2)

The purpose of Extensions for Remote Sensing Metadata is to provide a common terminology and set of definitions for documenting geospatial data obtained by remote sensing, within the framework of FGDC Content Standard for Digital Geospatial Metadata. Extensions for Remote Sensing will allow the description of geospatial data derived from remote sensing measurements using a standard FGDC form.

The remote sensing extensions are not used alone. As extensions, they are used to define metadata to supplement the FGDC Content Standard for Digital Geospatial Metadata (base standard). Elements in the base standard are not repeated in the Remote Sensing Extensions, unless they have extended elements under them or appear in the production rules for extended elements.

The following table lists the Metadata levels (sections) from ISO/TC211 19115.3 Metadata document and FGDC Remote Sensing Extensions (version 0.2) for comparison.

ISO/TC211 (ISO 19115.3)	FGDC Remote Sensing Extensions
Metadata entity set	
Identification	Identification
Constraint	
Maintenance	
Spatial Representation	
Reference System	Spatial Reference
Content	Entity/Attributes
Portrayal Catalogue	
Distribution	Distribution
Metadata Extension	
Application Schema	
Extent	
Citation and Responsible Party	
Data quality	Data quality
Metadata application	
	Platform Information
	Sensor Information

“Language” element is missing in FGDC RS Extensions under “Identification information” section. Since FGDC is a US standard, it therefore assumes English.

“Geographic Box” element is not missing? It is equivalent to “Spatial domain” entity under the base standard.

“Processing level” element under “Identification information” section in FGDC RS Extensions has its equivalent under “Content Information/Image description” section. However, the “Image quality code” and “Processing level code” refer both to the same “MD_Identifier” code list.

“Access constraints”, “User constraints”, and “Security information” are within “Identification Information” level/section in FGDC RS Extensions, while they are in “Constraint information” in ISO/TC211 19115.3 document.

New entities, namely “Algorithm information” and “Processing information” have been added to “Lineage” in FGDC RS Extensions.

The “Geo-location and Geo-coding Information” entity has been added to “Spatial reference information” section in FGDC RS Extensions. Among entities included in “Geo-location and Geo-coding Information” is a “Pixel description” sub-entity. Elements of this sub-entity, such as “Pixel system origin” and “Pixel resolution” should be described in ISO/TC 211 19115.3 document under “Content Information” section.

Sensor Information elements in ISO/TC 211 19115.3 document are described under “Content information”/”Image description”, while in FGDC RS Extensions there is a new section called “Sensor Information”.

The “Platform Information” section is not covered in ISO/TC 211 19115.3 document.

Neither “Maintenance”, nor “Citation and Responsibility party” is described in FGDC RS Extensions.

9. Comparison with Image Transfer Standard - ISPRS

The purpose of Image Transfer Standard (ITS) – International Society for Photogrammetry and Remote Sensing (ISPRS) is to develop a data format accepted world wide for the storage and the exchange of photogrammetric data. The standard format should be independent of manufacturer sensor and platform.

ITS describes all geometric aspects of the transformation between imaging sensor, 3D data acquisition and ortho-photo production. A metadata description of all sensors geometry is a part of ITS.

The following table lists the Metadata levels (sections) from ISO/TC211 19115.3 Metadata document and Image Transfer Standard metadata elements for comparison.

ISO/TC211 (ISO 19115.3)	ITS – ISPRS
Metadata entity set Identification Constraint Maintenance Spatial Representation Reference System Content	Identification Information Spatial Reference Information Entity/Attributes

Portrayal Catalogue Distribution Metadata Extension Application Schema Extent Citation and Responsible Party Data quality Metadata application	 Distribution Information Data Quality Information Sensor Information Platform Information

ISPRS-ITS covers all the necessarily elements for geometric correction of Remote Sensing imagery. In fact, geometric correction needs several parameters, such as Earth rotation effects, Earth curvature, terrain relief, satellite altitude/attitude/speed, panoramic distortion, non-linearity, collinearity, collinearity related to Celestial mechanics and polynomial equations. Those parameters are within Platform information, Sensor Information and Spatial Reference information in ISPR-ITS metadata. Although, Sensor type parameters in Sensor Information section need to be expanded on radar, whiskbroom, panoramic and laser image producing sensors.

10. Comparison with Self Defined Standard – SDF

The Self-Defined Standard (SDS) is a specification being proposed to the ISO/TC211 for encapsulated storage of data for long time archival of very large data sets. The goals of SDS are to facilitate and ensure information survivability for long term archives by providing encapsulated standardized mechanisms within the file itself. This means dependence on applications and outside meta information for data interpretation can be minimized. The SDF is based on object oriented paradigm.

The SDS file is described by meta information stored within the file concerning the contents of the SDS file. The meta information describes the structure of the file along with the contents of the file. SDS allows applications to obtain information about the underlying schemas and formats from defined sections within the SDS file. A user may alter the schema (i.e. add or delete columns). All column definitions and characteristics are also encapsulated within the file. The smart raster idea has been addressed by allowing the ability to store tessellation with associated attributes and RGB colour values within the same file.

A header within SDF file carries these elements:

Version = 2.0.0
Creation date =
Conversion Tool =
Vendor =
Source Type =
Sorted = Yes, using: LON, LAT
Record Size = xx bytes
Header size = xxxx bytes
Primary Key Offset = x bytes
Primary Key Size = xx bytes
Number of Records = xxxxxx
Number of Columns = xx
Number of Variable = x

Endian = Little

Word Size = 64 bits
Float Format = IEEE754

The SDF file (with Helical Hyperspectral Codes – HHCodes) is described by these metadata elements:

```
COLUMN      GEO_TEMP        HHCODE PRIMARY MINMAX
DIMENSION   LON             GEO_TEMP(1,-180.00,180.00,32) MINMAX
DIMENSION   LAT             GEO_TEMP(2,-90.00,90.00,32) MINMAX
DIMENSION   TIME            GEO_TIME(1,205502140800000.00,306484387200000.00,51) MINMAX
COLUMN      AGENCY_UID      CHAR(6)
COLUMN      PLATFORM_UID    CHAR(4)
COLUMN      PRO_VALUE       NUMBER(8,0) MINMAX
COLUMN      BEAMID          NUMBER(8,0)
COLUMN      COUNT_RECORDS   NUMBER(8,0) MINMAX
COLUMN      MIN_VALUE       NUMBER(8,0) MINMAX
COLUMN      MAX_VALUE       NUMBER(8,0) MINMAX
COLUMN      AVERAGE_VALUE   NUMBER(8,0) MINMAX
COLUMN      STDDEV_VALUE    NUMBER(8,0) MINMAX
COLUMN      MEDIAN_VALUE    NUMBER(8,0) MINMAX
COLUMN      COLOR           NUMBER(8,0) MINMAX
COLUMN      OBJNAME         CHAR(15)
COLUMN      TOPOLOGY        CHAR(1)

OPTION Endian(Little)
OPTION WordSize(64)
```

Appendix 2: Relevant Sections/Elements for defining Metadata in Imagery and Gridded Data.

1. From ISO/TC 211 – 19115.3 document

Identification information
- Data identification
  - Spatial representation type (raster)
    - Raster
    - Image
    - Matrix
    - TIN
    - Stereo Model
  - Pass sequence identifier
  - Image orbital identifier
  - Orbit number

Data quality information
- Lineage
  - Source
    - Datum (i.e. spatial reference system used by the source data)

Spatial representation information
- Raster spatial representation
  - Cell geometry
    - Matrix
    - Pixel
  - Transformation parameter availability (i.e. code which indicates whether or not transformation algorithm exists)
  - Georectified

        - Point in Pixel (Pixel Orientation)
        - Transformation dimension description
        - Transformation dimension mapping
- Dimension information
    - Resolution (i.e. degree of detail visible in an image)

Reference system information
- CRS
    - Projection
    - Ellipsoid (ellipsoid parameters)
    - Datum (datum parameters)

Content information
- Content description
    - Raster description
    - Image description

Citation and Responsible party
- Citation
    - Presentation form code
        - Image
        - Model
        - Raster Map
        - View

2. From DIGEST, version 2.0 (A and D)

Geo Reference Description
- Geodetic parameters
    - Horizontal datum
    - Vertical datum
        - Vertical datum reference
        - Code of vertical reference
            - **Sounding datum**
                - **Sounding datum name**
                - **Sounding datum code**

Sensor Parameters Description
- Field of application
    - Derived Layer
    - Extent of derived data

- Source Image Band Identification(s)
    - Band designation (identification of the band, i.e. Red)
    - Band description
        - Signal lower limit (lower wavelength in nanometers)
        - Signal upper limit (upper wavelength in nanometers)

- Image resolution
    - Resolution E-W direction
    - Resolution N-S direction
    - Ground sample distance (E-W direction) (measured before any rectification)

- Ground sample distance (N-S direction) (measured before any rectification)
- Unit of resolution

- Basic auxiliary parameters
  - Image and Sensor identification
    - Vector or mission name
    - Sensor or Instrument name
    - Spectral mode
    - Processing level
    - Source Image ID
    - Acquisition date and time
    - Incidence angle
    - Angle value
    - Angle unit
  - Altitude
    - Altitude value
    - Unit of altitude
    - Image center location (Provides the location of the center of the Source image referring to WGS84 datum in seconds of arc)
    - Longitude
    - Latitude
  - Solar angles at image center
    - Solar angles at image center
    - Solar azimuth
    - Solar elevation
    - Unit of Solar angles
  - Attitude angles at image center
    - Roll
    - Pitch
    - Yaw
    - Unit of attitude angles
    - Pixel time
    - Unit of pixel time

  - Attitude speed at image center
    - Roll speed
    - Pitch speed
    - Yaw speed
    - Unit of attitude speed

- Additional auxiliary parameters
  - Number of auxiliary parameters
  - Parameter ID(s) and Value(s)

3. From National Imagery Transmission Format, Version 2.1 = STANAG 4545 = BIIF

The file structure of NITF (2.1) can accommodate all needed imagery, modifications, and associated data, such as: images, annotated images, graphics, text, maps, and tables. The format is adaptable to changing requirements by allowing for the addition or modification of file extensions to accommodate new types of data.

Information concerning all mission, platform, orbital, orientation, sensor, calibration, lineage, geolocation, product attributes, security and description data can be accommodated.

Examples are:

Mission identification
Platform identification
Orbital or flight information
Ephemeris
Platform orientation
Geo positioning and mensuration data
Geo position of a image “chip” in relation to an original full image
Blocked imagery data
Row and column indexing scheme for pixel location within an image
Camera specifications
Sensor configuration
Radar parameters
Geographic coordinates
Mapping data
Stereo imagery data, stereo mates,convergence angles, asymmetry angles
Digital display and exploitation data
Sun elevation, sun azimuth
Obliquity
Processed imagery data
Raw imagery data
Collection start time
Collector location, position, velocity, acceleration, etc.
Spot mode collection info, sweep mode collection, sweep angle etc
Sensor type, sensor mode
Moving target data
Ampltude data
Multiband data
Engineering data
Processing data
Processing history
Radiometric data
Date and time of collection
Resolution
Information about objects in the imagery
Offset data
Non-displayable data such as elevation data, location grid and matrix data
Computer generated graphics (CGM)
Descriptive text associated with the imagery
Security classification
Downgrading instructions
Number of bits per pixel
Product attributes
Data volume

4. From GeoTIFF

In GeoTIFF, the geolocation information is stored by using the combination of limited numbers of reserved private TIFF tags (total 6) and GeoKeys (dozens), defined in GeoTIFF specification. GeoTIFF specification defines four categories of GeoKeys: GeoTIFF Configuration Keys (3 keys), Geographic Coordinate System (CS) Parameter Keys (14 keys), Projected CS Parameter Keys (24 keys), and Vertical CS Keys (4 keys).

GeoKey Category	GeoKey Name and ID
GeoTIFF Configuration Keys	GTModelTypeGeoKey = 1024 GTRasterTypeGeoKey = 1025 GTCitationGeoKey = 1026
Geographic CS Parameter Keys	GeographicTypeGeoKey = 2048 GeogCitationGeoKey = 2049 GeogGeodeticDatumGeoKey = 2050 GeogPrimeMeridianGeoKey = 2051 GeogLinearUnitsGeoKey = 2052 GeogLinearUnitSizeGeoKey = 2053 GeogAngularUnitsGeoKey = 2054 GeogAngularUnitSizeGeoKey = 2055 GeogEllipsoidGeoKey = 2056 GeogSemiMajorAxisGeoKey = 2057 GeogSemiMinorAxisGeoKey = 2058 GeogInvFlatteningGeoKey = 2059 GeogAzimuthUnitsGeoKey = 2060 GeogPrimeMeridianLongGeoKey = 2061
Projected CS Parameter Keys	ProjectedCSTypeGeoKey = 3072 PCSCitationGeoKey = 3073 ProjectionGeoKey = 3074 ProjCoordTransGeoKey = 3075 ProjLinearUnitsGeoKey = 3076 ProjLinearUnitSizeGeoKey = 3077 ProjStdParallel1GeoKey = 3078 ProjStdParallel2GeoKey = 3079 ProjNatOriginLongGeoKey = 3080 ProjNatOriginLatGeoKey = 3081 ProjFalseEastingGeoKey = 3082 ProjFalseNorthingGeoKey = 3083 ProjFalseOriginLongGeoKey = 3084 ProjFalseOriginLatGeoKey = 3085 ProjFalseOriginEastingGeoKey = 3086 ProjFalseOriginNorthingGeoKey = 3087 ProjCenterLongGeoKey = 3088 ProjCenterLatGeoKey = 3089 ProjCenterEastingGeoKey = 3090 ProjCenterNorthingGeoKey = 3091 ProjScaleAtNatOriginGeoKey = 3092 ProjScaleAtCenterGeoKey = 3093 ProjAzimuthAngleGeoKey = 3094 ProjStraightVertPoleLongGeoKey = 3095 Aliases: ProjStdParallelGeoKey = ProjStdParallel1GeoKey ProjOriginLongGeoKey = ProjNatOriginLongGeoKey

	ProjOriginLatGeoKey = ProjNatOriginLatGeoKey ProjScaleAtOriginGeoKey = ProjScaleAtNatOriginGeoKey
Vertical CS Keys	VerticalCSTypeGeoKey = 4096 VerticalCitationGeoKey = 4097 VerticalDatumGeoKey = 4098 VerticalUnitsGeoKey = 4099

5. From CEOS

The aim of the Committee on Earth Observation Satellite (CEOS) superstructure format usually referred to, as simply CEOS format is to minimise the effort to read and write data products from similar Earth observation sensors. This is achieved by establishing a standard for a family of formats, and then making further recommendations for specific sensor classes (i.e. optical and SAR sensors).

The handling of data description information is very poor in CEOS files. When data is interchanged in CEOS files, there is a strong reliance on paper documentation to describe the parameters, especially in the Leader and Header files.

The following table lists the Metadata levels (sections) from the ICS (Interoperable Catalogue System) - System Design Document (SDD) Data Model.

- Product/Collection
- Spatial Reference/Coverage
- Attributes
- Contact
- Quality Product Stats
- Order
- Query?
- Platform Information
- Sensor Information

Additional metadata information shall be added to address the data fields from the following CEOS data records or fields. The radar parameters may be appropriate for a future version of the metadata standard.

6. From FGDC: Extensions for Remote Sensing Metadata (version 0.2)

Identification Information
- Aggregation Information (information relating a data set to its components or to data sets of which it is a member)
  - Container Packet ID
  - Component Information
- **Processing Level** (i.e. 0, 1A, 1B, 2, 3, 4)

Data Quality Information
- **Lineage**
  - Process Step
    - **Algorithm Information**

        - Algorithm Identifier
            - Algorithm Name
            - Algorithm Date
            - Algorithm Version
        - Algorithm Description
    - **Processing Information**
        - Processing Identifier
        - Processing Input
        - Processing Software
        - Processing Procedure
        - Processing Change History

Spatial Reference Information

- **Vertical Coordinate System Definition**
    - Altitude System Definition
    - Depth System Definition
- **Geolocation and Geocoding Information**
    - Ground Control Point
    - Time period of measurement
    - Grid Image Conversion (information describing mapping between image and grid)
        - Pixel System Origin
        - Pixel Resolution
        - Pixel Orientation
        - Grid Point Location
    - Pixel Description (description of the geometry of individual pixels)
        - Ground Shape (shape of pixel on ground)
        - Track Motion (direction and pattern of measurements relative to track)

Platform Information

- Mission Identification
- Mission Description
- Mission History
- Platform Identification
- Platform Description
- Orbit Information

Sensor Information

- Sensor Description
- Sensor Configuration
- Operational Mode

7. From International Society for Photogrammetry and Remote Sensing (ISPRS)- Image Transfer Standard (ITS)

- **Identification Information**
    - Flight Protocol
- **Data quality**
    - **Lineage**
- **Entity and Attributes Information**
- **Sensor Information**
    - Sensor description
    - Sensor type

- Frame
  - Geometric Properties
    - Calibration focal length
    - Calibrated focal length
    - Principle Point (x_0', y_0') of Autocollimation (PPA)
    - Principle Point of Symmetry (PPS)
    - Distorsion Type
      - Radial
      - Angle
      - Reseau
    - Quality of Focal Length
    - Quality of Principle Point
    - Date of last Calibration
  - Radiometric Properties
    - ZI dugurak frame camera

- Puchbroom
  - Geometric properties
    - Calibrated Focal Length
    - Number of Sensor-Pixels per Line
    - Calibrated x-Value of Sensor-Pixel in Camera-CS
    - Calibrated y-Value of Sensor- Pixel in Camera-CS
    - Time_Period_of_Measurement
    - Transformation from Camera-CS of 1^{st} to Camera-CS of 2^{nd} to n^{th} sensor
      - x-Position of Origin of Camera-CS (X_0)
      - y-Position of Origin of Camera-CS (Y_0)
      - z-Position of Origin of Camera-CS (Z_0)
      - omega
      - phi
      - kappa
    - Quality of Focal Length
    - Quality of Sensor-Pixel-Coordinates
    - Date of last Calibration
  - Radiometric properties
    - Number of bands
    - Band properties
      - Band_ID
      - Wavelength_Units
      - Short_Wavelength_Limit
      - Long_Wavelength_Limit
      - Calibration_Function
      - Field_of_View
      - radiometric correction code
    - LH digital cameras

- Whiskbroom

- Panoramic

- Radar

- Laser

- Sensor configuration
    - Sensor configuration description
    - Sensor configuration reference

- Operational mode
- Number of individual sensors in the complete sensor

- **Platform Information**
    - Mission_Identification
    - Mission_Description
    - Mission_History
    - Platform_Identification
    - Platform_Description
    - Orbit_Information

- **Spatial Reference Information**
    - Object Coordinate System
        - Ellipsoid
        - Datum
    - Model of Sensor Orientation
        - Central perspective
            - x-Position of Projection Center (X_0)
            - y-Position of Projection Center (Y_0)
            - z-Position of Projection Center (Z_0)
            - omega (roll)
            - phi (pitch)
            - kappa (yaw)
            - Time_Period_of_Measurement
            - gps-reading
            - Excentricity vector GPS to INS
                - Length of vector
                - Phi
                - Kappa
            - ins-reading
            - Excentricity vector INS to Projection Center of Camera
                - Length of vector
                - Phi
                - Kappa
            - Misalignment matrix INS to Camera Coordinate System
                - Time offset
                - Delta omega
                - Delta phi
                - Delta kappa
            - Accuracy Parameters of Exterior Orientation
            - Rotation sequence
            - Rotated or fixed axis
            - Aerotriangulation ID
        - Polynomial
            - Degree of polynomial
            - Polynomial coefficient
            - Other parameters according to OGC-Proposal
        - Ratio of polynomials
            - Degree of ratio

        - Polynomial coefficient
        - Other parameters according to OGC proposal
- Geolocation Information
    - Ground Control Points
        - X, Y, Z-Position of GCP
        - Type of GCP
        - ID of GCP (GCP-Number)
        - Status of GCP
        - Origin of GCP
        - Use-Flag of GCP
        - Horizontal Accuracy of GCP
        - Vertical Accuracy of GCP
    - Digital height model
        - X, Y, Z-Position of DHM-Points
    - Grid image conversion
        - Pixel system origin
        - Pixel resolution
        - Pixel orientation
        - Grid point location
    - Pixel description
        - Ground shape
        - Track motion
- Photogrammetric Block
    - Number of images
    - Image ID
    - Accuracy
- Stereomodel
    - 2-image Ids
    - 2 epipolar image-Ids
- Geocoding Information / Orthophoto
    - Lower Left Corner of Orthophoto
    - Height in Ground Units
    - Width in Ground Units
    - Size, Row-Direction
    - Size, Column-Direction
    - Angle to North, Azimuth
    - Resolution (Pixel-Size in Ground Units)
    - Rectification Method
        - Differential Rectification
        - Perspective Rectification
        - Reference Height
    - Interpolation Method
        - Nearest Neighbour
        - Bilinear
        - Bicubic
        - Lagrange

8. From White papers (Metadata Category)

In Herndon meeting (13-14 of December 1999), the project team (ISO/TC 211 – WG 1) discussed the Potential Imagery and Gridded Data Standards Components. The relevant sections/elements for defining Metadata are as follow:

- Platform Information
    - Mission identification
    - Platform Identification
    - Orbital Information
    - Platform Orientation

- Sensor Information
    - Sensor identification
    - Sensor configuration
    - Sensor orientation

- Sensor calibration
    - Geometric calibration
    - Radiometric calibration

- Lineage
    - Algorithm
    - Processing history
    - Processing parameters
    - Data processing procedures
    - Processing facility parameter
    - Radiometric correction
    - Radiometric data transformation tables
    - Radiometric compensation
    - Geoparameter calculation

- Geolocation/Gecoding
    - Ground Control Points (GCP)
    - Geometric correction
    - Data and time of recording
    - Characteristics of DEM used to generate geocode terrain height correction
    - Stereo model
    - Grid to image coefficients
    - Image orientation
    - Spectral resolution
    - Origin
    - Map projection information
    - Image coefficient information
    - Scale factor information
    - Image offset information
    - Reseau point

- Product Attributes
    - Product name
    - Product Identifier
    - Product content description
    - Minimum bounding box
    - Surface description

    - Image identifier
    - Quality
    - Image/Pixel classification
    - Data volume
    - Aggregation information

- Data dictionary
- Encoding description
- Data security information
- On-line documentation