Open Geospatial Consortium

CDB Multi-Spectral Imagery Extension

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Contents

i.   Abstract

The "Multi-Spectral Imagery" extension defines how to encode and store reflected electromagnetic radiation from the infrared wavelengths into a CDB. The portion of the spectrum targeted is between the visible spectrum (current imagery and texture in CDB), and longer wavelength infrared that is primarily emissive and can be simulated based on the material temperature.

ii.   Keywords

The following are keywords to be used by search engines and document catalogues.

ogcdoc, OGC document, CDB, simulation, synthetic environment, data store, infrared, NIR, near-infrared, SWIR, short-wave infrared, imagery

iii.   Preface

iv.   Submitting organizations

The following organizations submitted this Document to the Open Geospatial Consortium (OGC):

The OGC CDB Standards Working Group:

   http://www.opengeospatial.org/projects/groups/cdbswg

v.   Submitters

All questions regarding this submission should be directed to the editor or the submitters:

Name	Affiliation
William (Ryan) Franz	FlightSafety International
Holly Black	CACI International Inc.
Carl Reed	Carl Reed and Associates

1. Scope

The scope of this optional extension is to add non-visible reflected light energy that falls between red visible light and mid-wave infrared light energy that is primarily emissive. This extension is limited to only adding this new data type and does not change any existing requirements or structure of the CDB. This standard also attempts to harmonize with the existing component selectors of CDB in visual spectrum.

2. Conformance

This standard defines requirements for a Multi-Spectral extension of CDB.

Conformance with this standard shall be checked using all the relevant tests specified in Annex A (normative) of this document. The framework, concepts, and methodology for testing, and the criteria to be achieved to claim conformance are specified in the OGC Compliance Testing Policies and Procedures and the OGC Compliance Testing web site1.

3. References

The following normative documents contain provisions that, through reference in this text, constitute provisions of this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

OGC: OGC 15-115r3 Volume 1 *CDB Core Standard: Model and Physical Data Store Structure version 1.0*, 2016. https://portal.opengeospatial.org/files/?artifact_id=72712

OGC: OGC 07-011, Abstract Specification Topic 6: The Coverage Type and its Subtypes, version 7.0 (identical to ISO 19123:2005), 2007.

OGC: OGC 09-146r6, OGC Coverage Implementation Schema (CIS), 2015.

4. Terms and Definitions

This document uses the terms defined in Sub-clause 5.3 of [OGC 06-121r8], which is based on the ISO/IEC Directives, Part 2, Rules for the structure and drafting of International Standards. In particular, the word "shall" (not "must") is the verb form used to indicate a requirement to be strictly followed to conform to this standard.

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1 www.opengeospatial.org/cite

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

4.1
Coordinate Reference Systems
Coordinate system that is related to the real world by a datum
[ISO 19111:2007]

4.2
Direct Position
Position described by a single set of coordinates within a coordinate reference system.
[ISO 19123:2005]

4.3
Spectrum
The entire range of frequencies of electromagnetic radiation, and their respective wavelengths

4.4
Infrared (IR)
Electromagnetic radiation with wavelengths longer than those of visible light, approximately between 700 nm to 1.0 mm. The sub-divisions within the infrared spectrum are not fixed and vary between industries. The subdivisions used here are based on typical remote sensing usage, but are not fixed by a standard.

4.5
Near-Infrared (NIR)
The portion of the Infrared spectrum immediately longer than red visible light. In remote sensing applications, this is typically defined by the wavelengths detected by silicon sensors, and is usually defined as light in the 0.750 µm to 1.0 or 1.1 µm (400THz to 272 THz or 300THz) range. This light energy is reflected by most objects.

4.6
Short-Wavelength Infrared (SWIR)
The portion of the Infrared spectrum longer than Near Infrared. In remote sensing applications, this is typically defined as light in the 1.0 µm to 3.0 µm (100 – 300 THz) range. In these wavelengths, silicon is transparent and detectors are typically manufactured with gallium arsenide (GaA). These wavelengths are reflected by most objects, although a very hot object might emit energy in this range.

4.7
Mid-Wavelength Infrared (MWIR)
The portion of the Infrared spectrum consisting of wavelengths usually defined as 3.0 µm to 8.0 µm (37 – 100 THz). These wavelengths are typically emissive and from very hot objects, such as jet engines.

4.8
Long-Wavelength Infrared (LWIR)
The portion of the Infrared spectrum consisting of wavelengths usually defined as 8.0 µm to 15.0 µm (20 – 37 THz). These wavelengths are typically emissive and are generated from objects slightly higher than room temperature.

4.9
Far-Infrared (FIR)
The portion of the Infrared spectrum consisting of wavelengths between 15 µm and 1000 µm (0.3 – 20 THz)

5. Conventions

This section provides details and examples for any conventions used in the document. Examples of conventions are symbols, abbreviations, use of XML schema, or special notes regarding how to read the document.

5.1 Identifiers
The normative provisions in this standard are denoted by the URI

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http://www.opengis.net/spec/cdb-multi-spectral/1.0
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All requirements and conformance tests that appear in this document are denoted by partial URIs which are relative to this base. The three letter acronym "Req" is equivalent to the above URI.

6. Introduction

CDB defines datasets that represent the visual appearance of objects, from the terrain to buildings and trees, in the visible spectrum that humans can detect. CDB also contains material datasets that can help create representations of other wavelengths that can be detected, such as, passively emitted heat in the Mid- or Long-Wavelength Infrared (MWIR or LWIR) or reflected Radar (radio wavelengths). Image sensors that can detect wavelengths between the visible spectrum and Mid-Wavelength Infrared are becoming more prevalent, as is data on these wavelengths. In addition, this portion of the spectrum is primarily reflective, so the material information is insufficient to accurately replicate these wavelengths. This portion of the spectrum contains Near Infrared (NIR) and Short-Wave Infrared (SWIR) energy.

The need for data that comprise these wavelengths comes from the increasing number of sensors and data collections in this portion of the spectrum, as well as the commercial and military uses of this data. Several current commercial satellites collect NIR imagery, and several government satellites collect multiple bands of both NIR and SWIR imagery. In addition, available sensors of this data include night-vision that detect light energy

primarily in the NIR bands, and newer SWIR sensors that work well in low light and can "see" through haze and smoke in the atmosphere. One characteristic of these wavelengths is that most vegetation is highly reflective of this energy, and water is highly absorptive, which can aid in better feature recognition during poor visibility conditions by pilots and flight crews.

This extension defines three large wavelength bands within the near and short wavelength infrared wavelengths to store in CDB. The selection of these bands is influenced by the capabilities of remote sensors and the atmospheric transmission characteristics. Several commercial and governmental satellites collect data in these ranges, while avoiding wavelengths that water vapor in the atmosphere absorbs.

6.1 Relationship to ISO 19123 and OGC Coverage Implementation Schema (Informative)

Please note: This clause is informative. For this version of CDB, all extensions and related best practices shall remain 100% backwards compatible with existing CDB implementations and CDB Versions 1.0 and 1.1. While there has been considerable effort to align CDB 1.0 and CDB 1.1 with various elements, terms and definitions, and models documented in the OGC standards baseline, more harmonization work is needed. As such, CDB Version 2.0 will incorporate normative requirements from the OGC standards baseline, including specific requirements as specified in CIS.

SWIR data can be represented by a set of regular pixels (grid cells). A SWIR data set is of type grid regular and continuous coverage. This is a coverage that returns different values for the same feature attribute at different **direct positions** within a single spatial object, temporal object or spatiotemporal object in its domain. [ISO 19123].

Therefore, this CDB SWIR extension is conceptually grounded in the OGC Coverage Implementation Schema (CIS). CIS specifies the OGC coverage model by establishing a concrete, interoperable, conformance-testable coverage structure. CIS is based on the abstract concepts of OGC Abstract Topic 6 (which is identical to ISO 19123). ISO 19123 specifies an abstract model for coverages which is not per se interoperable. In other words, many different and incompatible implementations of the abstract model are possible. CIS, on the other hand, is interoperable in the sense that coverages can be conformance tested, regardless of their data format encoding, down to the level of single grid cell.

Coverages can be encoded in any suitable format (such as GML, JSON, GeoTIFF, TIFF, PNG, JPEG2000, GMLJP2, or NetCDF) and can be partitioned, e.g., for a time-interleaved representation. Coverages are independent from service definitions and, therefore, can be accessed through a variety of OGC services types, such as the Web Coverage Service (WCS) Standard. The coverage structure can serve a wide range of coverage application domains, thereby contributing to harmonization and interoperability between and across these domains. The SWIR extension uses JPEG2000 as the encoding format. JPEG2000 is used for compatibility with the current CDB standards baseline. Future version may include requirements for other encoding mechanisms that provide better performance, compression, and streaming capabilities.

More specifically, within the CDB SWIR extension, a grid of SWIR values is a type of a regular gridded coverage that has a grid as their domain set describing the direct positions in multi-dimensional coordinate space, depending on the type of grid. In the class *grid-regular*, simple equidistant grids are established.
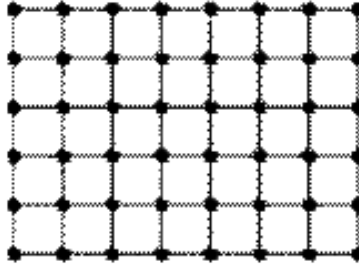
7. CDB Multi-Spectral Extension Requirement Clauses

Clause 7 defines the requirements for encoding and storing multi-spectral imagery and texture in a CDB. These dataset extensions follow the existing CDB requirements for the dataset type they occur within, as defined in the core CDB standard.

7.1 Extension Definition

Requirements Class Table Definitions	
/req/multi-spectral/filetypes	
Target type	Operations
Dependency	Various XML schema
Requirement 1	**Req/core/wavelength-ranges**
Requirement 2	**Req/core/channel-count**

7.2 Wavelength Ranges

The CDB Multi-Spectral Extension supports three spectral ranges. The first covers Near Infrared. The other two ranges cover the two portions of the Short-Wave Infrared band that the atmosphere is transparent to. Roughly in the middle of the SWIR bands is a large range of wavelengths that the atmosphere (water vapor) absorbs, which is not included in these ranges.

Requirement 1
http://www.opengis.net/spec/cdb-multi-spectral/1.0/core/wavelength-ranges
There *SHALL* be a maximum of three new infrared wavelength datasets. Multi-spectral data *SHALL* fall into one of the defined wavelength bands, defined by the following table:

Spectral Band Label	Nominal Wavelength Range	Nominal Frequencies	New CS1 values
NIR	0.74 – 1.0 micrometers	405 – 300 THz	1xx
SWIR1	1.5 – 1.8 micrometers	200 – 165 THz	2xx
SWIR2	2.0 – 2.5 micrometers	150 – 120 THz	3xx

Requirement 2
http://www.opengis.net/spec/cdb-multi-spectral/1.0/core/channel-count
There *SHALL* be only one channel of data in any multi-spectral data file. The file format *SHALL* be consistent with the existing dataset file types.

7.3 Terrain Imagery Extension

In a CDB data store, the Visible Spectrum Terrain Imagery (VSTI) is stored in the Tiled Imagery Dataset (CDB 1.0 Volume 1, Section 5.6.2). The new multi-spectral data files that represents the terrain imagery in the three defined wavelength bands will be stored alongside the existing VSTI using new component selector codes. This approach also uses the existing time of year alternate representations, due to vegetation being highly reflective.

In addition, this extension defines a subordinate light map representation that is appropriate for the wavelength range. This would represent any night-time light sources that transmit in these wavelengths, which might be different than the visual terrain light map.

7.3.1 File Type

This extension also conforms to CDB Volume 1, Section 5.6.2.1, where the file types in this dataset are JPEG2000. These files should also adhere to CDB Volume 1 Requirements 99 & 100. Specifically, these two requirements detail:

- The rules for metadata about the origin of data defined SHALL be implemented with a JPEG2000 image in the CDB data store; and
- The rules for metadata about the security of data defined SHALL be implemented with a JPEG2000 image in the CDB data store.

7.3.2 Updated Terrain Imagery Table

The extended Table 5-15 is below, with the new rows and CS1 and CS2 values highlighted.

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CS1	CS2	File Extension	Component Name	Component Description
Dataset 004, Imagery				
001	001	*.jp2	Yearly VSTI Representation	Corresponds to the terrain imagery draped (orthographically) over the terrain skin derived from the Primary Terrain Elevation Dataset. This is the preferred Dataset Component for year-round representative terrain imagery. It may be single-channel monochrome or 3-channel color image. This Dataset Component follows the center grid conventions. Can be used interchangeably with all other Alternate VSTI representations.
002	001..004	*.jp2	Seasonal VSTI Representations	Deprecated – Replaced with Quarterly VSTI Representations below
003	001..012	*.jp2	Monthly VSTI Representations	Monthly equivalent of Yearly VSTI representation, i.e., this is the preferred Dataset Component for month-based representative terrain imagery. Can be used interchangeably with all other Alternate VSTI representations.
004	001..004	*.jp2	Quarterly VSTI Representations	Equivalent to Yearly VSTI representation but for the selected quarter of the year. Can be used interchangeably with all other Alternate VSTI representations.
005	001	*.jp2	Subordinate VSTLM	Corresponds to the terrain light maps draped (orthographically) over the terrain skin derived from the Primary Terrain Elevation Dataset. It may be single-channel monochrome or 3-channel color image. This Dataset Component follows the center grid conventions.
101	001	*.jp2	Yearly NIR Terrain Imagery Representation	Corresponds to the Yearly VSTI Representation, but storing near infrared reflected light. This dataset is a single channel monochrome image.
103	001..012	*.jp2	Monthly NIR Terrain Imagery Representations	Corresponds to the Monthly VSTI Representation, but storing near infrared reflected light. This dataset is a single channel monochrome image.
104	001..004	*.jp2	Quarterly NIR Terrain Imagery Representation	Corresponds to the Quarterly VSTI Representation, but storing near infrared reflected light. This dataset is a single channel monochrome image.
105	001	*.jp2	Subordinate NIR Terrain Light Map	Corresponds to the VSTLM, but storing near infrared produced light. This dataset is a single channel monochrome image.
201	001	*.jp2	Yearly SWIR1 Terrain Imagery Representation	Corresponds to the Yearly VSTI Representation, but storing short-wave infrared reflected light. This dataset is a single channel monochrome image.
203	001..012	*.jp2	Monthly SWIR1 Terrain Imagery	Corresponds to the Monthly VSTI Representation, but storing short-wave infrared reflected light. This dataset is a single channel

			Representations	monochrome image.
204	001..004	*.jp2	Quarterly SWIR1 Terrain Imagery Representation	Corresponds to the Quarterly VSTI Representation, but storing short-wave infrared reflected light. This dataset is a single channel monochrome image.
205	001	*.jp2	Subordinate SWIR1 Terrain Light Map	Corresponds to the VSTLM, but storing short-wave infrared produced light. This dataset is a single channel monochrome image.
301	001	*.jp2	Yearly SWIR2 Terrain Imagery Representation	Corresponds to the Yearly VSTI Representation, but storing short-wave infrared reflected light. This dataset is a single channel monochrome image.
303	001..012	*.jp2	Monthly SWIR2 Terrain Imagery Representations	Corresponds to the Monthly VSTI Representation, but storing short-wave infrared reflected light. This dataset is a single channel monochrome image.
304	001..004	*.jp2	Quarterly SWIR2 Terrain Imagery Representation	Corresponds to the Quarterly VSTI Representation, but storing short-wave infrared reflected light. This dataset is a single channel monochrome image.
305	001	*.jp2	Subordinate SWIR2 Terrain Light Map	Corresponds to the VSTLM, but storing short-wave infrared produced light. This dataset is a single channel monochrome image.

7.3.3 Default Read Value

Client-devices should default the NIR and SWIR1/SWIR2 values if the data values are not available (files associated with the appropriate wavelength covered by a tile, at a given LOD or coarser, are either missing or cannot be accessed). The default value can be found in \CDB\Metadata\Defaults.xml and can be provided to the client-devices on demand. In the case where the default value cannot be found, the CDB standard recommends that client-devices use a default value of half-intensity (0.5). Note that the default values are expressed as floating-point numbers ranging from 0.0 to 1.0. This ensures that the default is interpreted in a consistent manner independently of the data representation.

7.4 Model Texture Dataset Extension

This extension extends Table 5-8 of Section 5.3 in adding new CS1 values for all texture types that describe visible light and not physical properties. This table contains model textures that can be found in one of the following CDB datasets:

- 301_GSModelTexture
- 511_GTModelTexture
- 601_MMModelTexture
- 306_GSModelInteriorTexture
- 507_GTModelInteriorTexture

7.4.1 File Types

The file types to represent multi-spectral data should be same type as the visual representation version.

7.4.2 Updated Model Texture Table

The highlighted rows are added by this extension.

Visual CS1 (Kind)	NIR CS1 (Kind)	SWIR1 CS1 (Kind)	SWIR2 CS1 (Kind)	CS2 (Index)	Component Name	Component Description
001	101	201	301	001	Year-Round Texture	Base textures for year-round usage on model shells or general base textures for model interiors.
002	102	202	302	001..012	Monthly Texture	Base textures for monthly usage on the shell of models (enumeration values in Annex O, details in section 6.13.5.2)
003	X	X	X	001..004	Seasonal Texture	Deprecated – Replaced with kind 009
004	104	204	304	001..999	Uniform Paint Scheme	Base textures for Moving Models with Uniform Paint Schemes (enumeration values in Annex O, details in section 6.13.5.2)
005	105	205	305	001..999	Camouflage Paint Scheme	Base textures for Moving Models with Camouflage Paint Schemes (enumeration values in Annex O, details in section 6.13.5.2)
006	106	206	306	001..999	Airline Paint Scheme	Base textures for Moving Models with Airline Paint Schemes (enumeration values in Annex O, details in section 6.13.5.2)
007	107	207	307	001..999	Shadow Map	Base textures of Moving Models Shadows to be projected onto terrain and/or culture (details in section 6.13.5.1.2)
008	108	208	308	001..999	Motion Blur Texture	Base textures for use with rotating parts (details in section 6.9.2.3)
009	109	209	309	001..004	Quarterly Texture	Base textures for quarterly usage on the shell of models (enumeration values in Annex O, details in section 6.13.5.2)
051	151	251	351	001..999	Night Map	Subordinate textures to simulate the effect of lights inside 3D model shells (details in section 6.13.5.3)
052	X	X	X	001..999	Tangent-Space Normal Map	Subordinate textures used to simulate the effect of irregular surfaces (details in section 6.13.5.5)
053	153	253	353	001..999	Light Map	Subordinate textures to simulate the effect of lights on surrounding surfaces (detail in section 6.13.5.4)
054	154	254	354	001..999	Contaminant	Subordinate textures to represent the presence of particles on runways, taxiways, and roads in general (enumeration

						values in Annex O, details in section 6.13.5.7)
055	155	255	355	001..999	Skid Mark	Subordinate textures to represent the visible mark left by any solid which moves against another one; especially marks of tires on roads and runways (enumeration values in Annex O, details in section 6.13.5.7)
056	X	X	X	001..999	Detail Texture	Subordinate texture used to add detail to the surface. In most cases, modelers use detail textures to add a finer scaled texture to the base texture (details in section 6.13.5.6)
057	157	257	357	001..999	Cubic Reflection Map	Subordinate textures to simulate reflective surfaces (details in section 6.13.5.8)
058	X	X	X	001..999	Gloss Map	Subordinate textures providing the glossiness of a surface on a per-pixel basis (details in section 6.13.5.9)
099	X	X	X	001	Night Map	Deprecated – Replaced with kind 051
				002	Bump Map	Deprecated – Replaced with kind 052
				003	Light Map	Deprecated – Replaced with kind 053

Annex A: Conformance Class Abstract Test Suite (Normative)

A.1   Conformance Test Class: OGC CDB Multi-Spectral Standard (Extension)

This section describes conformance tests for the OGC CDB Multi-Spectral Standard extension. These abstract test cases describe the conformance criteria for verifying the structure and content of any database claiming conformance to the CDB standard.

The conformance class id is "http://www.opengis.net/spec/CDB-multi-spectral/1.0/" and all of the other conformance tests URLs are created in this path.

Conformance Class	/conf/core	
Requirements	/req/core	
Dependency	JPEG 2000 format, generic model texture read algorithm	
Test 1	/conf/core/wavelength-ranges	
	Requirement	req/core/hierarchy
	Test purpose	Verify that, if data exists, the files contain one of the new Component Selector 1 values.
	Test method	Check each new file and verify that they are in an extended dataset, using one of the new Component Selector 1 values.
	Test type	Conformance
Test 2	/conf/core/channel-count	
	Requirement	/req/core/channel-count
	Test purpose	Verify that each new file has a single channel of data.
	Test method	Open the file and read the number of channels in the file
	Test type	Conformance

Annex B: Revision history

Date	Release	Author	Paragraph modified	Description