STANDARDIZATION DOCUMENT

Geospatial Intelligence Standard (Proposed)

Title: SENSOR INDEPENDENT DERIVED DATA (SIDD)
Volume 3, GeoTIFF File Format Description Document
Version 1.0 Final

Project: Documentation to describe the implementation of various SIDD products for data products generated by Synthetic Aperture Radar (SAR) systems and their data processing elements.

The scope of Volume 1 is the description needed by producers of SAR data to design a SIDD product that contains the image data and the set of metadata that describe it.

The scope of Volume 2 is to define the placement of SIDD data products in the NITF V2.1 image file format.

The scope of Volume 3 is to define the placement of SIDD data products in the GeoTIFF 1.0 format.

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NGA STANDARDIZATION DOCUMENT

SENSOR INDEPENDENT DERIVED DATA (SIDD)

Volume 3,

GeoTIFF File Format Description Document

Specification of the placement of SIDD data products
in the GeoTIFF 1.0 image file format.

(2011-06-03)

Version 1.0

NATIONAL CENTER FOR GEOSPATIAL INTELLIGENCE STANDARDS

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FOREWORD

The suite of Sensor Independent Derived Data (SIDD) standardization documents describe the implementation of various data products generated by Synthetic Aperture Radar (SAR) systems and their data processing elements.

SAR-derived image products, and their associated metadata, are grouped around common tasks for downstream users. The SIDD documentation provides specifications for these common tasks which are designed to support basic exploitation, geographic measurements, and proper visual display. Additionally, the documentation specifies the SIDD supported coordinate systems and product image pixel arrays. The real utility of SAR image collection is in the products and measurements that may be derived from it. The quality of the pixel array data along with the set of metadata provided are critical in generating the derived products. The "sensor independence" of the SIDD product refers to the ability of the allowed pixel array and metadata options to accurately describe the image products from different sensors and data processing systems. Sensor independence does NOT mean that all products have the same format for the pixel array or the same set of metadata parameters.

The SIDD documentation has been organized into four volumes:

Volume 1 is the description needed by producers of SAR data to design a SIDD product that contains the image data and the set of metadata that describe it.

Volume 2 defines the placement of SIDD data products in the NITF V2.1 image file format. Also provided is the description needed by users of SIDD products to read and properly extract the SIDD data components from a SIDD NITF product file.

Volume 3 defines the placement of SIDD data products in the GeoTIFF 1.0 image file format. Also provided is the description needed by users of SIDD products to read and properly extract the SIDD data components from a SIDD GeoTIFF product file.

Volume 4 consists of the XML artifacts used to describe the content of the various SIDD products.

A companion suite of standardization documents, collectively known as Sensor Independent Complex Data (SICD), describe standardized complex image products and measurements from which SIDD products may be derived.

The SICD and SIDD documentation and associated XML artifacts are available on the National System For Geospatial-Intelligence (NSG) Standards Registry (https://nsgreg.nga.mil).

Table of Contents

List of Tables

List of Figures

1 Introduction

1.1 Scope

The Sensor Independent Derived Data (SIDD) GeoTIFF File Format Description Document specifies the placement of derived image products into a GeoTIFF 1.0 file-format container. For this container file format, the following topics are covered:

- Capabilities & limitations
- File container organization
- File container metadata
- SIDD product metadata
- SIDD product image pixel data

The file name format for SIDD products is outside the scope of this standard and is left to the program-specific implementation profile.

1.2 Applicable Documents

The documents listed in Table 1-1 and Table 1-2 are referenced throughout this document. All reference documents are subject to revision, and users of this document should investigate recent editions and change notices.

Table 1-1 Government Documents and Publications

Number	Title & Website	Date
NGA.STND.0012_2.0	National System for Geospatial Intelligence metadata Foundation (NMF) - Part 1: Conceptual Schema Profile, Version 2.0 https://nsgreg.nga.mil/doc/view?i=2142	16 December 2010
NGA.STND.xxxx-1_1.0	Sensor Independent Complex Data (SICD) Design & Exploitation Description Document	12 February 2010 version 1.0.0
NGA.STND.xxxx-1_1.0	Sensor Independent Derived Data (SIDD) Design & Implementation Description Document	3 June 2011 version 1.0.0
NGA.IP.0001_1.0	Implementation Profile for Tagged Image File Format (TIFF) and Geographic Tagged Image File Format (GeoTIFF) https://nsgreg.nga.mil/	18 November 2008 version 1.0

Table 1-2 Other Applicable Documents

Number	Title & Website	Date
	GeoTIFF Format Specification, GeoTIFF Revision 1.0 http://www.remotesensing.org/geotiff/spec/geotiffhome.html	28 December 2000
	TIFF, Revision 6.0 Final http://partners.adobe.com/public/developer/en/tiff/TIFF6.pdf	3 June 1992

2 SIDD Products in GeoTIFF 1.0 Format

GeoTIFF 1.0 is a format for storing geo-referenced data and is an extension of the standard TIFF 6.0 format. SIDD products contained in a GeoTIFF 1.0 file container use GeoTIFF tags to

tie the raster image to a known model space. The GeoTIFF 1.0 and TIFF 6.0 specifications are referenced in Table 1-2.

The purpose of this section is to define the items below for SIDD GeoTIFF 1.0 products.

- Capabilities and limitations of GeoTIFF 1.0 file container for SIDD products
- SIDD GeoTIFF 1.0 file container metadata
- Placement of SIDD product metadata in GeoTIFF 1.0 container
- Placement of SIDD product image data in GeoTIFF 1.0 container
- SIDD GeoTIFF 1.0 file container organization

2.1 Capabilities and Limitations

The GeoTIFF 1.0 container file format can support SIDD products with one or more product images and can be generated from a single or multiple SICD inputs

The GeoTIFF 1.0 file format has a couple of limitations that impact SIDD products. The GeoTIFF 1.0 container file format is limited to 32-bit offsets, thus limiting the size of potential output products to 4 GB. Additionally, the GeoTIFF 1.0 file format does not readily support legends or other types of annotations.

The GeoTIFF file format conforms to the NGA GeoTIFF IP (Table 1-1) with the exception of the Appendix B.2. This means that only the geodetic gridded display, or GGD (see SIDD Design & Implementation document listed in Table 1-1) is allowed in SIDD GeoTIFF products. No chipped or rotated GeoTIFF is allowed by this specification (using the *GeometricChip* metadata). In addition, any compression of the GeoTIFF image data is strictly prohibited by the NGA GeoTIFF IP.

2.1.1 Future Considerations

A future version of this document may allow for SIDD GeoTIFF 1.0 products to use tiling instead of strips to store the image pixel data thus enabling faster loading for display tools. In addition, future versions of this specification will update to conform to NGA GeoTIFF IP Appendix B.2 which require the use of the NMIS schema for NMF conformance.

2.2 SIDD GeoTIFF 1.0 File Container Metadata

The purpose of this section is to specify all of the file container metadata that is required for populating a valid GeoTIFF 1.0 file. This section defines the Image File Header (IFH), Image File Directory (IFD), baseline TIFF tags, and GeoTIFF tags. Further information on the Image File Header, Image File Directory, and baseline TIFF tags are found in the TIFF specification document referenced in Table 1-2. More information on the GeoTIFF tags and keys can be found in the GeoTIFF specification listed in the same table.

2.2.1 Image File Header

The Image File Header is located in the first eight bytes of the SIDD GeoTIFF 1.0 products. The instructions for populating these eight bytes are described in Table 2-1. This information is also in Section 2 of the TIFF specification document.

Table 2-1 SIDD GeoTIFF 1.0 Image File Header Definition

Purpose	Bytes	Value	Comment
Specify Byte Order	Bytes 0-1	"MM" or "II"	Big-endian products will contain "MM", little-endian products contain "II"
File identifier	Bytes 2-3	"42"	Arbitrary but carefully chosen number that further indentifies the file as TIFF
IFD Offset	Bytes 4-7	Byte offset to first IFD	The offset in bytes of the first IFD. The byte offset is with respect to the start of the file

2.2.2 Image File Directory

An Image File Directory (IFD) exists for each product image in the SIDD GeoTIFF 1.0 file container. An IFD can be located almost anywhere in the file and its structure is defined in Table 2-2. The first IFD is located by using the IFD offset value in the Image File Header. When multiple IFDs exist in a file, the last 4 bytes of the N^{th} IFD point to the $N+1^{th}$ IFD. The length of the IFD is 2+12*A+4 bytes, where A is the number of entries in the IFD. More information regarding the Image File Directory definition is in Section 2 of the TIFF specification document.

Table 2-2 SIDD GeoTIFF 1.0 Image File Directory Definition

Purpose	Bytes	Value	Comment
Number of Directory Entries	2	# of directory entries	
Repeat the next 4 fields for each dictionary entry specified in the first 2 bytes			
Tag	2	Each entry has a unique tag number, see Sections 2.2.3 and 2.2.4 below.	Entries in an IFD must be sort ordered in ascending order by Tag.
Field Type	2	1-12, value depends on entry type	Specified in the sections below. Also see section 2 of TIFF specification
Number of Values	4	Number of values	
Value/Offset	4	If the *TotalSize* is larger than 4 bytes this field contains an byte offset, if not this field contains the value	*TotalSize* of the value is the size in bytes of *FieldType * Number of Values*
IFD entries complete			

Table 2-2 SIDD GeoTIFF 1.0 Image File Directory Definition			
Purpose	**Bytes**	**Value**	**Comment**
Next IFD offset	4	NULL or byte offset	The NULL value (0000) is used to denote that the IFD is the last IFD in the file. Otherwise a byte offset to the next IFD is given

2.2.3 Baseline TIFF Tags

The purpose of this section is to specify the baseline TIFF tags that are required by the SIDD GeoTIFF 1.0 products. The columns in Table 2-3 reference the entries in Table 2-2. The baseline TIFF tag definitions are expanded upon in Sections 2 through 8 of the TIFF specification document.

Table 2-3 SIDD GeoTIFF 1.0 Baseline TIFF Tag Definitions				
Name	**Tag #**	**Field Type**	**Number of Values**	**Value/Offset**
ImageWidth	256	Short (3) or Long (4)	1	Value – Generate
ImageLength	257	Short (3) or Long (4)	1	Value – Generate
BitsPerSample	258	Short (3)	8 or 16	Value – See Table 2-4
Compression	259	Short (3)	1	Value – 1
PhotometricInterpretation	262	Short(3)	1	Value – See Table 2-4
ImageDescription	270	ASCII (2)	Based on length of string	Offset – Populate with security marking for the image data and provide abstract description formatted as follows; *"SECURITY BANNER:* *(CAPCO security marking information as free text – should match SIDD XML)* *ABSTRACT:* *(SIDD filename)"*
StripOffsets	273	Short (3) or Long (4)	Based on stripping algorithm	Value – Generate
Orientation	274	Short (3)	1	Value – 1
SamplesPerPixel	277	Short (3)	See Table 2-4	Value – See Table 2-4
RowsPerStrip	278	Short (3) or Long (4)	Based on stripping algorithm	Value – Generate

Table 2-3 SIDD GeoTIFF 1.0 Baseline TIFF Tag Definitions				
Name	**Tag #**	**Field Type**	**Number of Values**	**Value/Offset**
StripByteCounts	279	Short (3) or Long (4)	Based on stripping algorithm	Value – Generate
XResolution	282	Rational (5)	1	Offset – 1,1
YResolution	283	Rational (5)	1	Offset – 1,1
PlanerConfiguration	284	Short (3)	1	Value – 1
ResolutionUnit	296	Short (3)	1	Value – 1 (no unit specified)
Software	305	ASCII (2)	Based on length of string	Offset – Populated equivalent to SIDD XML – *SIDD.ProductCreation.ProcessorInformation.Application*
DateTime	306	ASCII (2)	20	Populated equivalent to SIDD XML – *SIDD.ProductCreation.ProcessorInformation.ProcessingDateTime* Format - "YYYY:MM:DD HH:MM:SS" (19 bytes + terminating NULL)
Artist	315	ASCII (2)	Based on length of string	Populated equivalent to SIDD XML - *SIDD.ProductCreation.ProcessorInformation.Site*
ColorMap	320	Short (3)	See Table 2-4	Value – See Table 2-4

SIDD GeoTIFF 1.0 products can utilize five types of pixels as specified in the SIDD XML field *SIDD.Display.PixelType*. The instructions for populating the baseline TIFF fields to support these pixel types are shown in Table 2-4.

Table 2-4 SIDD GeoTIFF 1.0 Baseline TIFF Tag Instructions for Supported Pixel Types					
Field Name	**MONO8I**	**MONO8LU**	**MONO16I**	**RGB8LU**	**RGB24I**
BitsPerSample (258)	# of Values: 1 Value: 8	# of Values: 1 Value: 8	# of Value: 1 Value: 16	# of Values: 1 Value: 8	# of Values: 3 Value: 8,8,8
PhotometricInterpretation (262)	Value: 1	Value: 1	Value: 1	Value: 3	Value: 2
SamplesPerPixel (277)	Not used	Not used	Value: 2	Not used	Value: 3

Table 2-4 SIDD GeoTIFF 1.0 Baseline TIFF Tag Instructions for Supported Pixel Types					
Field Name	**MONO8I**	**MONO8LU**	**MONO16I**	**RGB8LU**	**RGB24I**
ColorMap (320)	Not used	Not used	Not used	# Values: 3*2^bitsPerSample :768 Value: User defined	Not used

2.2.4 GeoTIFF TIFF Tags

The purpose of this section is to specify the GeoTIFF TIFF tags that are required for SIDD GeoTIFF 1.0 products. The GeoTIFF TIFF tags are incorporated in the IFD with the same requirements (increasing order of tag number) as the baseline TIFF tags. For the purposes of this document, the baseline and GeoTIFF TIFF tags are split up to show the differences between the GeoTIFF requirements and TIFF requirements. The four GeoTIFF TIFF tags required by SIDD GeoTIFF 1.0 products are shown in Table 2-5.

Table 2-5 SIDD GeoTIFF 1.0 TIFF Tag Definitions				
Name	**Tag #**	**Field Type**	**Number of Values**	**Value/Offset**
ModelPixelScaleTag	33550	Double (12)	3	Offset – Scale of pixels. The ModelPixelScaleTag tag may be used to specify the size of raster pixel spacing in the model space units, when the raster space can be embedded in the model space coordinate system without rotation, and consists of (ScaleX, ScaleY, ScaleZ).
ModelTiepointTag	33922	Double (12)	6	Offset – Upper left corner. Specifies the point (I,J,K) where the location (I,J) is in raster space with pixel-value K and (X,Y,Z) is a vector in model space.
GeoKeyDirectoryTag	34735	Short (3)	Variable	Offset - See section 2.2.4.1
GeoAsciiParamsTag	34737	ASCII (2)	Variable	Offset - See section 2.2.4.1

2.2.4.1 GeoTIFF GeoKey Definition

The GeoTIFF 1.0 specification utilizes the four TIFF tags in Table 2-5 to geo-reference the raster image pixel data which is a sub-tagging structure, referred to as keys. Please refer to the TIFF 6.0 and GeoTIFF 1.0 specifications for detailed information regarding the file structure. In addition, the GeoKeyDirectoryTag Structure population instructions are defined in Table 2-6.

Table 2-6 GeoKeyDirectoryTag Structure				
Name	**Key # (Dec.)**	**TIFFTagLocation**	**Count**	**Value/Offset**
GTModelTypeGeoKey	1024	0	1	Value – 2 (Geodetic)
GTRasterTypeGeoKey	1025	0	1	Value – 1 (RasterPixelsArea)
GeographicTypeGeoKey	2048	0	1	Value – 4326 (GCS_WGS84)

2.3 SIDD GeoTIFF 1.0 SIDD Product Metadata

The purpose of this section is to specify how SIDD and SICD (if available) product metadata is included in the SIDD GeoTIFF 1.0 products. An existing GeoTIFF reader/writer can be updated to accommodate SIDD GeoTIFF 1.0 products by incorporating the information in this section.

Note that both SIDD and SICD XML are identified using one GeoTIFF tag for Geo_Metadata as specified by the NGA GeoTIFF IP (Table 1-1).

2.3.1 SIDD and SICD XML Tag Definition

The purpose of this section is to define how the SIDD and SICD XML metadata is included in the Image File Directory. The SIDD and SICD XML metadata is defined in the Sensor Independent Derived Data (SIDD) Design & Exploitation Description referenced in Table 1-1.

The Geo_Metadata TIFF tag number is 50909 is used to identify the location of SIDD metadata. Table 2-7 summarizes the definition of the SIDD GeoTIFF tag definition.

Table 2-7 SIDD GeoTIFF Tag Definition				
Name	**Tag # (Dec.)**	**Field Type**	**Number of Values**	**Value/Offset**
Geo_Metadata	50909	ASCII	Variable	Offset – See SIDD D&I Document

2.3.2 SIDD & SICD XML Field Definition

The SIDD & SICD XML metadata is included using the tag identified in Table 2-7. The SIDD XML data must be contained within this field. If SICD input data was used to create the product, then each SICD XML must be present in the value and should be separated by a NULL character. For example, the value of the field for a SIDD product generated from three SICD input products would look like the following:
{<SIDD_XML_Input>”NULL”<SICD_XML_Input_1>”NULL”<SICD_XML_Input_2>”NULL”
<SICD_XML_Input_3>}. The SICD XML metadata is defined in the Sensor Independent Complex Data (SICD) Design & Exploitation Description referenced in Table 1-1.

2.4 SIDD GeoTIFF 1.0 SIDD Product Image Pixel Data

The purpose of this section is to define how product image pixel data is stored in SIDD GeoTIFF 1.0 products. Product image pixel data is stored according to TIFF standards. SIDD GeoTIFF 1.0 products can use one of three TIFF pixel types: MONO, RGB/LUT, and RGB. Section 2.2.3 describes the metadata requirements for using these different data types. The TIFF 6.0 specification should be used as the primary reference for instructions in storing image pixel data in a SIDD GeoTIFF 1.0 product.

At present, the SIDD product image pixel data is stored in a single strip (RowsPerStrip = ImageLength). TIFF specifications allow for the data to be stored in strips or tiles, but the current recommendation is to utilize a single strip.

SIDD GeoTIFF products require that the Orientation tag is set to 1. The tag indicates that the first pixel in the strip refers to the visual upper left corner of the image. For RGB image pixel data, the PlanerConfiguration value of 1 indicates “chunky” storage. “Chunky” storage means that data is stored such that color channels are interleaved on a pixel by pixel basis, i.e., the 8 bit values would be read RGBRGBRGB where the first RGB value corresponds to the first pixel, the second RGB value corresponds to the second pixel, and so on.

2.5 SIDD GeoTIFF 1.0 File Container Organization

The purpose of this section is to define how the three basic components of the SIDD GeoTIFF 1.0 are organized. These include the GeoTIFF 1.0 file container metadata, SIDD product metadata, and SIDD product image data. Each of the three components is discussed in greater detail in Sections 2.2, 2.3, and 2.4 respectively.

The GeoTIFF 1.0 file container organization is identical, at the highest level, to the TIFF. However, the GeoTIFF 1.0 product format defines an additional set of required tags. A TIFF file starts with an Image File Header. The Image File Header points to the first Image File Directory (IFD). TIFF files can be organized in almost any manner because file offset pointers are used to reference the location of components.

For example, in a single image TIFF file, the data could be organized with the Image File Header, followed by the image pixel data, and ending with the IFD. The order could also be switched such that the IFD follows the Image File Header and the pixel data appears last. This is supported through the IFD which contains the metadata for its associated image. TIFF does not support sharing metadata across multiples images. Thus, the SICD input metadata must be included for each image of a multi-image SIDD GeoTIFF 1.0 product.

The following sections provide examples of the organization of SIDD GeoTIFF 1.0 products.

2.5.1 Single Product Image

The simplest SIDD GeoTIFF 1.0 product is a single product image generated from a single input SICD image. The basic organization of a SIDD GeoTIFF 1.0 product with single product image is shown in Figure 2.5-1.

The file begins with the Image File Header which points to the Image File Directory. The baseline TIFF tags, GeoTIFF tags, and SIDD/SICD XML tag are stored in the IFD by increasing tag number. The entries in figure below are a collection of tags, which are found in the IFD and are described in Section 2.2.

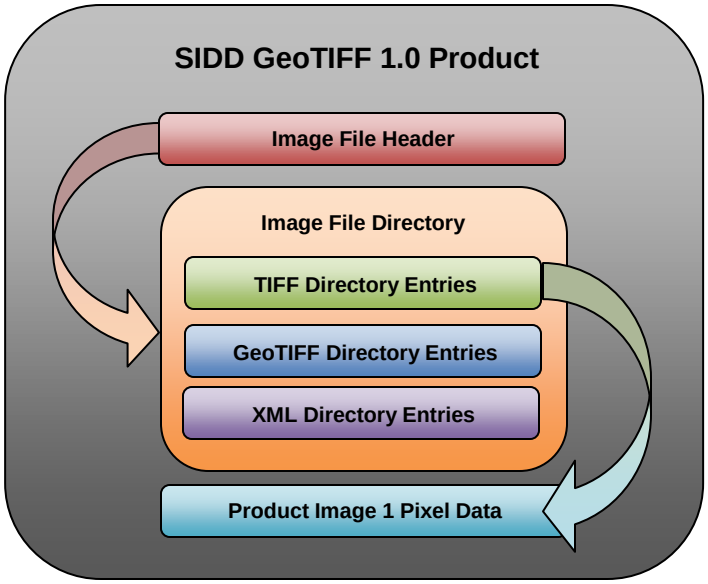

Figure 2.5-1 SIDD GeoTIFF 1.0 Single Product Image Example

2.5.2 Multiple Product Images

A more advanced SIDD GeoTIFF 1.0 product consists of multiple product images. In the TIFF specification, having multiple images in a single TIFF is referred to as having multiple subfiles, or pages. An example file organization of a SIDD GeoTIFF 1.0 with multiple product images is shown in Figure 2.5-2. All of the concepts that are related to a product with a single image apply to the multiple product image SIDD GeoTIFF file. The primary difference is that at the end of the first IFD an offset is given to the beginning of the next IFD.

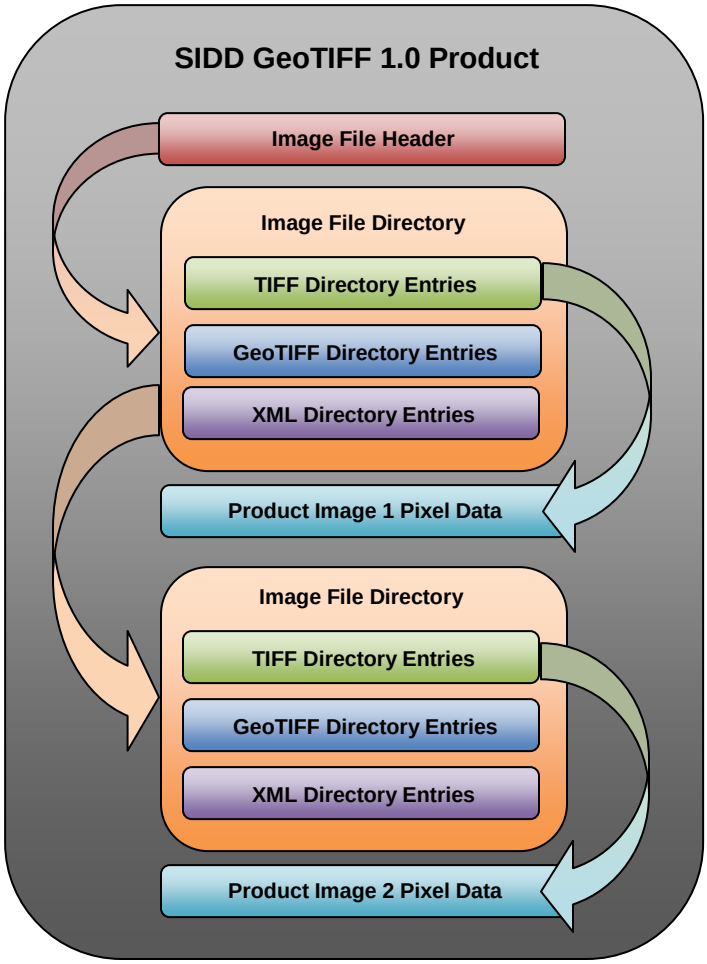

Figure 2.5-2 SIDD GeoTIFF 1.0 Multiple Product Image Example

Appendix A - Terms & Definition

Table A-1 Terms & Definitions	
Term	**Definition**
GeoTIFF	Standard for providing georeferencing data within a TIFF file
IFD	Image File Directory (GeoTIFF)
LUT	Lookup Table
RGB	Red-Green-Blue
SICD	Sensor Independent Complex Data.
TIFF	Tagged Image File Format – a public standard image container
XML	Extensible Markup Language