EXECUTIVE SUMMARY

This annex is part of the SDSFIE Raster (SDSFIE-R) standard issued by the Assistant Secretary of Defense for Energy, Installations & Environment (ASD (EI&E)), as part of the governance of installation geospatial information and services (IGI&S) under the authority granted in DoDI 8130.01. The IGI&S Governance Group (IGG) developed this standard (or “compendium of standards”) in order to foster coordinated and integrated approaches for IGI&S across the Department.

This annex to SDSFIE-R is a stand-alone reference of raster and related standards adopted, endorsed, recommended or referenced by the Department of Defense (DoD) via the DoD Information Technology Standards Registry (DISR). It is intended as a single comprehensive listing of a wide range of imagery and raster standards which have applicability to one or more organizations or missions within the community. It is not intended to prescribe or mandate the use of such standards. It includes both DISR and non-DISR standards in common use for IGI&S in the Active, Guard, and Reserve Components, as well as the US Army Corps of Engineers Civil Works community.
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1 Introduction

This annex to the SDSFIE Raster (SDSFIE-R) standard is a compendium of raster and related standards adopted, endorsed, recommended or referenced by the Department of Defense (DoD) via the National System for Geospatial Intelligence (NSG). It is intended as a stand-alone reference for the IGI&S community, providing a single comprehensive listing of a wide range of imagery and raster standards which have applicability to one or more organizations or missions within the community. It is not intended to prescribe or mandate the use of such standards.

1.1 Purpose

This compendium is designed as a stand-alone reference to the IGI&S community, providing a single comprehensive source for descriptions of a wide range of imagery and raster standards which have applicability to one or more organizations or missions within the community. It is not intended to prescribe or mandate the use of such standards. Please refer to SDSFIE-R section 2 for more prescriptive guidance. Many of these raster standards can be found in the DoD IT Standards Registry (DISR), but some exist outside of this formal structure.

1.2 Authority

In accordance with DoDI 8130.01, this document applies to installation geospatial information and services (IGI&S) and supplements the imagery guidance contained in the main SDSFIE-R document. IGI&S is applicable to the management of DoD installations and environment to support military readiness in the Active, Guard, and Reserve Components with regard to facility construction, sustainment, and modernization including the operation and sustainment of military test and training ranges, as well as, the US Army Corps of Engineers Civil Works community. Its applicability for other interested organizations is suggested but not mandatory.

1.3 Scope

This document includes all or nearly all known raster standards in common use for IGI&S missions and requirements. It is intended to include both DISR and non-DISR standards in common use for IGI&S in the Active, Guard, and Reserve Components, as well as the US Army Corps of Engineers Civil Works community.
2 Normative References

Attention is drawn to the possibility that some of the standards of this document are the subject of copyright or patent rights. Examples of copyrighted standards include the Tagged Image File Format and some International Standards Organization (ISO) standards. Examples of standards that include information that may be subject to patents include MPEG 2\(^1\) and GeoPDF.

The authors of this document shall not be held responsible for identifying any or all such rights, or the terms under which these rights are asserted. Portions of this document are paraphrased from documentation associated with each of the respective standards. No additional citations are given in the standard descriptions found in the sections below.

This compendium includes 12 normative references, described below.

2.1 ISO TC211 Standards for Imagery and Gridded Data

- ISO 19115-2:2009 Metadata – Extensions for imagery and gridded data
- ISO 19123:2005 Schema for coverage geometry and functions
- ISO TS 19129:2009 Geographic information -- Framework for Imagery and Gridded Data
- ISO TS 19130:2010 Geographic information -- Imagery sensor models for geopositioning
- ISO TS 19130-2:2014 Geographic information -- Imagery sensor models for geopositioning - Part 2: SAR, InSAR, LiDAR and SONAR
- ISO/TS 19139:2007 Geographic information -- Metadata - XML schema
- ISO 19156:2011 Geographic information -- Observations and measurements
- ISO 19159-1:2013 Geographic information -- Calibration and validation of remote sensing imagery sensors and data -- Part 1: Optical sensors (under publication)

2.2 Other ISO Imagery Standards

- ISO/IEC 15444-1:2004 JTC1 SC29 Portable JPEG2000 image coding system - Core coding system (+ amendments 1 to 3, and corrigenda 1 and 2)
- ISO/IEC 15444-9:2005 JTC1 SC29 Information technology -- JPEG 2000 image coding system: Interactivity tools, APIs and protocols (JPIP) (+ amendments 1 to 4, and corrigenda 1 to 3)

\(^1\) MPEG 2, MPEG 4, AVC, and MVC video technology patents are serviced by the MPEG LA patent license clearing house, representing over 1,000 patents applicable to the Motion Picture Experts Group (MPEG) H.262, H.264 video encoding standard.
2.3 Other Standards for Imagery, Elevation, Bathymetry, and Gridded Data

- American Society of Photogrammetry and Remote Sensing (ASPRS) LAS Domain Profile – Topographic Bathymetric LiDAR Profile
- International Hydrographic Organization Spatial Data Infrastructures – The Marine Dimension, IHO Publication C-17, Edition 1.1, February 2011

2.4 OGC Standards for Imagery and Gridded Data

- OGC GML in JPEG 2000 for Geographic Imagery (GMLJP2K) Encoding Specification (ref. OGC 05-047r3)
- OGC Observations & Measurements (Topic 20) (ref. OGC 10-004r3, aligned with ISO 19156)
- OGC Web Coverage Service Implementation Specification (WCS1.1.2) (ref. OGC 07-067r5)
- OGC Web WCS 2.0 Interface Standard - Core (ref. OGC 09-110r4) + KVP, XML/SOAP and XML/POST protocol bindings
- OGC GML Application Schema - Coverages (1.0.1) (GMLCOV) (ref. OGC 09-146r2)
- OGC Sensor Model Language (SensorML) (ref. OGC 07-000)
- OGC Sensor Model Language: SensorML 2.0: Model and XML Encoding Standard (ref. OGC 12-000)
- OGC Sensor Observation Service (SOS) (ref. OGC 06-009r6)
- OGC SOS, OGC Sensor Observation Service (SOS), version 2.0, OGC 12-006

2.5 NATO Standards (STANAGs)

- STANAG 4545 NATO Secondary Imagery Format (NSIF) Ed. 2 6/05/2013
- STANAG 4559 NATO Secondary Imagery Library Interface (NSILII) Ed 3 12/11/2010
- STANAG 7023 NATO Primary Image Format Ed 4 12/10/2009
- STANAG 4607 Ground Moving Target Imagery Format (GMTIF) Ed 3 14/09/2010
- STANAG 4609 NATO Digital Motion Imagery Format Ed 3 13/10/2009
- STANAG 2215 Evaluation of land maps, aeronautical charts and digital
- Topographic data Ed 7 13/07/2010 (including horizontal and vertical accuracies)
2.6 DGIWG Standards for Imagery

- **DGIWG GeoTIFF profile**  
  [DGIWG-GeoTIFF 2.0] STD-DR-08-89- GeoTIFF profile Ed2.0.3 30/01/2013  
  (https://portal.dgiwg.org/files/?artifact_id=5440&format=doc)

- **DGIWG GMLJP2 profile**  
  [DGIWG-GMLJP2 1.0] – DGIWG-STD-104 Ed 1.0 4/02/2014

- **STANAG 4387**  
  Arc standard raster products (ASRP) (also known as AGeoP5)  
  Version 1 12/05/1998 STANAG 7077 - Specification for  
  UTM/UPS standards raster products (USR) (also known as  
  AGeoP6) Version 1.2 13/07/1998 (cancelled in 2011)

2.7 Other Military “Legacy” Imagery Standards

- **STANAG 3809**  
  Digital terrain elevation data exchange format – version 4 Jan. 2004  
  (also US as Mil-PRF-89020B)

- **STANAG 7098**  
  Compressed arc digitized graphics (CADRG) Version 1.1 15/02/1999

- **STANAG 7099**  
  Controlled image base (CIB) Version 1.1 04/02/1999

2.8 De facto Imagery Standards

- GeoTIFF format specification - JPL-SI Corp. Revision 1.0, Version 1.8.2 28/12/2000

- TIFF format specification Aldus/Adobe. Final revision 6.0 3/06/1992

2.9 Motion Imagery Standards

- Motion Imagery Standards Profile (MISP)

- Advanced Authoring Format (AAF)

- MISB Aerial Surveillance and Photogrammetry Applications (ASPA) Profile [MISB ASPA]

- MISB Common Metadata System Structure [MISB RP 0701.0]

- MISB Large Volume Streaming Data (LVSD) Profile [MISB LVSD RP 0705.2]

- MISB Motion Imagery ID Recommended Practice [MISB MOID RP0608.1]

- MISB Security Metadata Universal and Local Sets [MISB ULS]

- MISB Sensor Minimum Metadata Set (MMS)[MISB SMMS 0902.1]

- Society of Motion Picture and Television Engineers (SMPTE) KLV Encoding

- Synchronized Multimedia Integration Language (SMIL)

- Unmanned Systems Interoperability Profile (USIP) No. 1 , Line of Sight Transmission of Motion Imagery for Battle Space Awareness (BA) Using Common Data Link (CDL) [USIP-1-LOS-MIBSA-CDL]

- Moving Pictures Exports Group (MPEG)
  - MPEG-2 [ISO/IEC 13818-1:2007]
2.10 **NGA National Imagery Standards (Emerging)**

- High Resolution Elevation (HRE) Product Profile Version 1.1 (approved for publication)
- Enhanced Compressed Raster Graphic (ECRG) (US MIL-PRF-32283) (21 February 2008)
- Enhanced Controlled Image Base (ECIB) (US MIL-PRF-32466, 26 June 2013)
- NITF Profile for Hyperspectral Imagery Version 1.0 (27 July 2011)
- NGA Sensor Independent Complex Data Version 1.0
- NGA Sensor Independent Device Data Version 1.0

2.11 **Other Raster-Related Standards**

The DoD Information Technology Standards and Profile Registry (DISR) is an online repository of Information Technology (IT) standards. DISR standards are to be used within DoD as the “building codes” for all new systems. The standards are intended to facilitate interoperability and integration of systems within the Global Information Grid (GIG). Continued emphasis on the use of commercial off the shelf and open source software means that the DISR may not cite standards that are in use in operational systems, as the raster standard ecosystem is constantly evolving. New standards, new revisions, and new standard profiles are developed and updated on a regular basis.

Raster standards do not exist in isolation of other data standards. Raster standards frequently incorporate or reference metadata standards, such as the ISO 19100 series for Geographic Information Standards, or in a complimentary manner, such as the standards enumerated in SDSFIE-V and SDSFIE-M.

2.12 **Standard Bundling**

Raster standards frequently bundle raster data, vector data and metadata to meet mission or system interchange requirements. Conversely some vector and multimedia standards incorporate raster data. Examples of this bundling include NITF, which is primarily an imagery standard, HDF a scientific data standard, Scalable Vector Graphics (SVG), primarily a vector graphics standard, and Advanced Authoring Format (AAF), which is primarily a multimedia/video standard. All of these standards combine raster data with other forms of data, and must therefore be included in compendium of raster standards.

2.12.1 **Bundling Data as HDF**

Sensor output such as LiDAR data presents a particular challenge to characterize. Processed LiDAR data may be stored as regular gridded digital elevation models, irregular 3D, multi-temporal point clouds, or triangulated irregular networks (TIN). With the exception of Hierarchical Data Format (HDF), no existing standard spans this data modality variety. HDF is widely used in the Earth sciences community to include climatology, meteorology, oceanography (e.g., weather forecasting, climate change) and GIS applications. It is an input/output format for some GIS applications, and for general scientific data exchange.
2.12.2 Bundling Data as NITF

NITF incorporates by reference, dozens of standards that define metadata encoding, image compression, messaging, elevation models, vector encoding, map projection encoding, and numerous other standards. The family of NITF related standards in particular leverages a complex web of inter-related, and interdependent standards that have evolved together to achieve mission requirements.

The NITF Technical Board (NTB) is the technical focal point within the Geospatial Intelligence Standards Working Group² (GWG) for imagery and imagery-related standardization activities within the community. The charter of the NTB includes standards related to:

- Still imagery and gridded data
- Imagery and gridded data formats and compression
- Graphical, textual, and other means to annotate imagery and imagery products
- Imagery-related support data, metadata and data quality
- Imagery-derived data and metadata, to include foundation data

For example, the NITF imagery standardization spawned several derivative standards that serve communities outside of DoD, including the NATO Imagery Standard (STANAG 4545), the ISO Basic Image File Format (ISO 12087 – Part 5), and the Open Skies File Format. The NITF Tagged Record Extension (TRE) and Data Extension Segment (DES) with NITF spawned the Digital Geographic Information Exchange Standard (DIGEST), developed by an international consortium³. In turn, DIGEST is referenced in the DISR as the map projection parameter standard.

Portions of the complex NITF standard ecosystem are cataloged in the Compendium of Controlled Extensions for NITF (STDI-0001), and in the Implementation Practices of the NITF Standard (STDI-0005).

The Motion Imagery Standards Board (MISB) is a standards body convened by GWG to oversee the development of video and motion imagery data and metadata interchange standards. MISB membership consists of Department of Defense, Intelligence Community, and Industry representatives that leverage existing video, imagery and metadata standards to promulgate interoperability between the NSG, Allied Systems for Geospatial-Intelligence (ASG), commercial industry and other systems.

In the section below, Enumeration of Raster Standards, a summary description each standard and relationships the standard and other standards will be provided.

3 Informative References

The following raster and raster-related standards (including those in sections 4-8) are organized functionally according to raster data utilization. Many common raster standards, such as PNG, JPEG, JPEG 2000, and TIFF have no inherent support for encoding geospatial data. Some raster image

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² The Geospatial Intelligence Standards Working Group (GWG) is a NSG forum that serves the National Geospatial-Intelligence Agency (NGA). The GWG recommendations for mandating standards for DoD are approved by the DoD Architecture and Standards Review Group (ASRG). Approved GEOINT standards are then cited in the DoD Information Technology (IT) Standards Registry (DISR).

³ Defense Geospatial Information Working Group (DGIWG) is a multi-national body responsible for geospatial standardization of the defense organizations of participating member nations.
standards, such as TIFF and JPEG 2000 have been extended to include geospatial metadata to allow geospatial data, such as raster maps, to contain map data.

### 3.1 BMP

The Bitmap File Format (BMP) is a de facto raster standard developed by Microsoft. BMP defines Device-Independent Bitmaps (DIBs) in various color resolutions. The Windows Metafile Format (WMF) specification is a proprietary standard that formally defined the BMP format.

BMP raster files are often larger than comparable images in other formats as BMP does not support internal compressed encoding. BMP files but may be packaged using standard compression algorithms such as ZIP, resulting in lossless compression.

### 3.2 Exif

Strictly speaking, Exif is not an image data standard, but an image metadata exchange standard for embedding metadata information within standard commercial image formats. Metadata includes about collection device parameters and settings create from devices such as cameras, sound recorders, scanners and smartphones. Exif establishes a schema for metadata embedded within formats such as TIFF, JFIF/JPG and audio files such as RIFF, Linear PCM, and u-law PMC. Exif is not supported in PNG, GIF, or JPEG 2000.

### 3.3 World File Format

World File Format is a convention for an auxiliary file to define map extents of an image file that does not otherwise define geospatial extent. A World File consists of 6 ASCII encoded numbers that express an affine transformation of the four corner points of the image, and assumes the image is map projected. Because the world file does not explicitly contain all of the map projection information required to completely specify the transformation, World File Format should not be used.

### 3.4 GeoPDF

GeoPDF® is an extension to the Adobe PDF file format from TerraGo Technologies that allows geospatial data to be represented as a map in a standard Adobe Systems PDF illustration. It has been adopted and published by the Open Geospatial Consortium (OGC) as “GeoPDF Encoding Best Practice Version 2.2” (08-139r2) to guide software developers creating GeoPDF documents. Note that GeoPDF is codification of an existing best practice, not an OGC standard.

GeoPDF® adds map frames with coordinate transformation matrices and dictionaries containing parameter values that define the datum, ellipsoid, and geodetic or projected coordinate reference system (CRS) required to represent geospatial data to be represented as a map. These map frames and dictionaries enable supporting software like the National Geospatial-Intelligence Agency (NGA) GEOTRANS library to perform bidirectional coordinate conversions between projected or geodetic CRS that describe the earth, including the one for geospatial data used to create an illustration, and the PDF coordinate system (CS). Multiple map frames may be embedded in a single page, and they can be nested to present map insets.
Plug-ins to the Adobe software can use coordinate transformation functions on GeoPDF documents to offer additional capabilities. Coordinate transformation from PDF CS to projected or geodetic CRS enables display of cursor positions in a map image to geographic positions, either for a static cursor position or dynamically during cursor movement. These geographic positions can be presented to the user in any geographic or projected coordinate reference system or location grid such as the U.S. National Grid (USNG) or military grid reference system (MGRS). Coordinate transformation from geographic CRS to PDF CS enables placement and zoom to a marker in a map illustration representing a user-specified position, such as that reported by a GPS device. For multiple points, coordinate transformations allow calculation of the distance and true bearing between points, angles between lines, and areas of polygons. A plug-in with access to a model of magnetic declinations at various points on the Earth's surface (the [National Geospatial-Intelligence US/UK World Magnetic Model] for 2005–2010) could also calculate the magnetic bearing between two points. A plug-in with access to a digital terrain model (DTM) could also report the elevation at a point covered by the DTM.

GeoPDF® can be used for storage, distribution, and visualization of static maps or spatially referenced images in disconnected environments. The OGC Web Map Service is the mandated standard for net access to data to be displayed as a map or spatially referenced image.

3.5 GIF

The Graphics Interchange Format (GIF) is a bitmap image format that supports up to 8 bits per pixel, allowing a single image to reference a palette of up to 256 distinct colors chosen from the 24-bit RGB color space. GIF supports 1 bit alpha transparency, progressive screen display, frame animations with separate palette of 256 colors for each animation frame. The color palette limitation leaves GIF unsuitable for reproducing color photographs and other images with continuous color, but it is well-suited for simpler images such as graphics or logos with solid areas of color. The JFIF/JPEG encoding standard is preferable to GIF when encoding photographic images.

GIF images are compressed using the Lempel-Ziv-Welch (LZW) lossless data compression technique to reduce the file size without degrading the visual quality.

The compression technique used in GIF was subject to a patent infringement claim on all commercial use, spurring the development of the Portable Network Graphics (PNG) standard as an alternative with free and unrestricted usage rights. Although all relevant patents applicable to GIF have expired, PNG has displaced GIF as the preferred encoding standard for non-photographic images.

3.6 Hierarchical Data Format (HDF) [HDF5]

HDF5 is a Hierarchical Data Format product designed to address some of the limitations of the older Hierarchical Data Format version 4 product originally developed by the National Center for Supercomputing Applications (NCSA) and the Lawrence Livermore National Laboratory, and to address current and anticipated requirements of modern systems and applications. HDF5 is currently developed, owned, licensed, distributed and maintained by The HDF Group.

HDF5 is a technology suite comprised of a data model, a file format and a software library for storing and managing extremely large and complex data collections such as those amassed in various scientific fields like environmental science, oceanography, and atmospheric modeling. It supports an unlimited variety of data types, and is designed for flexible and efficient I/O and for high data volume and complex data.
HDF5 is portable and is extensible, allowing applications to evolve in their use of HDF5. The HDF5 Technology suite includes tools and applications for managing, manipulating, viewing, and analyzing data in HDF5 format.

The open source HDF5 technology suite includes:

- A versatile data model that can represent very complex data objects including images, multidimensional arrays, structured and unstructured grids, structures, tables and text, relationships and dependencies among data objects, and a wide variety of metadata.
- Support for an unlimited variety of self-describing pre-defined and user-defined data types with definitions that include information on byte order and floating point representation to fully describe how data is stored, insuring cross-platform dataset portability.
- A completely portable file format with no limit on the number or size of data objects in the collection allows multiple storage layouts to support complex data subsetting.
- A software library that runs on a range of computational platforms, from laptops to massively parallel systems, and implements a high-level API with C, C++, Fortran 90, and Java interfaces which can be used to access HDF5 data or subsets without prior knowledge of the actual data format.
- A rich set of integrated performance features such as standard (Posix), parallel and network I/O drivers, data type and spatial transformation during I/O operations, and various compression, extensibility and chunking strategies that allow for access time and storage space optimizations.
- Tools and applications for managing, manipulating, viewing, and analyzing the data in the collection.

HDF5 is used worldwide by government, industry and academia in a wide range of science, engineering and business disciplines. Higher-level libraries, such as NASA’s HDF-EOS5 and Unidata’s netCDF-4 use HDF5 as the data management layer.

3.7 JPEG File Image Format (JFIF) [ISO/IEC 10918-5]

The file format commonly known as Joint Photographic Expert Group (JPEG) is actually the JPEG File Image Format (JFIF). The JPEG acronym actually refers to the Joint Photographic Experts Group, which is the name of the committee that created the JPEG compression algorithm standard. JFIF refers to a standard encoding of the JPEG algorithm support parameters.

The traditional JPEG algorithm standard specifies a discrete cosine transform (DCT) compression/decompression algorithm (codec) which defines how a still photographic image is compressed into a stream of bytes and decompressed back into an image. The DCT compression method is lossy, meaning that some original image information is not recoverable during the decompression process. Although the JFIF standard specifies an optional lossless mode, this mode is not widely supported in commercial products. Consequently, JFIF should not be used in scenarios where the exact reproduction of the data is required (such as some astronomical and medical imaging applications).

Although JPEG’s lossy compression can introduce visible artifacts into resulting image output, these artifacts can often be minimized, and the savings in file size even at high quality levels is much better than is generally possible with alternative lossless compression formats, with the exception of JPEG 2000 compression.
The file format for standalone JPEG compressed images is specified by ISO/IEC 10918-5, JPEG File Interchange Format (JFIF). In 1996, the Internet Engineering Task Force (IETF) Request for Comments (RFC) 2046 specified that the image format used for transmitting JPEG images across the internet should be JFIF. The Multipurpose Internet Mail Extensions (MIME) type of "image/jpeg" must be encoded as JFIF. The JFIF format does not include any of the advanced features found in the National Imagery Transmission Format Standard (NITFS), TIFF or other file formats that support JPEG compressed image encoding.

The JPEG algorithm standard does not specify a complete coded image representation. Such representations may include certain parameters, such as aspect ratio, component sample registration, and color space designation, which are application-dependent.

The JPEG compression algorithm is at its best on digitized photographs and paintings of realistic scenes with smooth variations of tone and color. JPEG is very popular for World Wide Web usage, where the amount of data used for an image is important, and loss of visual accuracy is less important. JFIF + EXIF (Exchangeable Image File Format) is also the most common format saved by digital cameras, and camera phones.

Conversely, the JPEG compression algorithm is not as well suited for line drawings, User Interface screen captures and other textual or iconic graphics, where the sharp contrasts between adjacent pixels can cause noticeable visual artifacts. Such images are better saved in a lossless graphics format such as Tagged Image File Format (TIFF), Graphics Interchange Format (GIF), Portable Network Graphics (PNG), or a raw image format.


The term "JPEG" is an acronym for the Joint Photographic Experts Group. This is that , the name of the committee that created the JPEG and JPEG 2000 standards. It is one of two sub-groups of the International Organization for Standardization (ISO) International Electrical Commission (IEC) (ISO/IEC) Joint Technical Committee 1, Subcommittee 29, Working Group 1 (ISO/IEC JTC 1/SC 29/WG 1), organized in 1986, which issued the first JPEG standard in 1992. In 2000 the JPEG sub-group created the JPEG 2000 standard as a discrete wavelet transform (DWT)-based compression method for still imagery to replace the original discrete cosine transform (DCT)-based JPEG standard. The JPEG 2000 standard was published as ISO/IEC 15444-1 and International Telecommunication Union (ITU) Telecommunication Standardization Sector (ITU-T) Recommendation T.800.

JPEG 2000 defines a set of lossless (bit-preserving) and lossy compression methods for coding bi-level, continuous-tone gray-scale, palletized color, or continuous-tone color digital still images. The standard:
• Specifies decoding processes for converting compressed image data to reconstructed image data;
• Specifies a code stream syntax containing information for interpreting the compressed image data;
• Specifies a file format;
• Provides guidance on encoding processes for converting source image data to compressed image data;
• Provides guidance on how to implement these processes in practice.

While there is a modest increase in compression performance of JPEG 2000 compared to JPEG, the main advantage offered by JPEG 2000 is the significant flexibility of the code-stream. The code-stream obtained after compression of an image with JPEG 2000 is scalable in nature, meaning that it can be decoded in a number of ways; for instance, by truncating the code-stream at any point, one may obtain a representation of the image at a lower resolution. Other JPEG2000 features include:

• Superior compression efficiency: At high bit rates, where artifacts become nearly imperceptible, JPEG 2000 has a small machine-measured fidelity advantage over JPEG. At lower bit rates (e.g., less than 0.25 bits/pixel for grayscale images), JPEG 2000 has a significant advantage over certain modes of JPEG: artifacts are less visible and there is almost no blocking. The compression gains over JPEG are attributed to the use of DWT and a more sophisticated entropy encoding scheme.
• Multiple resolution representation: JPEG 2000 decomposes the image into a multiple resolution representation in the course of its compression process. This representation can be put to use for other image presentation purposes beyond compression as such.
• Progressive transmission by pixel and resolution accuracy, commonly referred to as progressive decoding and signal-to-noise ratio (SNR) scalability: JPEG 2000 provides efficient code-stream organizations which are progressive by pixel accuracy and by image resolution (or by image size). This way, after a smaller part of the whole file has been received, the viewer can see a lower quality version of the final picture. The quality then improves progressively through downloading more data bits from the source. The 1992 JPEG standard also has a progressive transmission feature but it's rarely used.
• Lossless and lossy compression: Like JPEG 1992, the JPEG 2000 standard provides both lossless and lossy compression in a single compression architecture. Lossless compression is provided by the use of a reversible integer wavelet transform in JPEG 2000.
• Random code-stream access and processing, also referred as Region Of Interest (ROI): JPEG 2000 code streams offer several mechanisms to support spatial random access or region of interest access at varying degrees of granularity. This way it is possible to store different parts of the same picture using different quality.
• Error resilience: Like JPEG 1992, JPEG 2000 is robust to bit errors introduced by noisy communication channels, due to the coding of data in relatively small independent blocks.
• Flexible file format: The JP2 and JPX file formats allow for handling of color-space information, metadata, and for interactivity in networked applications as developed in the JPEG Part 9 JPIP protocol.
• Side channel spatial information: it fully supports transparency and alpha planes.

JPEG 2000 is not widely supported in web browsers, and hence is not generally used on the World Wide Web.
3.9 Scalable Vector Graphics (SVG)

Scalable Vector Graphics (SVG) is an XML-based vector and image encoding standard for two-dimensional graphics. Although SVG is primarily valued for its ability to encode vector graphics that can be scaled through a continuous range of zoom levels, the image support in SVG permits images to be encoded as text, and is useful when combined with vectors for displaying content such as icons or glyphs, particularly in modern web browsers. SVG has become a replacement for Computer Graphics Metafile (CGM) and has achieved much broader community acceptance and development support than CGM. Native support of SVG within modern browsers and mobile devices is not uncommon, although it is far from universal.

Like many standards, SVG standard compliance is not an all or nothing proposition. Various SVG support profiles and standard revisions exist that define the subset of SVG that must be supported to be compliant with a profile or standard. SVG 1.0 became a W3C recommendation in September 2001, and was deprecated by SVG 1.1 in January 2003. SVG Tiny and SVG Basic simultaneously become recommendations in January 2003. SVG Tiny 1.2 became a W3C recommendation in 2008, and SVG 1.1 Second Edition addressed errata from the earlier release. SVG 2 is currently being readied for standardization as of late 2014.

3.10 Tagged Image File Format (TIFF)

The Tagged Image File Format, better known as “TIFF”, is a file format standard for storing and interchanging raster images based upon a framework of extensible “tags” or fields. Although TIFF was developed to store data originating from scanners and frame grabbers, it has evolved into a general-purpose raster storage format. A primary goal of TIFF is to provide a rich environment within which applications can exchange image data. This richness was required to take advantage of the varying capabilities of imaging devices and value-added applications. Though TIFF is a rich format, it can easily be used for simple devices and applications as well because the number of required fields to describe an image is relatively small.

3.10.1 TIFF 6.0 Standard

TIFF is capable of describing panchromatic, palette-color, and full-color image data in several color spaces and various radiometric resolutions. TIFF has been extended using a number of compression schemes that allow developers to choose the best space or time tradeoff for their applications. TIFF is portable across computing environment. TIFF allows the inclusion of an unlimited amount of private or special-purpose information.

TIFF use is widespread in the commercial sector, but numerous public and private extensions may non-interoperability among disparate communities. Several defacto standard extensions that serve the geospatial community include TIFF Tiled Image Extension, GeoTIFF and BigTIFF. These extensions are consistent with the TIFF standard, yet are not part of the base standard and therefore impact interoperability, especially among consumer-sector tools outside of the geospatial community.
3.10.2 GeoTIFF

GeoTIFF is a public domain specification of the content and structure of a group of industry-standard tag sets which allow georeferencing information to be embedded within Aldus-Adobe’s public domain Tagged Image File Format (TIFF). These tag sets describe geographic and cartographic information associated with TIFF imagery that originates from such sources as satellite imaging systems, scanned aerial photography, scanned maps, digital elevation models, or as a result of geographic analyses. GeoTIFF tag sets may be used to represent map projections, coordinate systems, ellipsoids, datums, and other information needed to establish the spatial reference for the imagery or gridded data contained in a GeoTIFF file to relate a raster image to a geodetic model and map projection. They are orthogonal to the raster-data descriptions of the TIFF specification, and impose no restrictions on how the standard TIFF tags are to be interpreted, which color spaces or compression types are to be used, etc.

GeoTIFF uses a set of reserved TIFF tags to store a broad range of georeferencing information, catering to geographic as well as projected coordinate system needs. Projections include UTM, US State Plane and National Grids, as well as the underlying projection types such as Transverse Mercator, Lambert Conformal Conic, etc. No information is stored in private structures, IFD’s or other mechanisms which would hide information from naive TIFF reading software. GeoTIFF is fully compliant with TIFF 6.0 so that software incapable of reading and interpreting the specialized metadata tags will still be able to open a GeoTIFF format file, and should be able to display the image or scanned map data it contains.

GeoTIFF is widely supported by commercial Geographic Information Systems (GIS) and image processing packages, and is widely used within the Department of Defense Intelligence Community (DoD/IC) and its interactions with the civil sector and coalition partners.

Note that TIFF and GeoTIFF are publicly available specifications, yet are not currently established or maintained by accredited Standards Development or Standards Setting Organizations (SDO/SSOs). The Open Geospatial Consortium has convened a working group to maintain the GeoTIFF standard.

3.10.3 BigTIFF Convention

The official TIFF standard limits TIFF format files to 4GB, due to the file byte offset maximum inherent in the use of a 32 bit unsigned integer offset. A set of extension tags has been proposed to support files larger than the 4GB limit. This set of tags is an emerging, defacto standard known as “BigTIFF”. The BigTIFF standards specifies that the 64 bit tags used to support larges should not be used unless the resulting file exceeds the 4GB size limit of TIFF extensions. Because of the recommended practices, most applications will not require modification unless they are expected to handle files larger than 4 GB. Most systems do not handle images this large, and fail long before the 4 GB file size limit is reached. For those applications supporting very large files, the modifications required are relatively minor.

3.10.4 Implementation Profile of TIFF and GeoTIFF Version 1.0 [NGA.IP.0001_1.0]

An NGA implementation profile of GeoTIFF, NGA.IP.0001_1.0, was developed to help meet objectives for deployment of TIFF-related capabilities within the NSG that will also be widely supported within the civilian sector. Compliance with the implementation profile requires compliance with the TIFF and GeoTIFF specifications. The Implementation Profile for GeoTIFF, NGA.IP.0001_1.0, is applicable for use with uncompressed imagery, gridded data and transparency masks that have been geo-referenced
(ortho-rectified, geo-rectified or equidistant-sampled data). The profile is not applicable for supporting requirements for compression and non-rectified imagery within the NSG (see NITFS and JPEG 2000 DISR citations for these applications).

NGA.IP.0001_1.0 was revised and updated in NGA.IP.0001_2.0, described in the following section 4.10.5.

### 3.10.5 Implementation Profile of TIFF and GeoTIFF Version 2.0 [NGA.IP.0001_2.0]

The GeoTIFF and TIFF Implementation Profile specifies the high-level requirements and encoding rules that shall be used for the exchange of imagery and gridded data when opting to use the Tagged Image File Format (TIFF) and Geographic Tagged Image File Format (GeoTIFF) file format structures within the NSG. It constitutes a description of the bounds and constraints for the use of TIFF and GeoTIFF within the design objectives of promoting interoperability for the exchange of imagery and gridded data within the National System for Geospatial Intelligence (NSG).

The main body of this profile addresses the general approach for using TIFF/GeoTIFF within the general context of imagery and gridded data. Appendix A outlines the internal TIFF/GeoTIFF data structures and defines the rules for representing imagery and gridded data using the syntax, structure and coding scheme available within the TIFF/GeoTIFF format. Appendix B describes the additional data and/or metadata to be associated with each GeoTIFF file, and provides an example of supplemental metadata to include a sample XML-encoded instance document. Lastly, Appendix C defines the abstract test criteria for measuring conformance with this profile when representing imagery and gridded data using TIFF/GeoTIFF.

Users of NGA.IP.0001_2.0 are encouraged to develop application-specific product profiles to capture the detailed design for using TIFF/GeoTIFF within the context of the intended deployment of GeoTIFF-encoded data, services and capabilities. For example, an application-specific implementation may require that some of the TIFF/GeoTIFF tags be populated with specific values from this profile’s list of allowed values. Such an implementation would be a specialization of this profile. For the XML requirement, additional xml metadata beyond that required by this profile may be specified, as long as the extension is done in accordance with NSG metadata standards.

### 4 Elevation Standards

Elevation standards define the height of surfaces relative to a reference surface or vertical datum. Typical reference surfaces include Mean Sea Level (MSL), the Ellipsoid, or Height above the Ellipsoid (HAE), and the Geoid.

Because it is physically impossible to determine the mean sea level inland, MSL is calculated using the Earth Gravitational Model (EGM).

#### 4.1 American Society of Photogrammetry and Remote Sensing LiDAR [ASPRS/LAS]

The ASPRS LiDAR LAS standard describes a device independent encoding of point-cloud data derived from multi-return LiDAR sensor emissions. Data is generally organized in device-dependent scan collection order, with little attention to spatial coherence or co-locality of adjacent samples. Point cloud
data is irregularly gridded multi-value data. LiDAR returns represent timing delay and direction of signals reflecting off of one or more surface in the path of the LiDAR emitter. Multiple returns signify signals that passed through the first surface encountered (first return), and reflected to toward the sensor.

LiDAR point cloud data may be processed into a triangulated irregular network or resampled into a regular gridded data, such as a raster elevation encoded such as DTED. Both regular gridded and TINs typically represent only one surface, such as canopy, derived from first return, or bare surface (last return). Significant processing is required to derive these surfaces from the raw return data, and often contains anomalous data such as birds in flight, and building structures.

4.2 ASPRS LiDAR Topo-Bathy Lidar Domain Profile

ASPRS LAS version 1.4 supports the ability to customize the LAS file format to meet application-specific requirements such as underwater topography. The mechanism that makes this possible is the LAS Domain Profile, which is a derivative of the base LAS v1.4 specification that adds (but does not remove or alter existing) point classes and attributes. The Topo-Bathy Lidar Domain Profile adds point classification values for bathymetric point (e.g., seafloor or riverbed; also known as submerged topography), water surface, derived water surface, submerged object, IHO S-57 object, and bottom-not-found depth. Extra records are added for pseudo-reflectance, uncertainty, water column depth, figure of merit, and processing specific flags. Additional domain profiles in the future; proposed additional domain profiles should be provided utilizing the LAS Domain Profile Description Template.

4.3 Digital Terrain Elevation Data (DTED) [MIL-PRF-89020B]

The Department of Defense (DoD) Performance Specification: Digital Terrain Elevation Data (DTED), MIL-PRF-89020B (23 May 2000), which defines the requirements within the National Imagery and Mapping Agency’s (NIMA) (now National Geospatial-Intelligence Agency, (NGA)) Digital Terrain Elevation Data Base which supports various weapon and training systems. Revision B includes the Shuttle Radar Topography Mission (SRTM) DTED Level 1 and Level 2 requirements.

This standardized specification is widely implemented throughout the defense communities and supports various weapon and training systems. Data has been produced according to this specification for more than 35 years and forms the bulk of NGA’s elevation data holdings. The data is provided as a uniform matrix of terrain elevation values. It provides basic quantitative data for all military systems that require terrain elevation, slope, and gross surface roughness information. Data density depends on the level (0,1,2) produced. DTED supports many applications, including line-of-sight analyses, terrain profiling, 3-D terrain visualization, mission planning/rehearsal, and modeling and simulation. Data conforming to this standard is distributed by NGA Gateway dissemination and on disk media through the Defense Logistics Agency. Elevation measurements produced by the Shuttle Radar Topography Mission (SRTM) is also distributed in DTED form.

DoD/IC systems requiring terrain information must be capable of interpreting DTED-formatted data.
The DTED specification does not support high-resolution requirements and does not provide adequate metadata (compliant with ISO 19115)\(^4\). As a result, some NATO nations complement DTED data with external metadata, conformant with ISO TC211 metadata model and encoded according to ISO 19139. DTED (STANAG 3809) is being deprecated and should be cancelled in 2015, to be replaced by the DGIWG specification and implementation profile.

NGA developed a product specification for High Resolution Elevation data, with associated metadata conformant to ISO 19115 model, and data encapsulated under NITF / NSIF. HRE is being aligned with ESM and may be considered the US equivalent to ESM. This action was finalized with the delivery of NGA HRE product specification v1.0 October 2009. NGA support for the DTED product will continue during a transition period, but NGA has advised NATO of its intention to phase out DTED and discontinue support for it after 2020.

**Synopsis**

The DTED horizontal datum is World Geodetic System (WGS 84), and the vertical datum is Mean Sea Level (MSL) as determined by the Earth Gravitational Model (EGM) 1996. Individual DTED cells have an accuracy calculated based on collection and production methods and stored in the ACC record header.

Contemporary DTED is produced at three different levels of detail. The three classes of DTED are known as DTED Level 0, DTED Level 1; and DTED Level 2. A DTED data file describes a 1° by 1° cell. DTED 0 and DTED 1 products are delimited by whole degree latitude and longitude cells. DTED 0, DTED 1 and DTED 2 cells contain 121x121, 1201x1201 and 3601x3601 samples per arc degree, respectively, at nominal latitudes\(^5\). A DTED cell does not cross whole degree latitude or longitude lines.

The DTED Level 1 absolute horizontal accuracy standard is 90% Circular Error (C.E.) World Geodetic System (WGS) < 50 meters. The DTED Level 1 vertical accuracy standard is 90% Linear Error (L.E.) Mean Sea Level (MSL) <= 30 meters. The DTED Level 1 relative vertical accuracy standard (point to point) is 90% L.E. MSL <= 20 meters over a 1° cell.

The DTED Level 2 absolute horizontal accuracy standard is 90% Circular Error (C.E.) World Geodetic System (WGS) <= 23 meters. The DTED Level 2 absolute vertical accuracy standard is 90% Linear Error (L.E.) Mean Sea Level (MSL) <= 18 meters. The DTED Level 2 relative vertical accuracy standard (point to point) is 90% L.E. MSL <= 12 meters over a 1° cell for low and medium relief terrain (0 to 20% predominant slope), and 90% L.E. MSL <= 15 meters over a 1° cell for high relief terrain (greater than 20% predominant slope).

**4.4 Elevation Surface Model (ESM) Standardized Profile**

The Elevation Surface Model (ESM) Standardized Profile is a conceptual model and metadata dictionary that standardizes the information content required for the exchange of surface elevation information within and among DGIWG member nations. It specifies a data model that may be used to describe a variety of material surfaces such as bare earth, vegetation canopy, or bathymetric depth. The new capabilities allowed by the standardization of the information content of the ESM datasets will improve discovery, interoperability, and exploitation of the data. The ESM profile specifies a content model for geospatial

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\(^4\) DGIWG Imagery and Gridded Data Roadmap, [https://portal.dgiwg.org/files/?artifact_id=5653&format=doc](https://portal.dgiwg.org/files/?artifact_id=5653&format=doc), Sep 2014

\(^5\) Horizontal sample rate is reduced at extreme latitudes.
elevation surface data of any spatial resolution. It supports the modelling of material surfaces such as bare earth, vegetation canopy, and bathymetric surfaces. Four optional data structures are described: grids, Triangulated Irregular Networks (TIN), point coverages, and point sets. The grid, TIN and point coverage structures are defined by the ISO 19123:2005 coverage geometry classes. The geometry for ESM point sets is provided by the GM_Point class, defined in ISO 19107. These structures are the most commonly stored and exchanged by systems managing elevation data.

4.5 High Resolution Elevation (HRE) [NGA.IP.0002_1.0 2009-10-13] Standard

Cell coverage may be incomplete at DTED level 2 or higher, resulting in partial cells that do not cover an entire one arc-degree. DTED Level 1 is produced with only full one-degree cells with no voids. Voids are missing data on the perimeter of the cell. Unknown elevation data values that occur on the interior of a partial or complete cell are assigned a NO DATA value, corresponding to the smallest negative elevation data value possible (-32,767).

Elevation values within a lake with a diameter equal to or greater than 1200 meters for DTED Level 1 or with a diameter equal to or greater than 600 meters for DTED Level 2 must be identical. Sea or ocean elevation values for DTED Level 1 or DTED Level 2 shall be zero. Drains with a width equal to or greater than 183 meters shall be visible in the DTED data.

The land elevation values along shorelines and coastlines shall be higher than the adjacent water elevations. Extremely shallow land just interior to coastlines shall have +1 meter elevation to force proper land boundary portrayal.

Islands with the major axis equal to or greater than 600 meters for DTED Level 1 or 300 meters for DTED Level 2 shall be included in the DTED data. Smaller islands shall be included in the DTED data if the relief is equal to or greater than 15 meters above the water level.

All land or water bodies below mean sea level shall have negative elevations, not to exceed -32,766.

Requirements for DTED product files, a gazetteer file, file formats and encoding are also specified. DTED level 0 produce include additional support metadata files that define minimum, maximum and average elevation values for regular sub-regions within a one degree cell.

Relationship to other Standards


STANAG 3809 specifies the standard format for low and medium resolution elevation data for use within the DoD/IC and NATO, and it is widely implemented. The DTED format is incapable of supporting high resolution (12-meter or better) data and the additional metadata that it requires. Current expectation for elevation data is to support the DTED format and line of products until the 2020 timeframe. Prior to that time, a new specification will be published that will be applicable to elevation data at any spatial resolution. Currently, NGA.IP.0002_1.0, Implementation Profile for High Resolution Elevation (HRE) Products defines the format and content requirements for high resolution elevation data. It is aligned with
International Organization for Standardization (ISO) TC211 standards for geographic data. The new comprehensive specification will also be aligned with the Elevation Surface Model international standard.

4.6 **Elevation Surface Model (ESM), Edition 1, 18 June 2013**

The Elevation Surface Model (ESM) Standardized Profile [DGIWG STD_FD-13-05-ed 1.0.0] is a conceptual model and metadata dictionary that standardizes the information content required for the exchange of surface elevation information within and among DGIWG member nations. It specifies a data model that may be used to describe a variety of material surfaces such as bare earth, vegetation canopy, or bathymetric depth. The new capabilities allowed by the standardization of the information content of the ESM datasets will improve discovery, interoperability, and exploitation of the data. The ESM profile specifies a content model for geospatial elevation surface data of any spatial resolution. It supports the modelling of material surfaces such as bare earth, vegetation canopy, and bathymetric surfaces. Four optional data structures are described: grids, Triangulated Irregular Networks (TIN), point coverages, and point sets. The grid, TIN and point coverage structures are defined by the ISO 19123:2005 coverage geometry classes. The geometry for ESM point sets is provided by the GM_Point class, defined in ISO 19107. These structures are the most commonly stored and exchanged by systems managing elevation data.

4.7 **High Resolution Elevation (HRE) [NGA.IP.0002_1.0 2009-10-13]**

The HRE standard, formally known as the National Geospatial-Intelligence Agency (NGA) Standardization Document NGA.IP.0002_1.0 Implementation Profile for High Resolution Elevation (HRE) Products Specification, describes the data content, structure and metadata requirements required to create standardized high-resolution gridded elevation data products that support data discovery, access, processing, exploitation, and exchange. HRE defines these products as a set of standard horizontal spatial resolution layers.

The HRE data structure is a uniform, orthogonal grid-based geospatial elevation topographic model. The profile supports geographic (HREGP) and Universal Transverse Mercator projections (HRE80-HRE01), multiple spatial resolutions, and multiple elevation data coverages where the various coverages allow for different surface classifications, such as reflective surface or bare earth.

The horizontal spatial extent of HRE data vary based on a number of factors. These factors can include but are not limited to spatial resolution, geographic location, customer requirements, and file size. Typically as the horizontal spatial resolution of the data set increases (points are closer together geographically) the horizontal spatial extent decreases in size.

The HRE grid structure is represented by a collection of regularly or uniformly spaced points encoded as binary data values. This structure provides several advantages over other types of elevation geospatial data models in that a regular spacing of elevation points requires that only one elevation point be referenced to a horizontal coordinate. From this one point and its horizontal coordinate value and the ground sample distance (GSD) between grid elevation points, the horizontal coordinate values of all other points can be determined. This eliminates the need to explicitly define the horizontal coordinate values of each elevation point and helps to minimize file size. The grid structure is also an efficient structure for data processing.
The Horizontal reference datum for HRE data shall be the World Geodetic System - WGS-84 and the specific epoch will be identified in metadata. The baseline vertical reference datum for all HRE data stored at NGA will be ellipsoid height as defined by WGS-84. HRE data may optionally be distributed to customers referenced to the current Earth Gravitational Model (EGM) implementation of WGS-84. Metadata will be populated to indicate the vertical reference system.

The HRE data file format and structure is a profile of National Imagery Transmission Format (NITF) version 2.1. Metadata to support the HRE profile is found in the NITF header, sub-headers, Tagged Record Extension (TRE) and Data Extension Segment (DES) field values, including a required XML metadata DES that implements ISO 19123 (Geographic Information Schema for coverage geometry and functions), ISO 19115 (Geographic Information Metadata) and ISO 19139 (Geographic Information Metadata XML schema implementation) as applicable to elevation data.

HRE data quality characteristics are defined by five factors, as well as, goal levels for absolute horizontal and vertical accuracy:

1. Point spacing;
2. Random horizontal error per point;
3. Relative horizontal accuracy between points,
4. Random vertical error per point; and
5. The relative vertical accuracy between points.

The profile is an integral part of the overall NSG elevation strategy to adopt a two-tiered architecture, enabling storage and accessibility of native format data from a variety of sources. This data can be used to create a suite of standard elevation product layers for the traditional geospatial customer. The profile describes these standard products. This architecture will also enable customers within the NSG to access and exploit the native format data to create custom products for specific intelligence/application requirements. The custom products may or may not be addressed by this profile depending on the mission specific nature of the requirement.

NGA began data production according to this profile in 2010. HRE data is intended for a wide variety of National Geospatial-Intelligence Agency (NGA) and National System for Geospatial Intelligence (NSG) partners and Alliance System for Geospatial Intelligence (ASG) partners, and Joint Interagency, International and Multinational (JIIM) partners to access and exploit standardized data products. HRE data deprecates the current non-standard High Resolution Terrain Elevation/Information (HRTE/HRTI) products and also replaces non-standard products referred to as Digital Terrain Elevation Data (DTED) level 3 thru 6. This profile is not intended to replace standard DTED 0, 1 and 2 products which will continue to be supported by NGA, as DTED constitutes a world-wide landmass coverage databases. HRE-based products will be used by many NSG organizations, and customers external to the NSG that access and exploit standardized geospatial products.

**4.8 High Resolution Terrain Information (HRTI)**

The High Resolution Terrain Elevation/Information (HRTE/HRTI) specification has been deprecated in favor of the HRE standard, formally known as the National Geospatial-Intelligence Agency (NGA) Standardization Document NGA.IP.0002_1.0 Implementation Profile for High Resolution Elevation (HRE) Products Specification.
4.9 United States Geological Survey DEM (USGS DEM)

The U.S. Geological Survey (USGS) Digital Elevation Model (DEM) standard specifies collection, processing, production and quality control of digital elevation model (DEM) data intended for entry into the National Digital Cartographic Data Base (NDCDB), which is limited to the United States. USGS DEM files consist of ascii encoded elevation data and metadata records. USGS DEM files consist of 1024 byte blocks comprised of records consisting of a header record, multiple data records containing elevation post heights and a single trailer record containing quality control metadata.

USGS DEM's consist of five primary types of DEM data, consisting of 7.5 minute, 30 minute and 1 degree products covering the Contiguous United States and Hawaii, and 7.5 minute and 25 minute coverage of Alaska.

<table>
<thead>
<tr>
<th>Type</th>
<th>Grid Spacing</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.5 minute</td>
<td>NTE 30 meter square grid spacing in a UTM projection</td>
<td>7.5 minute cell coverage with horizontal grid spacing between 1 and 30 meters (10 or 30 meter typical). Each product provides the same coverage as a standard USGS 7.5-minute quadrangle without overlap.</td>
</tr>
<tr>
<td>30 minute</td>
<td>2 arc second square grid spacing</td>
<td>Four (2x2) 15 minute cell coverage with horizontal grid spacing of 2 arc seconds. Each product provides the same coverage one half of a standard USGS 30 minutes x 60 minute quadrangle.</td>
</tr>
<tr>
<td>1 degree</td>
<td>3 arc second square grid spacing</td>
<td>1 degree cell coverage with horizontal grid spacing of 3 arc seconds.</td>
</tr>
</tbody>
</table>

Table 1: DEM Product Types - Contiguous United States and Hawaii (excludes Alaska)

<table>
<thead>
<tr>
<th>Type</th>
<th>Grid Spacing</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.5 minute</td>
<td>1 x 2 arc second grid spacing (lat x lon)</td>
<td>7.5 minute cell coverage with horizontal grid spacing of 1 arc seconds latitude by 2 arc seconds longitude. Longitudinal cell limits vary between 10 minutes at southernmost latitudes to 18 minutes at northernmost latitudes.</td>
</tr>
<tr>
<td>15 minute</td>
<td>2 x 3 arc second grid spacing (lat x lon)</td>
<td>15 minute cell coverage with horizontal grid spacing of 2 arc seconds latitude by 3 arc seconds longitude. Longitudinal cell limits vary between 20 minutes at southernmost latitudes to 36 minutes at northernmost latitudes.</td>
</tr>
</tbody>
</table>

Table 2: DEM Product Types - Alaska

USGS DEM products are categorized into one of three quality levels, primarily determined by the nature of the originating source data.
**Accuracy Categorization**

7.5 minute DEM’s with Level 1 accuracy are produced with a maximum vertical Root Mean Square Error (RMSE) of 15 meters horizontal, with a target of 7 meters or less. 30 minute DEM’s with Level 1 accuracy have not set maximum RMSE.

DEM’s with Level 2 accuracy are produced with a maximum vertical RMSE not to exceed 50% of the contour interval of the source data.

DEM’s with Level 3 accuracy are derived from USGS Digital Line Graph. Level 3 DEM’s are produced with a maximum vertical RMSE not to exceed 1/3rd of the contour interval of the source data.

**Horizontal and Vertical Datum**

USGS DEM's may be referenced to NAD 27, NAD 82 or WGS horizontal datum, and to the National Geodetic Vertical Datum of 1929(NGVD-29) vertical datum and more recently, the North American Vertical Datum (NAVD-88).

**4.10 Encoding Elevation using JPEG 2000**

The use of JPEG 2000 lossless compression, combined with GML metadata encoding is an emerging practice to encode geospatial analytical data, such as terrain models, soundings and other raster data that is used beyond radiometric raster value visualization.

The use of GML metadata within a JPEG 2000 data stream is described in the GMLJP2, described in OGC standard GML in JPEG 2000 for Geographic Imagery Encoding Specification.

**5 National Imagery Transmission Format Standards Ecosystem**

National Imagery Transmission Formation Standard (NITFS) or simply “NITF”, encodes data as header segments, data segments, metadata extension segments, and data extension segments. The header segments and metadata extension segments of the standard uses an extensible encoding framework to describe metadata and data extensions.

**5.1 National Imagery Transmission Format Standard [NITFS]**

The NITFS is a multi-modality standard that is often associated with imagery, but has broader application across the DoD and JIIM community. NITFS encompasses image raster, metadata, vector, elevation, message, and complex imagery data. NITF is also used as the encoding transport for Raster Product Format (RPF) data standards, which include Controlled Imagery Base (CIB), Enhanced Controlled Imagery Base (ECIB), Compressed Arc Digitized Raster Graphics (CADRG) Enhanced Compressed Raster Graphics (ECRG),and Digital Point Positioning Database (DPPDB). Other data forms stored in as NITF using specific-purpose profiles include Tactical Hyperspectral Imagery (HSI), High Resolution Elevation (HRE), Sensor Independent Complex Data (SICD), Sensor Independent Derived Data (SIDD). NITF is also used to support Wide Area Motion Imagery (WAMI), and Wide Area Persistent Surveillance (WAPS).
5.2 NITF Tagged Record Extensions and Data Extension Segments

A metadata extension, known as a Tagged Record Extensions (TRE), or formerly Support Data Extension (SDE) are bundled in various profiles of NITF to group purpose-related TREs to meet specific mission objectives. One such example profile of NITF is the Raster Product Format (RPF), that describes specific bundling of metadata and data organization to define raster map products (CADRG and ECRG), image map products (CIB and ECIB), and targeting image database products (DPPDB).

NITF also defines a data extension standard, known as a Data Extension Segment (DES). Data Extension Segments definitions are similar to TREs, except that a DES includes a standard security header, and is intended to store extension data, rather than metadata, and therefore subject to fewer size limitations that TREs.

The NITF file header consists of groups of metadata fields that describe the file identification, origin, and security, its length and header length, and all of its image, graphic, reserved, text, data extension, and reserved extension segments.

NITF extension lifecycles are independent of the NITF revision cycle, and generally apply across multiple versions and revisions of the NITF standard.

5.3 NITF Related Standards

The NITF Technical Board maintains this list of baseline NITF-related standards. The standards are applicable to all raster image data and raster master data used within DoD:
## Test Program Plan:

| Compliance and Certification | N-0105-98 | NITFS Standards Compliance and Interoperability Certification Test and Evaluation Program Plan |

## Format:

<table>
<thead>
<tr>
<th>Format</th>
<th>MIL-STD-2500C</th>
<th>National Imagery Transmission Format Version 2.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>NITF 2.0</td>
<td>MIL-STD-2500A</td>
<td>National Imagery Transmission Format (Version 2.0) through NOTICE 3</td>
</tr>
<tr>
<td>NSIF 1.0</td>
<td>STANAG 4545 *</td>
<td>Standardization Agreement 4545 for NATO Secondary Imagery Format (NSIF)</td>
</tr>
<tr>
<td>Extensions</td>
<td>STDI-0001</td>
<td>National Support Data Extensions (SDE) (Version 1.3) for the National Imagery Transmission Format (NITF)</td>
</tr>
<tr>
<td>Extensions</td>
<td>STDI-0002</td>
<td>The Compendium of Controlled Extensions (CE) for the National Imagery Transmission Format</td>
</tr>
<tr>
<td>NCDDD</td>
<td>NSG-STD-002-05</td>
<td>National Geospatial-Intelligence Agency (NGA) Commercial Data Definition Document (NCDDD)</td>
</tr>
<tr>
<td>NCDRD</td>
<td>STDI-0006</td>
<td>National Imagery Transmission Format (NITF) Version 2.1 Commercial Dataset Requirements Document (NCDRD)</td>
</tr>
<tr>
<td>GeoTIFF</td>
<td>NGA IP for TIFF/GeoTIFF *</td>
<td>GeoTIFF and TIFF Implementation Profile</td>
</tr>
<tr>
<td>HRE</td>
<td>NGA.IP.0002_1.0 HRE *</td>
<td>High Resolution Elevation Product Specification</td>
</tr>
<tr>
<td>HSI</td>
<td>NGA.IP.0006_1.0 HSI *</td>
<td>NITF 2.1 Implementation Profile for Tactical Hyperspectral Imagery Systems</td>
</tr>
<tr>
<td>SICD</td>
<td>NGA.STND.0024_1.0</td>
<td>Sensor Independent Complex Data (vol. 1,2,3)</td>
</tr>
<tr>
<td>SIDD</td>
<td>NGA.STND.0025_1.0</td>
<td>Sensor Independent Derived Data (vol. 1,2,3)</td>
</tr>
<tr>
<td>XMLSIG</td>
<td>XMLSIG_1.0</td>
<td>XML Signature Implementation Specification for NSIF/NITF</td>
</tr>
</tbody>
</table>

## Compression:
<table>
<thead>
<tr>
<th align="center"><strong>JPEG 2000</strong></th>
<th align="center"><strong>BPJ2K</strong></th>
<th align="center">BIIF Profile for JPEG 2000 Version 01.10</th>
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</thead>
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<tr>
<td align="center"><strong>JPEG 2000</strong></td>
<td align="center"><strong>TRD</strong></td>
<td align="center">JPEG 2000 for NSIF Test Requirement Documents</td>
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<tr>
<td align="center"><strong>JPEG 2000</strong></td>
<td align="center"><strong>J2K GUIDE</strong></td>
<td align="center">Bandwidth Compression Guide for JPEG2000 Compression of Imagery</td>
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<tr>
<td align="center"><strong>JPEG 2000</strong></td>
<td align="center"><strong>J2K Test Plan</strong></td>
<td align="center">The JPEG2000 Test Plan</td>
</tr>
<tr>
<td align="center"><strong>Baseline JPEG Lossy</strong></td>
<td align="center"><strong>MIL-STD-188-198A</strong></td>
<td align="center">Joint Photographic Experts Group (JPEG) Image Compression through NOTICE 2</td>
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<tr>
<td align="center"><strong>Baseline JPEG Lossy</strong></td>
<td align="center"><strong>N-0106-97</strong></td>
<td align="center">Bandwidth Compression Standards and Guidelines Document</td>
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<td align="center"><strong>N-0106-97</strong></td>
<td align="center">Bandwidth Compression Standards and Guidelines Document</td>
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<td align="center"><strong>Downsampled JPEG</strong></td>
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<td align="center"><strong>MIL-STD-188-196</strong></td>
<td align="center">Bi-Level Image Compression, with NOTICE 1</td>
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<td align="center"><strong>MIL-STD-188-199</strong></td>
<td align="center">Vector Quantization Decompression, with NOTICE 1</td>
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<td align="center"><strong>ARIDPCM</strong></td>
<td align="center"><strong>MIL-STD-188-197A</strong></td>
<td align="center">Adaptive Recursive Interpolated Differential Pulse Code Modulation (ARIDPCM) Compression Algorithm: Capability to read legacy MIL-STD-188-197A ARIDPCM compressed files is optional; specific USIGS segments, libraries, may be required to use this standard to ensure translation capabilities. (For NITF 1.1 only)</td>
</tr>
<tr>
<td align="center"><strong>Graphics: CGM</strong></td>
<td align="center"><strong>BPCGM01.00</strong></td>
<td align="center">BIIF Profile for Computer Graphics Metafile (CGM)</td>
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<tr>
<td align="center"><strong>Communications Protocol: TACO2</strong></td>
<td align="center"><strong>MIL-STD-2045-44500</strong></td>
<td align="center">Tactical Communications Protocol 2 (TACO2)</td>
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<td align="center"><strong>Information Documents:</strong></td>
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<td align="center">Allied Engineering Documentation Publication</td>
</tr>
<tr>
<td align="center">NSIF Extensions List</td>
<td align="center">List of AEDP-4 approved TREs and DESs for NSIF</td>
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</tr>
<tr>
<td align="center">---------------------</td>
<td align="center">-----------------------------------------------</td>
<td align="center"></td>
</tr>
<tr>
<td align="center">BIIF Part 5</td>
<td align="center">ISO/IEC 12087-5: 1998(E) Basic Image Interchange Format</td>
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<tr>
<td align="center">STDI-0005, IPON</td>
<td align="center">Implementation Practices of The National Imagery Transmission Format Standard</td>
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<td align="center">RPC</td>
<td align="center">Generation and Application of RPC Uncertainty Parameters</td>
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<tr>
<td align="center">RPC</td>
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<tr>
<td align="center">STANAG-4607 *</td>
<td align="center">Standardization Agreement 4607 for NATO Ground Moving Target Indicator Format (GMTIF)</td>
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<tr>
<td align="center">STANAG-7023 *</td>
<td align="center">Standardization Agreement 7023 for NATO Primary Image Format</td>
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</tr>
</tbody>
</table>

Table 3: NITF Related Standards

5.3.1 National Imagery Transmission Format Version 2.1 [MIL-STD-2500C]

The National Imagery Transmission Format Standard (NITFS) is the suite of standards for formatting digital imagery and imagery-related products for storage, transfer, and exchange among Department of Defense (DoD), Information Community (IC), and North Atlantic Treaty Organization (NATO) members. NITF is the default format for still imagery interchange between systems, and is mandated in the DISR for imagery product dissemination.

This standard describes the National Imagery Transmission Format (NITF) file format and establishes its application within the NITFS. It specifies the valid data content and format for all fields defined within an NITF file. NITF provides a very flexible means to package imagery products. It supports the dissemination of digital imagery from overhead collection platforms and post-processed imagery-derived products. In the NITF product and overlay concept, an image product may conceivably consist of the following:

a. A correlated set of multiple NITF files.
b. A single NITF file with multiple images, each with their own overlays and associated data.
c. An NITF file with no image.
d. A single NITF file with a single image and its overlays and associated data.

NITF image segments may contain images in the following categories: visible imagery, side looking radar, thermal infrared, forward looking infrared, radar, electro-optical, optical, high resolution radar, hyperspectral, color frame photography, black and white frame photography, synthetic aperture radar, SAR radio hologram, infrared, multispectral, fingerprints, magnetic resonance imagery, x-rays, CAT
scans, video, barometric pressure, water current, water depth, and wind air charts. An NITF image is a two-dimensional rectangular array of pixels indexed by row and column. A pixel is represented by an n-vector of sample values; where n corresponds to the number of bands comprising the image. Image data may be sequential, blocked or interleaved, and either uncompressed or compressed using an algorithm from one of the following standards: ITU-T T.4 (1993.03), AMD2 08/95, ISO/IEC 10918-1, ISO/IEC 12087-5, ISO/IEC 15444-1/4, and NGA-N0106-97.

Graphic data is used in the NITF to store two-dimensional pictorial information represented as a Computer Graphics Metafile (CGM) as described in ISO/IEC 8632-1. Such graphic data may be used to represent legends, vector overlays, arrows, and other textual, graphical, and symbolic annotations of digital imagery and raster maps.

Text segments contain text that is intended to convey information, such as annotation, about an associated segment in the NITF file. Text may be encoded with BCS codes, as Message Text Format (MTF) containing BCS-A characters formatted according to MIL-STD-6040, as ECS characters, or as U8S (ISO-Latin subset of UTF-8) characters.

NITF extensions allow the functionality of encoded data to be expanded with minimal impact on the underlying standard. These extensions are add to the NITF file to encapsulate information while maintaining backward compatibility. The data extension identifier and byte count mechanisms allow software developed prior to the addition of newly defined data to skip over extension fields that they were not designed to interpret.

There are three types of data extensions: Tagged Record Extensions (TRE), Data Extension Segments (DES), and Reserved Extension Segments (RES). A TRE, formerly known as a Support Data Extension (SDE) is a collection of data fields that provides space within the NITF file structure for adding, as yet unspecified, future capabilities to the standard. There are two TRE types: Controlled Extensions (CE) and Registered Extensions (RE). CEs are submitted for approval by the NITFS Technical Board (NTB) and are then maintained under formal configuration management control. CEs are described in the STDI-0001 and STDI-0002 Compendiums of Controlled Extensions. Reserved Extensions allow NITF users to establish user defined data constructs within an NITF file without NTB consensus by reserving the name of an extension without specifying the structure of the extension.

Extension segments are designated for future use and provide a mechanism for further expansion of the NITFS standard. Guidance on applying the suite of standards composing NITFS can be found in STDI-0005, Implementation Practices of the NITFS (IPON).

### 5.3.2 National Imagery Transmission Format Version 1.1

NITF version 1.1 has been deprecated and does not provide the functional capabilities required of modern imagery formats. Systems should limit NITF 1.1 interoperability to read-only functionality. Systems should write NITF version 2.0 or 2.1 as required by their SoS interoperability requirements.

### 5.3.3 National Imagery Transmission Format Version 2.0 and 2.1

MIL-STD-2500C, the National Imagery Transmission Format (Version 2.1) for the National Imagery Transmission Format Standard was adopted on 1 May 2006. MIL-STD-2500C was developed to keep the imagery format consistent with the emerging ISO Basic Imagery Interchange Format (BIIF) and the NATO
Secondary Imagery Format (NSIF). Previous revisions of NITF 2.1, MIL-STD-2500B and MIL-STD-2500A, were adopted on 22 August 1997 and 12 October 1994, respectively.

5.3.4 **NATO Secondary Imagery Format (NSIF) [STANAG 4545]**

NITF version 2.1 is the US documentation equivalent of STANAG 4545, NATO Secondary Imagery Format (NSIF), version 1.0. NITF/NSIF is applicable to the exchange of still imagery among NATO nations. The NATO Air Forces Armaments Group (NAFAG), Joint Intelligence, Surveillance and Reconnaissance Capabilities Working Group (JISRCWG) sponsors a Custodial Support Team (CST) for STANAG 4545; the CST and the NITFS Technical Board (NTB) closely coordinate standardization activities related to Mil-Std-2500B and STANAG 4545. These standards are both profiles of ISO/IEC 12087-5, Basic Image Interchange Format (BIIF).
5.3.5  National Support Data Extensions (SDE) for NITF [STDI-0001 v1.3]

The National Imagery Transmission Format (NITF) National Support Data Extensions Version 1.3/CN2 in
STDI-0001. This image metadata standard specifies the support data for specific National Technical
Means (NTM) assets encoded as Tagged Record Extensions (TRE), formerly known as Support Data
Extensions (SDE). NITFS is a DoD and Federal Intelligence Community suite of standards for the
exchange, storage, and transmission of digital-imagery products and image-related products. NITFS is
the common thread of interoperability for the formatting, storage, cataloging, discovery, retrieval,
dissemination, and exploitation of National Technical Means (NTM), Tactical Airborne, and Commercial
imaging sources. TREs/SDEs are a collection of data fields that provide space within the NITFS file
structure for adding parameters and metadata to enhance NITFS functionality (e.g. discovery and
retrieval in a net-centric environment). STDI-0001 provides the approved configuration managed
(controlled) Tagged Record Extensions (TREs) specifications to be used with the NITFS for the NTM
assets identified within the document. TRE implementation compliance requirements are defined in NGA
document, N0105, NITFS Standards Compliance and Interoperability Test and Evaluation Program Plan.

STDI-0001 is a compendium of NTM related TRE specifications specific to NTM sources, system
specifications, statements of work, and similar acquisition and design.

See STDI-0005, Implementation Practices of the NITFS, known as the (IPON), at

STDI-0001 is applicable to systems that task, collect, process, store, catalog, discover, retrieve,
disseminate, exploit and/or otherwise use NTM data formatted using the NITFS. STDI-0001 is applicable
to data from those specific NTM source assets identified within the standard.

5.3.6  The Compendium of Controlled Extensions for NITF [STDI-0002-1_4.0]

The National Imagery Transmission Format Standard (NITFS) is the suite of standards for formatting
digital imagery and imagery-related products for storage, transfer, and exchange among Department of
Defense (DoD), Information Community (IC), and North Atlantic Treaty Organization (NATO) members.
The NITF provides a very flexible means to package imagery products. It supports the dissemination of
digital imagery from overhead collection platforms and post-processed imagery-derived products.

This Controlled Extension (CE) compendium provides the approved, configuration managed (controlled)
TRE specifications to be used with NITF version 2.0 (NITF2.0) and version 2.1 (NITF2.1). It provides the
technical specifications and implementation requirements that United States Imagery and Geospatial
Information Service (USIGS) systems must support when implementing NITFS CEs. Specific
implementation requirements denoting which extensions should be implemented by the various USIGS
systems are defined in the N0102, USIGS Interoperability Profile (UIP). NITF2.0 CE implementation is
defined in MIL-STD-2500A. NITF2.1 CE implementation is defined in MIL-STD-2500C. TRE
implementation compliance requirements are defined in NGA document, N0105, NITFS Standards
Compliance and Interoperability Test and Evaluation Program Plan.

This Controlled Extension (CE) compendium contains extensions grouped in appendices. Each appendix
containing extensions has its own version number and date to simplify incorporating future changes.
Acronyms for and descriptions of these extensions are shown in the following table:
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICHIPB</td>
<td>The standard means whereby any recipient of a chipped image containing SDEs from the original full image, regardless of system or application, will be able to access the necessary data and apply a mensuration tool to the image chip in a uniform and consistent manner.</td>
</tr>
<tr>
<td>PIAE</td>
<td>The Profile for Imagery Access Image Support Extensions provide an area for fields not currently in NITF but that are contained in the Standards Profile for Imagery Access (SPIA).</td>
</tr>
<tr>
<td>CSDE</td>
<td>The Commercial Support Data Extensions include a standard ID extension that contains image identification data that supplements the NITF image subheader, an exploitation usability extension to allow a user program to determine if the image is usable for the exploitation problem currently being performed, a Stereo Information (STREO) extension that provides links between several images forming a stereo set to allow exploitation of elevation information, an exploitation and mapping support data extension to support accurate geo-positioning and mensuration.</td>
</tr>
<tr>
<td>ASDE</td>
<td>The Airborne Support Data Extensions incorporate all SDEs relevant to synthetic aperture radar (SAR), visible electro-optical (EO), infrared (IR), multispectral (MSI), and hyperspectral (HSI) primary imagery.</td>
</tr>
<tr>
<td>IOMAPA</td>
<td>This tagged extension contains the data necessary to perform the output amplitude mapping process for each scan within each image frame. This post-processing is applied after the image data has undergone the data expansion process using the 12-bit JPEG/DCT algorithm.</td>
</tr>
<tr>
<td>BCKGD</td>
<td>This extension is used for scaling National Imagery Transmission Format (NITF) images and overlays for the purposes of printing and for setting background color.</td>
</tr>
<tr>
<td>NBLOCA</td>
<td>This extension stores the offsets of each image frame relative to each other within a National Imagery Transmission Format (NITF) image, which allows the NITF image to be accessed in a random or parallel fashion by providing the ability to find the offset to the location of the first data byte of any frame or block.</td>
</tr>
<tr>
<td>OFFSET</td>
<td>This extension defines the offset of the first pixel of an NITF 2.0 image from the first pixel of the full image described by the accompanying support data. If the NITF 2.0 image is blocked differently from the full image, or is not aligned to the full image block structure, this extension allows the NITF 2.0 image to be located relative to the full image, such that the support data can be used properly.</td>
</tr>
<tr>
<td>RULER</td>
<td>Although still maintained on the Tagged Record Extension (TRE) registry for legacy purposes, this TRE is no longer used.</td>
</tr>
<tr>
<td>HISTOA</td>
<td>This extension provides a history of the softcopy processing functions that have been applied to NITF image pixels, and the current state of the image pixels.</td>
</tr>
<tr>
<td>CMETAA</td>
<td>This extension provides a foundation for interoperability in the interchange of Synthetic Aperture Radar (SAR) imagery and SAR imagery related data among applications.</td>
</tr>
<tr>
<td><strong>ENGRDA</strong></td>
<td>This Engineering Data SDE provides support to any real-time sensor system where NITF is the direct output format. Engineering data may include built-in-test results, operational status, operational modes, and other information such as temperatures and specialized information for the collecting system.</td>
</tr>
<tr>
<td><strong>MITOC</strong></td>
<td>The Multi-image Scene (MiS) Table of Contents extension provides a means to allow a collection of images (a multi-image scene), collected over a designated coverage area, to be treated as if it were a single image scene. This includes sensors collecting multiple images in order to image the full scene and sensors which image the same footprint multiple times.</td>
</tr>
<tr>
<td><strong>GEOSDE</strong></td>
<td>The Geospatial Support Data Extensions are for extraction of geo-referenced imagery, matrix, or raster map data formatted according to North Atlantic Treaty Organization (NATO) Standardization Agreement (STANAG) 4545 in accordance with the extensions described in STANAG 7074, Digital Information Geographic Exchange Standard (DIGEST) Part 2 Annex D (DIGEST - Part 2, Annex D).</td>
</tr>
<tr>
<td><strong>SRTM</strong></td>
<td>The Shuttle Radar Topography Mission Terrain Height Error Data TRE is used to provide cell and sub-cell attribute information that describes null and negative elevation postings and those postings in the data that are associated with water bodies. Additionally, Systematic Height Error Spectral Component information is also provided. The THEDSA TRE is used in conjunction with the following DIGEST GeoSDEs to fully describe the error data: GEOPSB, GEOLOB, ACCHZB and ACCVTB.</td>
</tr>
<tr>
<td><strong>NSDE</strong></td>
<td>The National Support Data Extensions are documented in STDI-0001, National Support Data Extensions (SDE).</td>
</tr>
<tr>
<td><strong>NCDRD</strong></td>
<td>The Commercial Dataset Requirements Document STDI-0006 specifies the requirements for imagery datasets generated by Commercial Data Providers (CDP) and delivered to the United States Government (USG) at the designated delivery ingest. It includes detailed layouts of each TRE and DES used.</td>
</tr>
<tr>
<td><strong>RPF</strong></td>
<td>The Raster Product Format shall be integrated into NITF as defined in MIL-STD-2411-2. Three TREs to support extraction of RPF images from NITF formatted files are found in RPF-formatted products.</td>
</tr>
<tr>
<td><strong>RSM</strong></td>
<td>The Replacement Sensor Model is a general sensor model designed to replace the full functionality of virtually any imaging sensor model. Eight TREs support an adjustable ground-to-image function and an error covariance that provides for rigorous error propagation.</td>
</tr>
<tr>
<td><strong>DPPDB</strong></td>
<td>Digital Point Positioning Data Bases (DPPDBs) are developed by the National Geospatial-Intelligence Agency (NGA) over user-specified areas to provide a capability for deriving accurate positional data on a quick-response basis for any identifiable feature within a DPPDB area. Thirteen TREs are found in DPPDB products.</td>
</tr>
<tr>
<td><strong>ATTPTA</strong></td>
<td>The Attribute Points SDE TRE provides a mechanism for assignment of a spatial location to a row/column pixel of an image array.</td>
</tr>
</tbody>
</table>
Table 4: Controlled Extensions for NITF Acronyms and Definitions

<table>
<thead>
<tr>
<th>BANDSB</th>
<th>The General Purpose Band Parameters TRE supplements information in the NITF image subheader where additional parametric data are required.</th>
</tr>
</thead>
<tbody>
<tr>
<td>J2KLRA</td>
<td>The Joint Photographic Experts Group 2000 Layers Extension TRE was primarily developed to allow providers and users of NSIF Preferred JPEG 2000 Encoding (NPJE) data to quickly access the compressed data, but is available to be used by other encodings. It provides users information about number of resolution levels, number of quality layers, and number of bands in both the original data and derived products.</td>
</tr>
</tbody>
</table>

5.3.7 Implementation Practices of the NITF (IPON)

Members of the Geospatial Intelligence Standards Working Group (GWG) NITFS Technical Board (NTB) compiled best common practices in STDI-0005 Implementation Practices of the NITFS as an aid to those involved with the implementation and use of the NITFS. The content is based upon common practices, procedures, and guidelines used in fielded systems that have successfully implemented the NITFS. To meet a wide range and variety of imagery-related functional requirements, the NITFS has many combinations of implementation options to select from. Those implementing the NITFS should select and apply common practices to meet operational requirements whenever practicable.

These practices describe the application of the NITFS suite of standards in support of interoperability among systems within the National Systems for Geospatial Intelligence (NSGI), systems that interface with the NSGI, and commercial systems that implement the NITFS. The suite of standards that comprise the NITFS has evolved over time to meet the requirements of user systems. These practices address implementation topics for the NITFS associated with National Imagery Transmission Format (NITF) version 1.1, NITF version 2.0, and NITF version 2.1. Many of these practices are also suitable for use with Standardization Agreement 4545, North Atlantic Treaty Organization (NATO) Secondary Imagery Format (NSIF). Both NITF version 2.1 and NSIF version 1.0 are now documented in the NSIF01.00 Profile of ISO/IEC 12087-5, Basic Image Interchange Format (BIIF).

STDI-0005 Implementation Practices of the NITFS cover three broad areas – general NITFS implementation compliance, common NITFS implementation practices and guidelines, and architecture-related NITFS implementation guidelines. NITFS compliance criteria are intended to strike a balance between fully implementing all the requirements in the standards and the planned operational requirements of the actual system(s) implementing the standard. The history of imagery systems is replete with examples of systems being deployed for use in environments for which they were not originally intended to operate. This fact drives the need to establish baseline requirements from the standards that are applicable to all implementations regardless of perceived operational requirements. Where clear architectural guidance exists, the applicable test criteria for the required services and features will be selected from among the criteria established in this plan.

Common NITFS implementation practices and guidelines address the following topics: general guidelines, originating station identification, product identification and file naming, date and time fields, security fields, file background color, originator’s name and phone number, image representation, image category and product discovery attributes, ICORDS/IGEOLO, image and data compression, reduced resolutions, image data mask tables, NITFS common coordinate system, overlays (image, graphic symbol and text), text segments, tagged record extensions, data extension segments, and NITFS usability.
Within the NSGI architecture there has evolved separate communities or sub architectures each with unique requirements; i.e., National, Airborne/Tactical. At the same time the objective NSGI architecture provides a homogeneous environment where data can easily be accessed and used between these individual communities, across the Global Information Grid (GIG). The NITFS has been designed to provide sufficient functionality to serve the entire NSGI community. The features supported by the NITFS fall into required and optional areas. This allows the acquisition community to properly size NITFS capable systems such that program costs are reduced while still affording a baseline level of interoperability across the NSGI. Full interoperability at the user level can only be achieved, however, if the optional NITF features are properly selected for support during the acquisition process. This encompasses understanding the data flow and interfaces involved with the subject system.

These practices do not of themselves establish implementation requirements. NITFS implementation requirements are detailed in appropriate requirement documents, system specifications, interface specifications, statements of work, etc. Those involved with developing requirements, preparing specifications and acquisition documents, and implementing the NITFS should cite or draw from the information in this document to promote consistent application of the NITFS throughout the digital imagery enterprise.

5.3.8 National Geospatial-Intelligence Agency National Imagery Transmission Format (NITF) 8.3.8 Version 2.0 Dataset Definition Document (NNDDD) [NSG-STD-001-05]

This document provides the current definition of commercial imagery datasets provided in National Imagery Transmission Format (2.0) (NITF) to elements of the National Geospatial-Intelligence Agency (NGA) for dissemination to worldwide customers and follow-on applications. Specifically, this standard establishes the definition of Commercial Imagery (CI) products, support data, and data management messages used within the National System for Geospatial-Intelligence (NSG). This standard profile is the single collection point for all commercial imagery data format definitions as well as data content and format specifications for all interface messages and support data files which are used within the NSG to manage the acquisition and exploitation of commercial image products. This document is the parent document for other data definition documents related to commercial image products – specifically the NGA NITF 2.0 Dataset Definition Document (NNDDD) and NGA National Imagery Transmission Format (NITF) Version 2.1 Commercial Dataset Requirements Document (NCDRD).

Commercial Data Provider (CDP) specifications, developed by and for the National Geospatial-Intelligence Agency (NGA), govern specific products, product formats, and support files that are delivered to NGA by each High Resolution CDP product image.

5.3.9 NITF 2.0 Commercial Data Definition Document (NCDDD) [NSG-STD-002-05-A]

This standard defines the interfaces, messages and product formats for all commercial imagery sources used within the NSG. The term Unclassified Library refers to the Unclassified National Information Library (UNIL) and/or the Unclassified St. Louis Information Library (USTIL) until UNIL retirement.

This document defines the interfaces, messages and product formats for all commercial imagery transactions within the NSG. The term Unclassified Library refers to the Unclassified National Information Library (UNIL) and/or the Unclassified St. Louis Information Library (USTIL) until UNIL retirement.
5.3.10 National Imagery Transmission Format (NITF) Version 2.1 Commercial Dataset Requirements Document (NCDRD) [STDI-0006]

The National Imagery Transmission Format Standard (NITFS) is the suite of standards for formatting digital imagery and imagery-related products for storage, transfer, and exchange among Department of Defense (DoD), Information Community (IC), and North Atlantic Treaty Organization (NATO) members. The Version 2.1 Commercial Dataset Requirements Document (NCDRD) provides the requirements for commercial imagery datasets provided by Commercial Data Providers (CDPs) in National Imagery Transmission Format (NITF) Version 2.1 to elements of the United States Government (USG) including the National Geospatial-Intelligence Agency (NGA) for dissemination to worldwide customers and follow-on applications.

Section 2 of the NCDRD covers the high-level requirements for commercial datasets. It describes the format of commercial datasets, dataset identifiers, and the population of NITF headers and sub-headers. The section includes a discussion of the wideband data format, JPEG 2000 compression methods, and image segment data field definitions. It concludes with alphabetically ordered lists of each Tagged Record Extension (TRE) and each Data Extension Segment (DES) defined for CDPs, as follows:
<table>
<thead>
<tr>
<th>Type</th>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRE</td>
<td>CSCCGA</td>
<td>The Cloud Cover Grid Data TRE provides support data that identifies which image segment and sensors were used to create the cloud grid.</td>
</tr>
<tr>
<td>TRE</td>
<td>CSCRNA</td>
<td>The Corner Footprint TRE provides the geodetic latitude, longitude, and ground elevation at the four-corners of the sensor (sub-image) footprint (or MBR, if the footprint is of irregular shape).</td>
</tr>
<tr>
<td>TRE</td>
<td>CSDIDA</td>
<td>The dataset identification TRE provides basic information describing the data contained in the NITF file.</td>
</tr>
<tr>
<td>TRE</td>
<td>CSEPHA</td>
<td>The Ephemeris Data TRE provides detailed space vehicle ephemeris information.</td>
</tr>
<tr>
<td>TRE</td>
<td>CSEXRA</td>
<td>The Exploitation Reference Data TRE provides exploitation support data -- acquisition, environment, and performance parameters.</td>
</tr>
<tr>
<td>TRE</td>
<td>CSPROA</td>
<td>The Processing Information TRE identifies processing options that were applied during image formation.</td>
</tr>
<tr>
<td>TRE</td>
<td>CSSFAA</td>
<td>The Sensor Field Alignment Data TRE provides information on detectors, sensor type, and field alignment including fields for the focal length and principal point offset components.</td>
</tr>
<tr>
<td>TRE</td>
<td>GEOLOB</td>
<td>For rectified data, the Local Geographic Coordinate System TRE describes the link between the local coordinate system (rows and columns) and the absolute geographic coordinate system (longitude and latitude) defined in the GEOPSB TRE.</td>
</tr>
<tr>
<td>TRE</td>
<td>GEOPSB</td>
<td>For rectified data, the Geo-Positioning Information TRE describes the absolute coordinate system to which the data is referenced.</td>
</tr>
<tr>
<td>TRE</td>
<td>HISTOA</td>
<td>The Softcopy History Tagged Record Extension TRE provides a history of softcopy processing functions that have been applied to a dataset.</td>
</tr>
<tr>
<td>TRE</td>
<td>J2KLRA</td>
<td>The JPEG 2000 Layers TRE provides support information for JPEG 2000 compressed files.</td>
</tr>
<tr>
<td>TRE</td>
<td>MAPLOB</td>
<td>For rectified data (rows and columns are aligned with the coordinate system axis), MAPLOB provides the description of the link between the local coordinate system (rows and columns) and the absolute cartographic coordinate system (Easting and Northing) defined by GEOPS and PRJPS.</td>
</tr>
<tr>
<td>TRE</td>
<td>PIAIMC</td>
<td>The Imagery Access Imagery Support Extension TRE provides an area to place fields not currently carried in NITF but which are contained in the Standards Profile for Imagery Access (SPIA).</td>
</tr>
<tr>
<td>TRE</td>
<td>PRJPSB</td>
<td>This TRE contains the projection parameters of the absolute coordinate system when it’s a cartographic (grid) coordinate system.</td>
</tr>
</tbody>
</table>
The Rational Polynomial Coefficient TRE contains rational function polynomial coefficients and normalization parameters that define a mathematical relationship between image coordinates and ground coordinates. These coefficients provide a transformation equation that is numerically equivalent to the transformations using a rigorous projection models, within specified error margins.

The Standard ID TRE contains image identification data that supplements the Image Sub-header.

The Stereo Information Extension TRE provides links between several images that form a stereo set to allow exploitation of elevation information.

The Exploitation Usability TRE allows a user program to determine if the image is usable for the exploitation problem currently being performed, and also contains some catalogue metadata.

This TRE provides the data needed to measure and calculate geospatial positions of features on image chips.

The Attitude Data DES provides sensor attitude information needed to run the rigorous math model to perform geolocation and mensuration.

The Shapefile DES is a general wrapper structure for an Esri Shapefile.

<table>
<thead>
<tr>
<th>TRE</th>
<th>DES</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPC00B</td>
<td>STDIDC</td>
<td>The Standard ID TRE contains image identification data that supplements the Image Sub-header.</td>
</tr>
<tr>
<td>STREOB</td>
<td>STREOB</td>
<td>The Stereo Information Extension TRE provides links between several images that form a stereo set to allow exploitation of elevation information.</td>
</tr>
<tr>
<td>USE00A</td>
<td>USE00A</td>
<td>The Exploitation Usability TRE allows a user program to determine if the image is usable for the exploitation problem currently being performed, and also contains some catalogue metadata.</td>
</tr>
<tr>
<td>ICHIPB</td>
<td>ICHIPB</td>
<td>This TRE provides the data needed to measure and calculate geospatial positions of features on image chips.</td>
</tr>
<tr>
<td>CSATTA</td>
<td>CSATTA</td>
<td>The Attitude Data DES provides sensor attitude information needed to run the rigorous math model to perform geolocation and mensuration.</td>
</tr>
<tr>
<td>CSSHPA</td>
<td>CSSHPA</td>
<td>The Shapefile DES is a general wrapper structure for an Esri Shapefile.</td>
</tr>
</tbody>
</table>

Table 5: NCDRD Acronym Definitions

Section 3 of the NCDRD presents the detailed layouts of each TRE, while Section 4 presents the details of each DES. Section 5 supplies a list of acronyms.

This document applies to all CDPs providing commercial imagery to USG to include NGA entities. This document also applies to USG elements to be able to process the CDP-provided commercial imagery.
5.3.11 RASTER PRODUCT FORMAT (RPF) [MIL-STD-2411-2(1)]

Raster Product Format (RPF) defines a common format for the interchange of raster-formatted digital geospatial data among DoD components. Existing geospatial products that implement RPF include Compressed ARC Digitized Raster Graphics (CADRG), Controlled Image Base (CIB). CADRG content may be stored within a Digital Point Positioning Data Base (DPPDB).

The Raster Product Format (RPF) defines a legacy format for geospatial databases composed of rectangular arrays of pixel values (e.g. in digitized maps or images) in compressed or uncompressed form. The National Imagery Transmission Format Standard (NITFS) is the suite of standards for formatting digital imagery and imagery-related products for storage, transfer, and exchange among Department of Defense (DoD), Information Community (IC), and North Atlantic Treaty Organization (NATO) members. MIL-STD-2411-2(1) specifies requirements for the integration of RPF files into NITF for recording on computer-readable media or for dissemination via digital communication lines. This standard facilitates a common interchange format for users of RPF data and of NITF data.

The general approach to RPF integration into NITF is specified by the following rules:

1. Every RPF file shall have an RPF header section, a location section, and other sections and components as specified for the RPF file type.
2. Type RPF header section shall be recorded in a NITF user-defined header data (UDHD) segment, and shall identify the physical location of the RPF location section.
3. The physical locations of the remaining RPF file components shall be specified in the RPF location section so these components may be recorded anywhere in the NITF consistent with NITF format rules.
4. Certain designated RPF components shall be recorded in the NITF image data area to enable access by NITF users who do not have the capability to interpret RPF. All other RPF components shall be recorded in the user-defined registered data segments of the NITF file.

An appendix provides a mapping of group and field names between RPF and NITF to support implementation of RPF integration into NITF following the general approach above.

The National Geospatial-Intelligence Agency (NGA) produces and outsources the production of Controlled Image Base (CIB), Enhanced Controlled Imagery Base (ECIB), Compressed ARC Digitized Raster Graphic (CADRG), and Enhanced Digitized Raster Graphics (ECRG) in RPF. This standard on RPF integration into NITF is only applicable to CADRG, ECRG, CIB and ECIB; it shall not be used for any other products or associated applications. It is mandated for applications that need to use these RPF-based products.

Each product category that represents a single profile of RPF, or a family of instantiations of RPF, such as CADRG, ECRG, CIB, and ECIB, shall be described in a separate product specification that makes appropriate reference to this RPF standard and its companion standard, MIL-STD-2411-1, which defines registered data values to be used with RPF files.

RPF file structures specify the structure of RPF directories, files, records, record fields, and record field data types using notations with a specified syntax in indented text. Recording standards for RPF data are specified for sequential and random-access media. These include requirements for specific 8-character file and directory names with 3-character file extensions.
For example, every RPF interchange volume must include a RPF root directory. For CADRG and CIB products, this directory is named “RPF”, and contains at least one subordinate frame directory or lookup table directory. A table of contents file named “RPF/A.TOC” shall be provided. All external color / grayscale files shall be stored on the interchange media in the “RPF/LOOKUP” directory. Frame files shall be stored in a separate directory hierarchy under the RPF directory. The producer shall determine a strategy for choosing the hierarchical structure, the name of each directory at each level in the hierarchy in a given volume, and a method for assigning frame files to specific directories. Each subordinate frame directory shall have the same structure as the frame directory.

For legacy RPF products, such as CIB and CADRG, the matrix of data in a given frame file will be organized into a matrix of subframes, each comprising, in decompressed form, a fixed number of data elements (e.g. 256 x 256 pixels in a typical map frame file). A typical frame, in turn, will be composed of a matrix of such subframes (e.g. 6 x 6 subframes). RPF includes conventions for frame and subframe sequence numbering, referencing, and recording, for transparent pixel encoding, for frame and subframe masks, for updating and replacing frames, for assigned reference designators, backward compatibility, and packaging standards. It also includes data structure standards for the various RPF files.

Contemporary RPF products, such as ECIB and ECRG, use a dynamic frame scheme, described within the support metadata headers.

The horizontal datum for RPF data shall be WGS-84. The vertical datum for RPF data shall be defined in individual product specifications. By default, RPF numeric data is recorded in big-endian order. The default byte ordering for numeric data fields in a given product shall be documented in its product specification. This standard applies to production or access by all DoD components of digital geographic data required or specified to be in RPF.

5.3.11.1 Controlled Imagery Base (CIB)

STANAG 7099 is based on US MIL-PRF-89041A, CIB, defining requirements for preparation and use of standard controlled geospatial imagery.

5.3.11.2 Enhanced Controlled Imagery Base (ECIB)

Specifies requirements for the preparation and use of the National Geospatial-Intelligence Agency's (NGA) Enhanced Controlled Image Base (ECIB), structured within a Raster Product Format (RPF). Defines the data format RPF and characteristics of ECIB for producers and users. Similar to CIB in structure, except the table of Contents is stored as XML, imagery base is color instead of panchromatic, and image compression is JPEG 2000, rather than Vector Quantization.

5.3.11.3 Compressed ARC Digitized Raster Graphics (CADRG)

STANAG 7098 is based on US MIL-PRF-89038, CADRG, a general purpose product comprising computer-readable digital map and chart images.
5.3.11.4 **Enhanced Compressed Raster Graphics (ECRG)**

Describes requirements for the preparation and use of the Enhanced Compressed Raster Graphic (ECRG). ECRG is a general purpose product, comprising computer-readable digital map and chart images, structured within a Raster Product Format (RPF), with appropriate attribution, as necessary. Similar to CADRG in structure, except the table of contents is stored as XML and compression is JPEG 2000, rather than Vector Quantization.

5.3.11.5 **Digital Point Positioning Database (DPPDB) [MIL-PRF-89034]**

Digital Point Positioning Database (DPPDB) defines a file database layout for stereo pair image segments that provide coverage of a rectangular area. Each stereo segment accompanied by a stereo overview image at a reduced image resolution. Each segment contains within it one designated rectangular region where stereo parallax is minimized and accuracy is maximized. This accuracy footprint is always slightly smaller than the image segment. Adjacent stereo segments provide overlapping coverage to eliminate the possibility that an area of interest occurs inside an image segment, but outside an accuracy footprint.

DPPDB file structures specify the structure of DPPDB directories, files, records, record fields, and record field data types using notations with a specified syntax in indented text. Recording standards for DPPDB data are specified for sequential and random-access media. These include requirements for specific 8-character file and directory names with 3-character file extensions. For example, every DPPDB interchange volume must a table of contents file named “RPF/A.TOC” shall be provided. All external color / grayscale files shall be stored on the interchange media in the “RPF/LOOKUP” directory. Frame files shall be stored in a separate directory hierarchy under the RPF directory. The producer shall determine a strategy for choosing the hierarchical structure, the name of each directory at each level in the hierarchy in a given volume, and a method for assigning frame files to specific directories. Each subordinate frame directory shall have the same structure as the frame directory.

Each image segment is accompanied by a number of Tagged Record Extensions (TREs) specific to NITF DPPDB product image segment files.

The general approach to DPPDB integration into NITF is specified by the following rules:

1. Every DPPDB database shall have a Master Product File that serves as a table of contents or index of image segments.
2. Type RPF header section shall be recorded in a NITF user-defined header data (UDHD) segment, and shall identify the physical location of the RPF location section.
3. The physical locations of the remaining image segment file components shall be specified in the DPPDB segment index section.
4. Certain designated RPF components shall be recorded in the NITF image data area to enable access by NITF users who do not have the capability to interpret RPF. All other RPF components shall be recorded in the user-defined registered data segments of the NITF file.

An appendix provides a mapping of group and field names between RPF and NITF to support implementation of RPF integration into NITF following the general approach above.
The National Geospatial-Intelligence Agency (NGA) produces and outsources the production of Controlled Image Base (CIB), Enhanced Controlled Imagery Base (ECIB), Compressed ARC Digitized Raster Graphic (CADRG), and Enhanced Digitized Raster Graphics (ECRG) in RPF. This standard on RPF integration into NITF is only applicable to CADRG, ECRG, CIB and ECIB; it shall not be used for any other products or associated applications. It is mandated for applications that need to use these RPF-based products.

Each product category that represents a single profile of RPF, or a family of instantiations of RPF, such as CADRG, ECRG, CIB, and ECIB, shall be described in a separate product specification that makes appropriate reference to this RPF standard and its companion standard, MIL-STD-2411-1, which defines registered data values to be used with RPF files.

RPF file structures specify the structure of RPF directories, files, records, record fields, and record field data types using notations with a specified syntax in indented text. Recording standards for RPF data are specified for sequential and random-access media. These include requirements for specific 8-character file and directory names with 3-character file extensions. For example, every RPF interchange volume must include a RPF root directory named “RPF” that contains at least one subordinate frame directory or lookup table directory. A table of contents file named "RPF/A.TOC" shall be provided. All external color / grayscale files shall be stored on the interchange media in the “RPF/LOOKUP”directory. Frame files shall be stored in a separate directory hierarchy under the RPF directory. The producer shall determine a strategy for choosing the hierarchical structure, the name of each directory at each level in the hierarchy in a given volume, and a method for assigning frame files to specific directories. Each subordinate frame directory shall have the same structure as the frame directory.

In general, the matrix of data in a given frame file will be organized into a matrix of subframes, each comprising, in decompressed form, a fixed number of data elements (e.g. 256 x 256 pixels in a typical map frame file). A typical frame, in turn, will be composed of a matrix of such subframes (e.g. 6 x 6 subframes). RPF includes conventions for frame and subframe sequence numbering, referencing, and recording, for transparent pixel encoding, for frame and subframe masks, for updating and replacing frames, for assigned reference designators, backward compatibility, and packaging standards. It also includes data structure standards for the various RPF files.

The horizontal datum for RPF data shall be WGS-84. The vertical datum for RPF data shall be defined in individual product specifications. By default, RPF numeric data is recorded in big-endian order. The default byte ordering for numeric data fields in a given product shall be documented in its product specification.

This standard applies to production or access by all DoD components of digital geographic data required or specified to be in RPF.

5.3.11.5.1 Digital Point Positioning Database (DPPDB) Reference Graphic

Digital Point Positioning Database (DPPDB) may contain a CADRG reference graphic to locate the stereo segments present in the database on a map graphic.
5.3.11.6 XML Signature Implementation Specification for NSIF/NITF [NGA.STND.0025-3_1.0]

- NITF LiDAR Implementation Profile 1 7-Sep-10 IMAGE NGA.IP.0003_1.0
- NGA Light Detection and Ranging (LiDAR) Sensor Model Supporting Precise Geopositioning NGA.SIG.0004_1.1, 1

5.3.12 Image Compression

5.3.12.1 BIIF Profile for JPEG 2000 Version 01.10

The Basic Image Interchange Format (BIIF) specified by ISO/IEC 12087-5 provides a file format that is suitable for the interchange, storage, and retrieval of map and imagery information. The BIIF file format consists of a file header and associated image(s), symbol(s), text and/or associated data in a way that is compatible between systems of different architectures and devices of differing capabilities and design.

JPEG 2000 specified by ISO/IEC 15444-1:2004 | ITU-T Rec. T.800 defines a set of lossless (bit-preserving) and lossy compression methods for coding bi-level, continuous-tone gray-scale, palletized color, or continuous-tone color digital still images. The JPEG 2000 standard:

- Specifies decoding processes for converting compressed image data to reconstructed image data;
- Specifies a code stream syntax containing information for interpreting the compressed image data;
- Specifies a file format;
- Provides guidance on encoding processes for converting source image data to compressed image data;
- Provides guidance on how to implement these processes in practice.

The National Imagery Transmission Format Standard (NITFS) is the suite of standards for formatting digital imagery and imagery-related products for storage, transfer, and exchange among Department of Defense (DoD), Information Community (IC), and North Atlantic Treaty Organization (NATO) members. Mil-Std-2500C describes the National Imagery Transmission Format (NITF) file format and establishes its application within the NITFS.

The North Atlantic Treaty Organization (NATO) Secondary Imagery Format Version 01.01 (NSIF01.01) allows for the compression of image data using JPEG 2000 compression. NITF version 2.1 is the US documentation equivalent of NSIF01.00. These standards are both BIIF profiles.

The ISO/IEC BIIF Profile BPJ2K01.10 is within the context of the BIIF Profile class of graphical items in accordance with ISO/IEC 9973, "Computer graphics and image processing – Procedures for registration of graphical items," and Annex C of ISO/IEC 12087-5:1998, "Profiling BIIF." It defines allowed data values and ranges for JPEG 2000 header and subheader fields and specifies how JPEG 2000 compression may be used for image data within NSIF. It contains sections on profile limits for the use of JPEG 2000, recommended encodings, interaction between NISF / BIIF and the JPEG2000 file format, and informative appendices on JPEG processing.
The BIIF Profile for JPEG 2000 Version 01.10 (BPJ2K01.10) was cooperatively developed by the ISO and NATO communities. It replaces Version 01.00 (BPJ2K01.00, 30 July 2004), includes additional JPEG 2000 encoding profiles and is restructured to place all profiles into the Appendices.

The new TPJE (Tactical Preferred JPEG 2000 Encoding) was created for certain airborne applications that utilize NSIF. The TPJE is not mandated for NSIF01.01 encoding systems, but future NSIF profiles might require its use.

The new LPJE (LVSD Preferred JPEG 2000 Encoding) is normative for certain systems described within STANAG 4609 NATO Digital Motion Imagery Standard. The LPJE was developed for a new class of sensors that NATO has designated as Large Volume Streaming Data (LVSD) sensors. The LVSD designation was created for sensors that capture very large array imagery at rates of one frame per second (1fps) and faster for extended periods of time over a common area of regard.

The new SPJE (STANAG 7023 Preferred JPEG 2000 Encoding) is the mandated JPEG2000 compression for STANAG 7023 compliant systems. This includes NATO air reconnaissance primary imagery data systems. The SPJE is not mandated for NSIF01.01 encoding systems, but future NSIF profiles might require its use.

All compliant NSIF decoders are required to decode all compliant data within the limits of this profile and their BIIF compliance level. All compliant NSIF encoders must also produce compressed data that is compliant and within the limits of this profile.

BPJ2K encoding recommendations were selected to achieve the greatest interoperability and functionality for large images. The compression efficiency, flexibility, and functionality of JPEG 2000 meets user requirements of all users from the Image Analyst, who needs the very best quality and resolution (lossless compression), all the way to the bandwidth constrained user, who only needs a low resolution lower quality image at high compression.

The BIIF Tagged Record Extension (TRE) is recommended for use when compressing image data per the preferred JPEG 2000 encoding recommendations.

This profile is intended for the compression of literal imagery (e.g., panchromatic, color, detected SAR, Multispectral, thermal IR, etc.). It is not expected to handle non-literal imagery types (e.g., I/Q data, M/P data, VPH data, Elevation data, Location-Grid data, etc.).

5.3.12.2 Joint Photographic Experts Group Image Compression [MIL-STD-188-198A(4)]

The National Imagery Transmission Format Standard (NITFS) is the suite of standards for formatting digital imagery and imagery-related products for storage, transfer, and exchange among Department of Defense (DoD), Information Community (IC), and North Atlantic Treaty Organization (NATO) members. The NITF provides a very flexible means to package imagery products. It supports the dissemination of digital imagery from overhead collection platforms and post-processed imagery-derived products.

MIL-STD-188-198A / STANAG 4545 establish the requirements to be met by systems complying with NITFS and/or the NATO Secondary Imagery Transmission Format (NSIF) when image data are compressed using a JPEG image compression algorithm (indicated by the code C3 in the Image Compression field of the NITF file image subheader) as described in ITU-T T.81 / ISO/IEC 10918-1
Digital Compression and Coding of Continuous-tone Still Images. This standard provides technical detail of the NITFS compression algorithms for eight- and 12-bit gray scale imagery, 24-bit color imagery, eight- and 12-bit spectral imagery, radar-derived imagery, and similar applications. It specifies the sequential Discrete Cosine Transform (DCT) with Huffman coding as a lossy compression algorithm, and Huffman or arithmetic coding as a lossless compression algorithm.

Four main categories of image compression process are specified. In a Sequential Lossless or Sequential DCT-based coding process, each component of the image is encoded in a single scan. A Progressive DCT-based coding process involves multiple scans in which each scan typically improves the quality of the reconstructed image. The progressive JPEG format is good for large images because when decompressed it allows a reasonable preview after only a portion of the data has been returned. In a Hierarchical coding process, the format frame for a given component is followed by frames that code the differences between the source data and the reconstructed data from the previous frame for that component.

This standard also provides the required default quantization tables for use in imagery dissemination systems complying with NITFS. For each combination of image data type, image sample precision, and image color, there are five default quantization tables allowing images to be coded at five different quality levels. Quality level 5 (Q5) reconstructed image data has the highest fidelity to the source image data but achieves the least compression. Levels 4.3, 2, and 1 trade the reconstructed fidelity for higher compression, with Q1 resulting in the most compression and the lowest fidelity.

5.3.12.3 Vector Quantization Decompression, with NOTICE 1

This standard establishes the requirements to be met by NITFS compliant systems when image data are decompressed using the Vector Quantization (VQ) compression algorithm. This allows NITFS-compliant systems to accept and decompress data that are compressed using a VQ compression scheme. This standard describes the VQ compression in the general requirements section, but does not fully describe the steps for compression. The steps involved in decompressing images compressed with VQ are fully described by this standard.

This standard provides technical detail of the NITFS VQ decompression algorithm, designated by the presence of C4 or M4 in the IC (image compression) field of the image subheader in a NITF file. VQ is a lossy compression approach defined in Vector Quantization, Abut, Huseyin (Ed.), IEEE Press, NY, 1990, chosen for use with certain types of image data (see MIL-HDBK-1300) because it can be implemented with acceptable performance and quality, because it provides a predictable compression ratio, and because decompression is very fast. The fundamental concept of VQ is to represent monochrome or color image blocks with representative kernels from a codebook. The indices of the representative kernels replace the image data in the compressed image. The codebook and color Lookup Table (LUT) are included in the file as overhead information. Essentially, VQ decompression involves replacing image codes in the compressed image with pixel values for use in display or exploitation of the data. The first step is decompression by replacing index values with kernels from a codebook. For a black and white or greyscale image, the codebook kernels provide the final pixel values. If the image has an associated color LUT, the decompression continues with replacement of the codebook values with corresponding RGB pixel values from the color LUT.

NITFS is mandatory for all Secondary Imagery Dissemination Systems (SIDS) in accordance with the memorandum by the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence ASD(C3I) Subject: National Imagery Transmission Format Standard (NITFS), 12 August
1991. This directive shall be implemented in accordance with the MIL-STD-2500, JIEO Circular 9008 and MIL-HDBK-1300. New digital imagery equipment and systems, those undergoing major modification, or those capable of rehabilitation shall conform to this standard.

Vector Quantization is used in the production of Digital Point Positioning Data Base (DPPDB), Controlled Image Base (CIB) and Compressed ARC Digitized Raster Graphic (CADRG) products. Conformance to this NITF standard option is required for systems that must read VQ compressed imagery, such as fCIB, CADRG, and DPPDB products.

5.3.12.4 Distributed Common Ground/Surface System (DCGS) Acquisition Standards Handbook - (DASH-I)

The Distributed Common Ground/Surface System (DCGS) Acquisition Standards Handbook - Imagery Intelligence (IMINT) (DASH-I), v3, 20 June 2008 addresses the TO-BE architecture of the DCGS. It promotes interoperability among Service DCGS imagery systems by presenting operational and system architectural views. The DASH-I allows for the acquisition standards to be overlaid onto the Service-provided system architectures. These views enable acquisition organizations to determine where the standards in this document apply within their system architectures. The DASH-I identifies the DCGS system and technical architecture and shows how the DCGS Enterprise integrates to the NSG Enterprise. It provides insight into the DCGS capabilities and elements. The DASH-I defines the standard functions, information standards, and interfaces required for implementing the DCGS TO-BE architectures.

The DoD DCGS is an Office of the Secretary of Defense (OSD) level strategy for achieving an interoperable family of systems that will provide an enterprise within which a multi-INT Task, Post, Process, and Use (TPPU) construct will be provided to the Joint Task Force (JTF) and below. This will be accomplished through a combination of web-services based capabilities and architectures that enable distributed workflow, exploitation, and analysis; collaboration amongst Service DCGS elements and within a single Service DCGS element; forward support to the C2 user and war-fighter; and reach back from theater to CONUS.

The DASH-I lists the physical, network, and information standards and identifies the fundamental architectural concept for use as a point of departure for the transformation of Service DCGS architectures. This has been vetted through the services, represented in the DCGS IMINT-IPT. This document is primarily based on commercial web-services standards and other web-based enterprise enabling standards, standards described in the DoD Information Technology Standards Registry (DISR), and standards described in the National System for Geospatial-Intelligence (NSG) technical architecture.

The DCGS Acquisition Standards Handbook - Imagery (DASH-I) is the guidance document of recommended standards for new system development or significant upgrades in DoD acquisition. In all cases, mandated standards listed in the most recent baseline of the DoD IT Standards Registry (DISR) shall take precedence over DASH-I recommended standards.

5.3.13 BlIF Profile for Computer Graphics Metafile (CGM) [BPCGM01.00]

Computer Graphics Metafile (CGM) is a graphics data interchange standard which defines a computer interpretable representation of 2D graphical and raster information in a manner that is independent from any particular application or system. The purpose of the standard is to facilitate the storage and retrieval of graphical information between applications, software systems, and/or devices. A CGM can contain:
vector graphics, raster graphics, and text. The BIIF Profile for CGM defines a subset of CGM elements, sets limits for generation and interpretation behavior according to the rules for profile definition. BPCGM01.00 is functionally equivalent to, and replaces MILSTD-2301A, Computer Graphics Metafile (CGM) Implementation Standard for National Imagery Transmission Format Standard.

BPCGM01.00 tailors the ISO/IEC 8632-1 and ISO/8632-3 Computer Graphics Metafile (CGM) standards for use with ISO/IEC 12087-5, Basic Image Interchange Format (BIIF). The BPCGM is used with the National Imagery Transmission Format (NITF) and the NATO Secondary Imagery Format (NSIF), both of which are implementation profiles of BIIF that are intended to promote interoperability for the exchange of imagery among military Command, Control, Communications, and Intelligence (C3I) systems.

The standard is technically mature and stable, to include established conformance test criteria, tools, services and technical consultation for the implementation profile used by the NITFS. The NITFS profile of this standard has been part of the NITFS suite of standards since 1994 and part of STANAG 4545, NATO Secondary Imagery Format (NSIF) since 1998. A follow on standard for use within NITFS/NSIF is not currently in consideration. A sunset status should not yet be added for this currently mandated (for use with NITFS/NSIF) standard implementation profile.

6 NATO Standardization Agreements

6.1 NATO Secondary Imagery Format (NSIF 1.0) [STANAG 4545]

The aim of STANAG 4545 is to promote interoperability for the exchange of Electronic Secondary Imagery among NATO C3I Systems. The NATO Secondary Imagery Format (NSIF) is the standard for formatting digital imagery and imagery-related products and exchanging them among members of NATO intelligence communities.

Edition 1 was promulgated on 27 November 1998. An editorial amendment was published in April 2000, and an Errata sheet was published on 1 July 2003.

Edition 1 of STANAG 4545 has been established in close coordination with the United States NITF Technical Board (NTB) which develops MIL-STD-2500C corresponding to version 2.1 of the NITF. Both NSIF 1.0 and NITF 2.1 have been specified to be conformant the Basic Imagery Interchange Format (BIIF) or ISO/IEC 12087-5. A common profile of BIIF was established later to avoid possible inconsistencies between STANAG 4545 Edition 1 and MIL-STD-2500C. Edition 2 of STANAG 4545 referencing the NSIF profile of BIIF has been published. It is the intention of the NTB to eventually adopt the NSIF profile and retire the US MIL-STD-2500C. US implementation guidance will continue to specify NITF-specific practices, and the US NTB will also maintain the Compendium of Controlled Extensions to NITF/NSIF on behalf of NATO.

NSIF 1.0 and NITF 2.1 propose interesting extension mechanisms. Interoperability management implies a good control of the NSIF/NITF extensions. A compendium of extensions has been established by the US NTB to document the most interesting extensions of NITF 2.1 developed initially for US military need. Some geographic extensions were developed by DGIWG and published in Annex D of DIGEST 2.1. With the retirement of DIGEST, these extensions are now maintained by the US NTB on behalf of DGIWG and NATO. Within NATO, a register of all NSIF-Approved extensions is maintained by the STANAG 4545 Custodial Support Team.
DIGEST Part 2 Annex D defines a profile of NSIF 1.0 including DIGEST compatible geographic extensions of NSIF. This profile explains how to encode DIGEST raster and imagery data in NSIF.

NSIF 1.0 is a mature format which does not mean that it is necessarily the best imagery format to consider in order to address emerging problems and needs, in particular requirements related to Web based dissemination. Yet, NSIF 1.0 is able to ensure efficiently the exchange of a wide variety of imagery products more or less processed. NSIF capabilities identify exhaustively general requirements concerning the interchange of imagery products. These requirements concern the organization and structure of imagery and gridded data as well as their metadata handled via standard NSIF Fields and via NSIF extensions. Commercial products supporting interactive network access of JPEG2000-compressed data within NITF2.1 file format using ISO/IEC JPEG 2000 Interactive Protocol (JPIP) and OGC Sensor Web Enablement (SWE) specifications are in operational use.

NSIF 2.0 has now been updated and published as a NATO profile of ISO/IEC 12087-5 (BIIF) recorded under ISO/IEC SC24.

6.2 Digital Terrain Elevation Data (DTED) [STANAG 3809 Edition 4]

For terrain elevation data, the US Defense community standard developed and registered as MIL-PRF-89020B was adopted by NATO as STANAG 3809. Product specifications are available for levels 0, 1 and 2 data, known as DTED0, DTED1 and DTED2. For higher-resolution grids (12m post spacing and higher), the High Resolution Elevation (HRE) Product Profile (NGA.IP.0002) is an implementation of the DGIWG Elevation Surface Model that specifies the encoding of topographic elevation data in NITF.

7 International Standards Organization (ISO)

The international Standards Organization (ISO) is an independent, non-governmental membership organization and developer of voluntary International Standards. ISO is made up of 164 member countries with national standards bodies around the world, overseeing the development and maintenance of nearly 20,000 international standards. ISO standards are copyrighted by the ISO, and often a fee is required to access ISO standards. Some ISO standards were developed jointly with organizations and are publicly available.

7.1 ISO Adopted Raster and Raster-Related Standards

Several raster and raster-related standards with civilian, military, industry and commercial origins have been adopted by the International Standards Organization (ISO). Examples include BIIF, Portable Network Graphics, JPEG, JPEG 2000, and MPEG.

7.2 Portable Network Graphics (PNG)

Portable Network Graphics (PNG) is an open, extensible, bitmapped (raster) image format that employs lossless data compression. The original specification for PNG, version 1.0, was written by Thomas Boutell and Tom Lane, with contributions by many others. On 1 October 1996 it was released by the World Wide Web Consortium (W3C) as its first Recommendation, and on 15 January 1997 it was released by the

PNG was created to improve upon and replace Graphics Interchange Format (GIF) as an image-file format not requiring a patent license. It is pronounced “ping” or spelled out as P-N-G.

PNG supports palette-based (palettes of 24-bit RGB or 32-bit RGBA) colors, greyscale RGB, or RGBA images. PNG was designed for transferring images on the Internet, not professional graphics, and so does not support other color spaces such as CMYK.

Important PNG features include:

- Multiple Cyclical Redundancy Check (CRC) algorithms to check file integrity without viewing
- File signature that can detect the most common types of file corruption
- Better compression than GIF, typically 5% to 25% (but often 40% or 50% better on tiny images)
- Completely lossless compression algorithm not subject to patent rights
- Two-dimensional interlacing scheme to support progressive image display
- 1-, 2-, 4- and 8-bit palette support (like GIF)
- 1-, 2-, 4-, 8- and 16-bit grayscale support
- 8- and 16-bit-per-sample (that is, 24- and 48-bit) true-color support
- Full alpha transparency in 8- and 16-bit modes, not just simple on-off transparency like GIF
- "Palette-Alpha" mode, effectively transforming normal RGB palette into RGBA
- Gamma correction for cross-platform "brightness" control
- Color correction for cross-platform, precision color
- Both compressed and uncompressed text chunks for copyright and other info
- Complete free reference implementation with full open-source code

The PNG standard is widely supported by web browsers, image viewers, image editors, image converters, 3-D applications, games, and business, graphical, and scientific applications. PNG files nearly always use file extension "PNG" or "png" and are assigned Multipart Internet Mail Extensions (MIME) media type "image/png".

PNG provides a useful format for the storage of intermediate stages of editing. Since PNG's compression is fully lossless saving, restoring and re-saving an image will not degrade its quality, unlike standard JPEG (even at its highest quality settings). The PNG specification leaves no room for implementers to pick and choose what features they'll support; the result is that a PNG image saved in one app is readable in any other PNG-supporting application.

PNG was designed to encode synthetically generated images efficiently, such as screen shots and icons. PNG is not well suited for photographic images, unless transparency is required. Note that for transmission of finished true-color images—especially photographic ones—JPEG is almost always a better choice, unless lossless compression or transparency is required. Although JPEG's lossy compression can introduce visible artifacts, these can be minimized, and the savings in file size even at high quality levels is much better than is generally possible with a lossless format like PNG. And for black-and-white images, particularly of text or drawings, TIFF's Group 4 fax compression or the JBIG format are often far better than 1-bit grayscale PNG.

PNG provides a useful format for the storage of intermediate stages of editing. PNG's compression is fully lossless, restoring and re-saving an image will not degrade its quality. In contrast, successive editing of
JPEG encoded images, even at its highest quality settings, may result in loss if image quality after each iteration. Theoretically, the PNG specification leaves no room for implementations to pick and choose what features they'll support; the objective is that a PNG image saved in one app is readable in any other PNG-supporting application. In practice, most systems rely on the open source LIBPNG library, which supports the full PNG feature set.

7.3 Basic Image Interchange Format (BIIF) [ISO/IEC 12087-5]

The Basic Image Interchange Format (BIIF) specified by ISO/IEC 12087-5 provides a file format that is suitable for the interchange, storage, and retrieval of map and imagery information. The BIIF file format consists of a file header and associated image(s), symbol(s), text and/or associated data in a way that is compatible between systems of different architectures and devices of differing capabilities and design.

Computer Graphics Metafile (CGM) is a graphics file format specified in ISO/IEC 8632-1 for representation of static 2D graphical (pictorial) information in a manner that is independent of any particular storage or display device, system, or application. A CGM can contain vector graphics, raster graphics, and text. CGM facilitates the storage, retrieval, exchange and display of such graphical information via different devices, software systems, and applications.

Symbols within a BIIF file may consist of CGMs. The BIIF Profile for Computer Graphics Metafile (BPCGM) tailors the CGM standard for use with BIIF by defining a Version 1 CGM that is suitable for use in the annotation of digital imagery in BIIF. The BPCGM specifies a subset of CGM elements, sets defaults and limits for CGM generation and interpretation behavior according to the rules for profile definition defined in ISO/IEC 8632, and requires use of the CBM binary encoding defined by ISO/IEC 8632-3. The BPCGM is registered as a BIIF profile according to ISO/IEC 12087-5 Annex C and ISO/IEC 9973.

The BPCGM is used with the National Imagery Transmission Format (NITF) and the NATO Secondary Imagery Format (NSIF), both of which are implementation profiles of BIIF that are intended to promote interoperability for the exchange of imagery among military Command, Control, Communications, and Intelligence (C3I) systems.


7.4 Computer Graphics Metafile (CGM) [ISO/IEC 8632-1]

Computer Graphics Metafile (CGM) is a graphics file format specified in ISO/IEC 8632-1 for representation of static 2D graphical (pictorial) information in a manner that is independent of any particular storage or display device, system, or application. A CGM can contain vector graphics, raster graphics, and text. CGM provides the means for textual, graphical, and symbolic annotation of digital imagery and raster maps. CGM facilitates the storage, retrieval, exchange and display of such graphical information via different devices, software systems, and applications.

A CGM must be encoded according to the rules in one of the standardized encodings; binary encoding for CGM is specified in ISO/IEC 8632-3; text encoding for CGM is specified in ISO/IEC 8632-4. The DISR mandates DoD use of the binary encoding for CGM. The Binary Encoding for CGM provides a
representation of the Metafile syntax that can be optimized for speed of generation and interpretation, while still providing a standard means of interchange among computer systems.

The Binary Encoding for CGM specifies an explicit representation for all CGM elements in terms of bits, 8-bit octets and 16-bit words. For some data types, the exact representation is a function of the precisions being used in the metafile, as recorded in the Metafile Descriptor. To optimize processing of the binary metafile on a wide collection of computers, metafile elements are constrained to start on word boundaries within the binary data, adding bad bits as necessary.

CGM provides for the definition of profiles consisting of a subset of CGM options, elements, and parameters to accomplish a particular function for use by an application constituency for graphical data interchange. The Basic Image Interchange Format (BIIF) Profile for CGM (BPCGM01.00) defined by DoD has replaced the functionally equivalent Mil-Std-2301A, CGM Implementation Standard for the National Imagery Transmission Format Standard (NITFS).

The Binary Encoding for CGM is used with the National Imagery Transmission Format (NITF) and the NATO Secondary Imagery Format (NSIF), both of which are implementation profiles of ISO/IEC 12087-5 (BIIF) that are intended to promote interoperability for the exchange of imagery among military Command, Control, Communications, and Intelligence (C3I) systems. For example, imagery analysts use CGM to graphically mark-up digital imagery and maps with the visualization of their analytic results. CGM is also used to provide visualization of the NITFS-embedded security markings and handling instructions. For example, every Digital Point Positioning Data Base (DPPDB) uses CGM encapsulated in a NITF image to present security information, national stock numbers, visual boundaries for associating image data with positioning and quality support data, and similar uses. The standard for this map image is CADRG.

CGM was the graphics standard used in both GeoSym [MIL-PRF-89045/ MIL-DTL-89045A] and MILSTD-2525 Rev. A/B symbology libraries. Scalable Vector Graphics (SVG) has displaced CGM as the preferred encoding standard for military symbology.

- CGM version 1 (CGM-V1) provides a basic drawing and picture interchange capability. The CGM-V1 metafile definition includes about 90 elements (i.e., individual function or entity). CGM-V1 metafiles are essentially the same as the original CGM standard, ISO 8632:1987.
- CGM version 2 (CGM-V2) metafile definition contains approximately 30 additional elements. (CGM-V1 metafile elements are allowed in CGM-V2 metafiles). The most significant new capability of CGM-V2 is the graphical segment. A segment is a group of primitives that is saved once and named, and then may be used repeatedly in the metafile.
- CGM version 3 (CGM-V3) metafiles represent a major increase in graphical expressive power. CGM-V3 metafiles contain about 40 new elements above the CGM-V2 capabilities. CGM-V3 metafiles can represent compressed tiled images, define external symbol libraries, and exert greater control of drawing aspects for graphics arts, presentation graphics, and electronic publishing.
- CGM version 4 adds support for application structures.
The following classes of elements are defined:

<table>
<thead>
<tr>
<th>CGM Element</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delimiter</td>
<td>Delimit significant structures within the Metafile.</td>
</tr>
<tr>
<td>Metafile Descriptor</td>
<td>Describe the functional content, default conditions, identification, and</td>
</tr>
<tr>
<td></td>
<td>characteristics of the CGM; and optionally, define a directory.</td>
</tr>
<tr>
<td>Picture Descriptor</td>
<td>Set the interpretation modes of attribute elements for each picture and</td>
</tr>
<tr>
<td></td>
<td>optionally, define a directory to the application structures contained in</td>
</tr>
<tr>
<td></td>
<td>each picture.</td>
</tr>
<tr>
<td>Control</td>
<td>Allow picture boundaries and coordinate representation to be modified.</td>
</tr>
<tr>
<td>Graphical Primitive</td>
<td>Describe the visual components of a picture in the CGM.</td>
</tr>
<tr>
<td>Attribute</td>
<td>Describe the appearance of graphical primitive elements.</td>
</tr>
<tr>
<td>Escape</td>
<td>Describes device- or system-dependent elements used to construct a picture;</td>
</tr>
<tr>
<td></td>
<td>however, the elements are not otherwise standardized.</td>
</tr>
<tr>
<td>External</td>
<td>Communicate information not directly related to the generation of a</td>
</tr>
<tr>
<td></td>
<td>graphical image.</td>
</tr>
<tr>
<td>Segment</td>
<td>Enable the grouping of graphic objects for graphical operations such as</td>
</tr>
<tr>
<td></td>
<td>copying.</td>
</tr>
<tr>
<td>Application Structure</td>
<td>Enable the grouping of elements for retrieval, electronic linking, and other</td>
</tr>
<tr>
<td></td>
<td>specific application-dependent operations.</td>
</tr>
</tbody>
</table>

Table 6: CGM Element Class Definitions


The name "JPEG" stands for Joint Photographic Experts Group, the name of the committee that created the JPEG standard and also other standards. It is one of two sub-groups of the International Organization for Standardization (ISO) International Electrical Commission (IEC) (ISO/IEC) Joint Technical Committee 1, Subcommittee 29, Working Group 1 (ISO/IEC JTC 1/SC 29/WG 1), organized in 1986, which issued the first JPEG standard in 1992. In 2000 the JPEG sub-group created the JPEG 2000 standard as a discrete wavelet transform (DWT)-based compression method for still imagery to replace the original discrete cosine transform (DCT)-based JPEG standard. The JPEG 2000 standard was published as ISO/IEC 15444-1 and International Telecommunication Union (ITU) Telecommunication Standardization Sector (ITU-T) Recommendation T.800. The JPEG 2000 part 6, Compound Image File Format, was published in 2003 as ISO/IEC 15444-6 and last amended in 2007. There is no corresponding ITU standard.

This International Standard defines a normative but optional file format for storing compound images using the JPEG 2000 file format family architecture. A compound image file contains multiple images,
both multi-level (color/continuous-tone) and bi-level (text and/or line-art), together with composition models describing how the individual images are combined to generate the compound image.

This standard is based on the multi-layer Mixed Raster Content (MRC) imaging model defined in ISO/IEC 16485 and the equivalent ITU-T T.44. In the MRC three-layer model, text and line-art data (bi-level data) are compressed with an approach that puts high emphasis on maintaining the detail and structure of the input. Pictures and color gradients (multi-level data) are compressed using an approach that puts a high emphasis on maintaining the smoothness and accuracy of the colors. Line-art data with multi-level colors is compressed with a compromise approach to achieve mid to high spatial resolution and mid color resolution.


The files that conform to the format defined in this standard are called JPM files. At its core, a JPM file is a collection (sequence) of pages, where each page in turn is a sequence of layout objects. A layout object normally consists of a mask object and an image object. Mask and image objects are composited to build up the final page image. A page in a JPM file is represented by a Page box, which is a compound superbox that consists of a Page Header box, containing general information about the page, a Page Collection Locator box, containing the location of the page’s primary page collection, an optional Base Color box, which describes the base page color, optional Metadata boxes, and Layout Object boxes, one for each layout object on the page.

Compositing a layout object involves decoding, scaling, clipping, positioning, and window-clipping both the mask object and the image object, and clipping the resulting image with the resulting mask for display. During image decoding, the image is converted to the specified color space. Layout objects are applied sequentially, in an order defined by the Layout Object Identifier field in the Layout Object Header boxes to create the final PageImage.

This standard is useful for applications storing multiple pages, images with mixed content, and/or images that need more structure than is provided by the JP2 file format. It enables efficient processing, interchange and archiving of images with mixed bi- and multi-level content by representing the image as multiple layers of different image types and by applying specialized encoding, spatial and color resolution processing to layers of different types. It is appropriate for document scanning, imaging, browsing and pre-press applications.

7.6 JPEG 2000 Core Coding System [ISO/IEC 15444-1:2004]

The name "JPEG" stands for Joint Photographic Experts Group, the name of the committee that created the JPEG standard and also other standards. It is one of two sub-groups of the International Organization for Standardization (ISO) International Electrical Commission (IEC) (ISO/IEC) Joint Technical Committee 1, Subcommittee 29, Working Group 1 (ISO/IEC JTC 1/SC 29/WG 1), organized in 1986, which issued the first JPEG standard in 1992. In 2000 the JPEG sub-group created the JPEG 2000 standard as a discrete wavelet transform (DWT)-based compression method for still imagery to replace the original discrete cosine transform (DCT)-based JPEG standard. The JPEG 2000 standard was published as ISO/IEC 15444-1 and International Telecommunication Union (ITU) Telecommunication Standardization Sector (ITU-T) Recommendation T.800.
JPEG 2000 defines a set of lossless (bit-preserving) and lossy compression methods for coding bi-level, continuous-tone gray-scale, palletized color, or continuous-tone color digital still images. The standard:

- Specifies decoding processes for converting compressed image data to reconstructed image data;
- Specifies a code stream syntax containing information for interpreting the compressed image data;
- Specifies a file format;
- Provides guidance on encoding processes for converting source image data to compressed image data;
- Provides guidance on how to implement these processes in practice.

While there is a modest increase in compression performance of JPEG 2000 compared to JPEG, the main advantage offered by JPEG 2000 is the significant flexibility of the code-stream. The code-stream obtained after compression of an image with JPEG 2000 is scalable in nature, meaning that it can be decoded in a number of ways; for instance, by truncating the code-stream at any point, one may obtain a representation of the image at a lower resolution. Other JPEG2000 features include:

- Superior compression performance: At high bit rates, where artifacts become nearly imperceptible, JPEG 2000 has a small machine-measured fidelity advantage over JPEG. At lower bit rates (e.g., less than 0.25 bits/pixel for grayscale images), JPEG 2000 has a much more significant advantage over certain modes of JPEG: artifacts are less visible and there is almost no blocking. The compression gains over JPEG are attributed to the use of DWT and a more sophisticated entropy encoding scheme.
- Multiple resolution representation: JPEG 2000 decomposes the image into a multiple resolution representation in the course of its compression process. This representation can be put to use for other image presentation purposes beyond compression as such.
- Progressive transmission by pixel and resolution accuracy, commonly referred to as progressive decoding and signal-to-noise ratio (SNR) scalability: JPEG 2000 provides efficient code-stream organizations which are progressive by pixel accuracy and by image resolution (or by image size). This way, after a smaller part of the whole file has been received, the viewer can see a lower quality version of the final picture. The quality then improves progressively through downloading more data bits from the source. The 1992 JPEG standard also has a progressive transmission feature but it's rarely used.
- Lossless and lossy compression: Like JPEG 1992, the JPEG 2000 standard provides both lossless and lossy compression in a single compression architecture. Lossless compression is provided by the use of a reversible integer wavelet transform in JPEG 2000.
- Random code-stream access and processing, also referred as Region Of Interest (ROI): JPEG 2000 code streams offer several mechanisms to support spatial random access or region of interest access at varying degrees of granularity. This way it is possible to store different parts of the same picture using different quality.
- Error resilience: Like JPEG 1992, JPEG 2000 is robust to bit errors introduced by noisy communication channels, due to the coding of data in relatively small independent blocks.
- Flexible file format: The JP2 and JPX file formats allow for handling of color-space information, metadata, and for interactivity in networked applications as developed in the JPEG Part 9 JPIP protocol.
- Side channel spatial information: it fully supports transparency and alpha planes.
- JPEG 2000 is not widely supported in web browsers, and hence is not generally used on the World Wide Web.
For systems implementing the National Imagery Transmission Format Standard (NITFS) [or its NATO instantiation, the NATO Secondary Imagery Transmission Format (NSIF)], the ISO/IEC Basic Image Interchange Format (BIIF) Profile for JPEG 2000 (BPJ2K) establishes (profiles) the features and functional behavior that must be supported when using the JPEG 2000 image compression algorithms.


The name "JPEG" stands for Joint Photographic Experts Group, the name of the committee that created the JPEG standard and also other standards. It is one of two sub-groups of the International Organization for Standardization (ISO) International Electrical Commission (IEC) (ISO/IEC) Joint Technical Committee 1, Subcommittee 29, Working Group 1 (ISO/IEC JTC 1/SC 29/WG 1), organized in 1986, which issued the first JPEG standard in 1992. In 2000 the JPEG sub-group created the JPEG 2000 standard as a discrete wavelet transform (DWT)-based compression method for still imagery to replace the original discrete cosine transform (DCT)-based JPEG standard. The JPEG 2000 standard was published as ISO/IEC 15444-1 and International Telecommunication Union (ITU) Telecommunication Standardization Sector (ITU-T) Recommendation T.800.

JPEG2000 is a specification that describes an image compression system that allows great flexibility, not only for the compression of images but also for access into the code-stream. The code-stream provides a number of mechanisms for locating and extracting portions of the compressed image data for the purpose of retransmission, storage, display, or editing. This access allows storage and retrieval of compressed image data appropriate for a given application without decoding.

ISO/IEC 15444-9:2005 JPEG 2000 image coding system Part 9: Interactivity tools, APIs and protocols, November 17, 2005 with Cor 1:2007, Cor 2:2008, Amd 1:2006, Amd 2:2008, and Amd 3:2008 defines the JPEG 2000 Interactive Protocol (JPIP). JPIP is a protocol for the interactive delivery of JPEG 2000 compressed imagery and Motion JPEG 2000 compressed video (see ISO/IEC 15444-1, ISO/IEC 15444-2 and ISO/IEC 15444-3). It allows for the interactive and progressive transmission of JPEG 2000 coded data and files from a server to a client. This protocol allows a client to request only the portions of an image (by region, quality or resolution level) that are applicable to the client’s needs. The protocol also allows the client to access metadata or other content from the file.

A JPIP client uses a view-window request to define the resolution, size, location, components, layers, and other parameters for the image and imagery related data that is requested by the client. The JPIP server response delivers imagery and imagery related data with precinct-based streams, tile-based streams, or whole images. The protocol also allows for the negotiation of client and server capabilities and limitations. The client may request information about an image as defined in index tables from the server, which enables the client to refine its view-window request to image specific parameters (e.g., byte range requests). The server’s cache model is based on the capabilities defined by the client and the statefulness of the session.

JPIP enables the scalable dissemination of large imagery over low-bandwidth communications links without the need to transmit an entire compressed image file. Oftentimes a mere 1-5% of a compressed image is transmitted in a typical JPIP session.

Technologies that compete with JPIP are Google Earth, which uses a proprietary compression and streaming protocol, and Google Maps/Microsoft Virtual Earth. The Google Earth approach is very similar to that of JPEG 2000/JPIP, but does not use ISO standards. The Google Earth/Microsoft Virtual Earth approaches use AJAX-based serving of small ortho-rectified image tiles and client-side tile mosaicking.
The net effect of these technologies is to allow the interactive roam and zoom of large image datasets over the Web. There are two basic techniques employed but only JPEG 2000/JPIP is an open standard.

### 7.7.1 Streaming Geospatial Raster Data using JPIP

Geospatial metadata may be encoded in the JPEG 2000 XML metadata area using as subset of OGC GML known as GMLJP2. GMLJP2 is used to encode geospatial metadata for images, maps, terrain models, soundings and other raster data.

The use of GML metadata within a JPEG 2000 data stream is described in OGC standard GML in JPEG 2000 for Geographic Imagery Encoding Specification, also known as GMLJP2.

### 7.8 Motion JPEG 2000 [ISO/IEC 15444-3:2007]

Motion JPEG 2000 is the video version of JPEG 2000. However, unlike other movie formats, which use inter-frame scene-differential coding to compress multiple frames, each JPEG 2000 frame is compressed independently. Motion JPEG 2000 is the standard for the digital cinema format for digital movie theaters and is commonly referred to as simply "JPEG 2000."

JPEG 2000's decoding is also a major advantage for digital cinema. For example, although the movie may have been mastered in 4K resolution, it can be decoded and projected at 2K without having to decode into 4K first and then down-convert into 2K afterwards. This enables the same source file to be used in different theaters.

### 8 Miscellaneous Commercial, Proprietary and Community of Interest Standards

#### 8.1 Topographic Data Store (TDS) Version 4. 7 July 2011 [TDS V 4.0]

Topographic Data Store [TDS V 4.0] is proprietary geospatial database format containing topographic information including embedded raster data that was retired from the DISR. No public documentation for this database has been released, and is subject to change without notice by the owner of the format.

Raster images are stored as blobs that may be compressed using JPEG2000, JPEG, or LZ77 compression.

The NSG TDS Content Specification specifies an extension to the NSG Entity Catalog (NEC) that: identifies specific content of the NEC that shall be obligatory for geospatial intelligence producers using this specification, and specifies the conditions under which this geospatial intelligence shall be collected by producers for use in net-centric data exchange with other NSG participants. The NEC specifies the domain data model for feature-based geospatial intelligence that determines the common semantic content of the NSG despite varying physical realizations across DoD/IC systems (i.e., regardless of whether geospatial features are represented as an image, a multi-dimensional grid of values, or a set of one or more vector shapes). The NSG TDS Content Specification identifies the topographic content of the Geospatial Intelligence Knowledge Base (GKB) that serves as the common DoD/IC virtual geospatial information environment on the Global Information Grid (GIG); it should be used by all applicable GKB content contributors. The NSG TDS Content Specification allows for multiple physical realizations as
constrained by system-specific technologies and requirements; in particular it adopts the consistent use of ESRI Shapefile technology as one common physical realization as well as supporting other technologies such as XML-based data encodings/exchange and relational DBMS (including COTS GIS).

8.2 Imagery Related Metadata Standards

8.2.1 Frame Sensor Model Metadata

The Frame Sensor Model Metadata [NGA.SIG.0002.2.1] Profile Supporting Precise Geo-positioning (FSMMP/PG) information and guidance document specifies the various sensor and collection system (platform and other external sources of data) parameters to be considered when constructing a frame sensor model that includes the minimum essential metadata necessary to enable a sensor exploitation tool to recognize the sensor and to support the capability of precise geolocation. This metadata includes measures of the sensor and collector physics and dynamics that enable photogrammetry equations to establish the geometric relationship between sensor, image, and object imaged.

A frame sensor is one that acquires all of the data for an image (frame) at an instant of time. Typically, this class of sensor has a fixed exposure and is comprised of a two-dimensional detector or array; e.g., focal plane array (FPA) or Charge-Coupled Device (CCD) array. Historically, the term sensor usually refers to digital collections, whereas the term camera is typically used to denote use of film-based collectors. This distinction is not universally observed.

The FSMMP/PG specifies parameters for defining coordinate systems for the earth, the sensor’s platform, the sensor, and the sensor’s storage format, and equations for coordinate transformations between these systems. It provides equations to compensate for array and film distortions, optical distortions, atmospheric refraction, and the curvature of the earth.

The FSMMP/PG also specifies parameters required for a complete frame sensor model. The focus is upon those sensor properties necessary for accurate and precise geolocation with electro-optical (visible) frame sensors and not on the spectral sensitivity of the sensor; although the definitions and development apply equally to film and infrared (IR) arrays.

Use of the information provided by the FSMMP/PG will enable the design, development, and Validation and configuration management of geopositioning capabilities across the DoD.

The FSMMP/PG is managed by the National Geospatial-Intelligence Agency (NGA) National Center for Geospatial Intelligence Standards (NCGIS) and Geospatial Intelligence Standards Working Group (GWG) Community Sensor Model Working Group (CSMWG). It has been formally adopted and implemented by the Air Force, Navy and NGA. The AF, under its Sensor Model Program, and NGA have completed numerous sensor models using the guidance provided by the document.

FSMMP/PG information and guidance is applicable to DoD Component/Intelligence Community sensor programs that are required to develop and/or revise a frame sensor model, to sensor model development programs and to geopositioning capability development programs that incorporate frame sensors.
8.2.2 Community Sensor Model (CSM)

The Community Sensor Model (CSM) Technical Requirements Document (TRD) specifies technical / functional requirements for development of sensor models and an evaluation methodology / verification and validation process to assure that a CSM meets the requirements. The CSM TRD and five appendixes are the basis for a standardized and cost effective program for developing, testing, and evaluating current and future sensor models supporting Sensor Exploitation Tools (SETs) and other application tools requiring a precise understanding of the image (data) and ground coordinate relationships. The objective of these CSM requirements is to standardize the coordinate transformations of community imagery—ensuring consistent, accurate coordinates are provided to all imagery users.

A CSM is a dynamically linked (or loaded) software library with the C++ language Application Programming Interface (API) specified in CSM appendix C. A SET can load or unload a CSM without requiring the SET to be recompiled, and without affecting other CSMs. SETs invoke CSM and sensor functions through this API to initialize a CSM for a sensor, adjust a sensor, get and set sensor parameters, get geopositioning information, and perform photogrammetric support operations on images from the sensor.

Underlying a CSM is a mathematical model described by equations, and algorithms and process that define coordinate transformations (ground to image, image to ground) between a sensor’s image space (2-dimensional) and ground space (3-dimensional). The CSM is based on the phenomenology, physics, and geometry of the image sensing/formation process–modeling the imaging ray from the sensor, through the optics (or antenna), down to the ground with a set of rigorous equations. It can correct for system or sensor specific aberrations, if needed.

Image to ground coordinate transformations accurately map a pixel (e.g., target location) on an image to a geo-referenced coordinate and provide rigorous circular and linear error estimates. CSMs use a rectangular Earth Centered Earth Fixed (ECEF) coordinate frame referenced to WGS-84. They report image collection times in Coordinated Universal Time (UTC) in ISO 8601:2000 format, and velocity vectors in meters per second.

CSM coordinate transformations and associated capabilities provide inputs used by the SETs to complete other photogrammetric and exploitation operations. SET operations may include mensuration, feature projection, extraction, registration, uncertainty propagation and other tasks.

Other CSM appendixes include a sensor definition document, hardware/software configuration information, sample statement of objectives and a test plan and procedures. These documents all augment the basic requirements documents above and allow a developer to build and test standard compliant sensor models. The acquisition strategy is that as new sensors are developed or existing sensors are revised, the sensor developer must deliver a sensor model built in accordance with the requirements of the TRD.

CSM sensor types include electro optic/infrared (EO/IR) and synthetic aperture radar (SAR). Specialized EO/IR sensor types include multi/hyper/ultra-spectral imagery, LiDAR, and video. EO/IR sensor imaging modes include frame, pushbroom, and whiskbroom. SAR sensor imaging modes include spot, strip mapping, and scan.

Each CSM operates as a single sensor model per image file. For most sensor models, this assumes a single image/frame/band per instantiation of the sensor model. It is the responsibility of the SET to structure the imagery and support data accordingly.
The CSM is managed by the National Geospatial-Intelligence Agency (NGA) National Center for Geospatial Intelligence Standards (NCGIS) and Geospatial Intelligence Standards Working Group (GWG) Community Sensor Model Working Group (CSMWG). It has been formally adopted and implemented by the Air Force, Navy and NGA. Twenty sensor models have been built by the DoD, tested, and are in full compliance with the standard. These sensor models are in use in over 1000 workstations worldwide.

This standard is applicable to DoD Component/Intelligence Community sensor programs that are required to develop and/or revise a sensor model, to sensor model development programs and to geopositioning capability development programs. This standard does not compete with any other standard.