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MAJIIC 2 STANAG 4545 NSIF IMPLEMENTATION GUIDE

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Abstract

This report highlights the key issues involved in bringing a synthetic aperture radar (SAR) imagery, electro-optical (EO) imagery, and infrared (IR) imagery capability to the Multi-Intelligence All Source Joint Intelligence, Surveillance and Reconnaissance Interoperability Coalition (MAJIIC 2) project. It is intended to provide a technical description of the profile of use of the STANAG 4545 NATO Secondary Imagery Format (NSIF) within MAJIIC 2 to participants in MAJIIC 2 who will be implementing STANAG 4545 within their simulation and exploitation systems.

In the past the imagery format in use within the Coalition Aerial Surveillance and Reconnaissance (CAESAR) project, and during part of the Multi-sensor Aerospace-ground Joint ISR Interoperability Coalition (MAJIIC) project, had been defined in the NATO EX Format.

Detailed description of the specification of the NSIF format is left to the STANAG documents. This document intends to contain information that is sufficient to allow developers to implement those portions of the STANAG 4545 format that will be necessary to be interoperable in the MAJIIC 2 project. Particular attention has been paid in this version of the document to revisiting the requirements for the handling of slanted imagery in three parts: simple, SENSRB, video to imagery.

NATO Communications and Information Agency
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(excluding covers)

EXECUTIVE SUMMARY

This document describes the STANAG 4545 use profile for exchanging synthetic aperture radar (SAR), electro-optical (EO) and infrared (IR) still imagery within the Multi-Intelligence All Source Joint Intelligence, Surveillance and Reconnaissance Interoperability Coalition (MAJIIC 2) communitywithin MAJIIC 2.

The document collates existing information necessary for the minimum implementation of STANAG 4545 within the MAJIIC 2 project. It does not present all of the answers but attempts to highlight those areas that will need to be addressed in the near future. It is not intended to be a stand-alone document and the reader should be familiar with the STANAG 4545 specification and related material. All cited contents of the particular format specifications and supporting documents should be referenced. The implementation guidelines in this document are complementary to STANAG 4545 and associated documents.

This document attempts to form a useful implementation guide for the MAJIIC 2 implementer, a technical reference document for STANAG 4545 issues within MAJIIC 2, and a record of the effective use.

Issues still remain in defining the best representation for exchange geo-registered of slanted imagery.

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1. INTRODUCTION

1.1 BACKGROUND

The NATO Secondary Imagery Format (NSIF) standard, STANAG 4545 [NATO STANAG 4545 Edition 2, 2013] is aimed at promoting interoperability of secondary imagery among NATO Command, Control and Communication (C3) and Intelligence (C3I) Systems. The NSIF is the standard for formatting digital imagery and imagery-related products and exchanging them among members of NATO. The NSIF is a collection of related standards and specifications developed to provide a foundation for interoperability in the dissemination of imagery and imagery-related products among different computer systems.

The NSIF Allied Engineering Documentation Publication 4 (AEDP-4) [NATO AEDP-4 Edition 2, 2013] provides implementation guidance for users of NATO STANAG 4545. The reader should note that since July 2012, the technical information originally contained in the STANAG as Annexes: A - Terms and definitions, B - NSIF concept of operations, C - NSIF File format, D - Standard geospatial support data extensions and E - Complexity levels and been moved to the NSIF allied engineering documentation publication 4 (AEDP-4) [NATO AEDP-4 Edition 2, 2013] and reformatted as annexes:

A: Implementation guidance

B: Sample implementation

C: NSIF test criteria (NTC)

D: Test criteria for JPEG 2000 data in STANAG 4545

E: NSIF approved support data extension listing

F: NSIF configuration management plan

G: Forms for requesting changes to documents or proposing new extensions

H: DIGEST extensions errata/configuration management

1.2 DOCUMENT OBJECTIVES

This document aims to define the formats for the exchange of synthetic aperture radar (SAR), electro-optical (EO) and infrared (IR) imagery, using STANAG 4545 and any necessary extensions, within the MAJIIC 2 community, and also to record a description of the corresponding requirements and a description of its use.

For the purposes of this document, SAR, EO, IR imagery is defined as visual static imagery. The use of EO and IR moving imagery is out of the scope of this document and will be covered in the MAJIIC 2 STANAG 4609 Implementation Guide [DOP-MAJIIC2-009, 2015].

Along with the handling of SAR, EO and IR imagery, this document will explain options for completing 4545 embedded metadata. Proper usage of metadata within the NSIF file (e.g. geo-location information) enables clients to make good use of the accompanying imagery. Incomplete or incorrect metadata in the NSIF file may mean a lack of success for ingestion into a CSD and failure of overall global reach and retrieval when moving NSIF files across boundary conditions or ingestion into CSD or location of images when querying the CSD.

1.3 CHANGE OF MAJIIC PROGRAMME AND INFLUENCE ON IMAGERY EFFORTS

When the MAJIIC 2 project was started, the imagery subject matter experts had the ambition to work with several new sensors and multi-sensor fusion. Several of the new sensors produce slanted imagery which for MAJIIC 2 would make a change from classical air reconnaissance and ortho-rectified images. New imagery sources included:

- Images taken from humans or vehicles (e.g. cameras, binoculars, elevated cameras, binoculars, turret cameras).
- Non ISR sensors such as gun cameras.
- Forward looking UAV camera motion imagery allowing a UAV pilot to remotely control the UAV

However, during the execution of MAJIIC 2 project it was recognized that the multi-sensor ambitions was too ambitious for the project and after the Utrecht meeting, the tasking was changed with significantly reduced efforts on multi-sensor and fusion.

Additionally, this document has evolved over time through a collaborative effort from several contributors. However, the level of effort that has gone into the document has not been sufficient to produce a holistic implementation guide for the MAJIIC 2 community that addresses all aspect of a MAJIIC 2 profile of the STANAG 4545. As a consequence there are several known issues and limitations with this document as seen in the list below:

1. Additional STANAG 4609 metadata mapping needed to map mission relevant information to the appropriate STANAG 4545 fields. [DOP-MAJIIC-28, 2010] identifies a Key, Length, Value (KLV) key to STANAG 4545 mapping. Need to harmonize with “NITF from Motion Imagery - coordination” activities.
2. A section with guidance on publishing handheld imagery is desired.
3. Guidance is needed on how to fill SENSRB in general if the image contains the horizon.
4. The mapping and use of the CSD metadata fields needs to be checked. Might be outdated and/or inaccurate.

2. REQUIREMENTS

MAJIIC 2 efforts have been guided by Operational User Requirements (OURs) and these have led to architectural and technical requirements. These requirements are presently contained in a spreadsheet named, "REQUIREMENTS TRACEBILITY SPREADSHEET.xlsx", see [MAJIIC 2 Requirements Traceability Matrix, 2015].

Individual worksheets in each of the three categories list the requirement IDs and requirement type, sub-type, name, description and category. These have been related to each other by cross referencing in matrices providing an operational to architectural mapping and an architectural to technical mapping. These will be maintained and continually updated and the reader is directed to that spreadsheet to get the latest mappings.

The list below supports a simplification, independent of indices that may change, of the 4545 NSIF Imagery elements as of January 2015, in terms of defining the formats for creation, exchange and processing of STANAG 4545 NSIF image files. This section is to help a new MAJIIC 2 sensor/collection system or exploitation system developer see the scope of designing a system to participate in image generation and utilization process and also perform as a development check list.

2.1 MAJIIC 2 OPERATIONAL REQUIREMENTS

The operational users have generated requirements related to 4545 NSIF imagery of availability and use.

<u>Operational:</u>

1. The user shall be provided a capability to INGEST and VISUALISE IMAGERY objects in order to complete EXPLOITATION tasks. The types of still imagery data formats that are required to be visualized: 7023, 4545 NSIF, NITF.

2.2 MAJIIC 2 ARCHITECTURIAL REQUIREMENTS:

The architecture designers generated a MAJIIC 2 Architecture Requirements Document or MARD as we call it and that document that document specifies the detail architecture driven requirements for all Collection, Exploitation and IRM & CM systems.

<u>Sensor:</u>

1. The sensor capability shall provide still images: In compliance with STANAG 4545 and AEDP-4 as specified in this implementation guide.

<u>Exploitation:</u>

1. The exploitation capability shall enable the operator to access, process, and display still imagery in compliance with STANAG 4545 and AEDP-4 as specified in the MAJIIC STANAG 4545 NSIF Implementation Guide (this guide).
2. The capability shall enable the operator to request, process, and display chips of still images in compliance with STANAG 4545 and AEDP-4 as specified in the MAJIIC STANAG 4545 NSIF Implementation Guide (this guide).

3. The capability shall enable the operator to generate and publish annotated imagery: in compliance with STANAG 4545, the Computer Graphics Metafile, and AEDP-4 as specified in the MAJIIC STANAG 4545 Static Imagery Implementation Guide (this guide).
4. The capability shall enable the operator to access, process, and display annotated imagery: in compliance with STANAG 4545, the Computer Graphics Metafile, and AEDP-4 as specified in the MAJIIC STANAG 4545 NSIF Implementation (this guide).

2.3 MAJIIC 2 TECHNICAL REQUIREMENTS:

The test and evaluation (T&E) subgroup made up of subject matter experts (SMEs) in each ISR data type monitor the NATO STANAGS and endeavour to guide our Collection, Exploitation and IRM&CM system developers as they strive to meet the MARD Requirements and that leads us to define, implement, test and improve the MAJIIC2 data exchange capabilities and system and client interfaces. Based on this, the following technical requirement set is derived and the way to meet the requirements are described following this section.

General:

1. MAJIIC 2 systems shall use STANAG 4545 for SAR, EO, IR (Must)
2. MAJIIC 2 SAR, EO, IR NSIF file shall contain exactly one image segment (Must)
3. A MAJIIC 2 SAR, EO, IR NSIF file shall contain the necessary NSIF NSIF-approved support data extensions (SDE) at their specified location (file header or segment header). (Must)
   - NSIF file features not currently considered for MAJIIC 2 are all multi/hyper-spectral features and all optional features.

Publishing:

1. The MAJIIC 2 requirement is for a national system to post an NSIF file into a CSD using the STANAG 4559 CreationMgr function (Must)
2. The NSIF file header shall supply information for MAJIIC2 interoperability as specified in Chapter 5.2. Advice for the content of the CSD metadata can be found in the business rules and in the exercise plan. Specific NSIF metadata requirements will be defined in the exercise plan. (Must)

Compression:

1. Systems should be able to handle JPEG and JPEG2000 compressed images. (Should)

Annotation:

1. Systems should be able to process NSIF files containing annotated imagery using CGM extension without falling over. (Should)

Geo Referencing:

1. MAJIIC 2 systems shall adopt the BLOCKA TRE for the production of ortho-rectified images and shall be placed in the Image Sub-header. (Must)
2. MAJIIC 2 geo-referencing requirement mandates the use of the IGEOLO field and the BLOCKA SDE for ortho-rectified images such as SAR images. (Must)

3. MAJIIC 2 systems shall adopt the SENSRB TRE for the production of slanted imagery. (Must)

Chipping:

1. MAJIIC 2 systems shall adopt the ICHIPB TRE for the production of chipped images. (Must)

Security:

1. MAJIIC 2 systems shall adopt the RELCCA TRE when addressing limitations in xSREL fields. (Must)

MAJIIC 2 use of STANAG 4545 (NSIF) in in this document is complementary to the STANAG and the AEDP. In the NSIF concept, imagery data interchange between systems is organised in NSIF files. Practically, the STANAG 4545 is a description of a file format for this interchange.

STANAG 4545 is complemented by the use of support data extensions (SDE). SDEs can take the form of either tagged record extensions (TREs) that are appended to the NSIF file header or segment sub-header, or Data Extension Segments (DES) which add functionality to the file. There are three groups of TREs that are frequently used together, plus miscellaneous TREs that have specific applications. The extensions associated with the groups can, in many cases, be used separately as well. The three groups of TREs are:

- Geospatial SDEs,
- Airborne SDEs, and
- Commercial SDEs.

For more information on the SDEs, see the discussion and hyperlink in [NATO STANAG 4545 Ed2, 2013], part 4 and in [NATO AEDP-4 Ed2, 2013], Annex E.

If complete compliance to everything in STANAG 4545 is not feasible, MAJIIC 2 must agree on a subset of SDEs that meet the requirements of the MAJIIC 2 project.

Intelligence, surveillance, and reconnaissance (ISR) Product Libraries (IPLs), e.g. the coalition shared data (CSD) server, based on STANAG 4559 [NATO STANAG 4559 Ed3Am1, 2014], store files containing ISR type information and among these files NSIF files are found. The IPLs use cataloguing metadata to enable effective querying of the repository. In the case of populating the IPL cataloguing metadata for NSIF files, metadata from within the NSIF files are used. This document includes a description of the NSIF embedded metadata that is extracted for IPL cataloguing purposes.

3. MAJIIC 2 USE OF STANAG 4545 (NSIF)

3.1 MAJIIC 2 MANDATED USE OF STANAG 4545 (NSIF)

As the STANAG 4545 is deemed able to support the MAJIIC 2 requirements, MAJIIC 2 has mandated the use of STANAG 4545 for SAR, EO and IR imagery. This move from the EX 2.01 format is in line with the NATO emphasis on using STANAG wherever possible.

3.2 CURRENT ASSESSMENT

This current assessment of the state of the standard and its use within MAJIIC2 wishes to highlight the available sources of NSIF imagery and especially new slanted imagery, the recent upgrade to the guidance on specifying geo-referencing and to note that MAJIIC2 has adopted the use of the RELCCA releasability tagged record extension (TRE) and is monitoring the NATO proposed changes to the approaches to specifying nationalities and releasability within many NATO formats.

There are a large number of real world and simulated MAJIIC 2 systems that are capable of producing static imagery. Real and simulated Sensors for Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR) systems such as Joint Surveillance Target Attack Radar System (JSTARS), Airborne Stand-Off Radar System (ASTOR), Global Hawk, and U2 are capable of producing simulated SAR imagery. There are a number of real Unmanned Aerial Vehicle (UAV) s and simulated UAVs in MAJIIC 2 that can produce EO or IR static imagery and full motion video (FMV) imagery. There have been a number of live systems, participating in MAJIIC 2 exercises such as Trial Quest, notably UAVs, that produce NSIF static and FMV images from a range of sensor types.

While the handling of the FMV data is specified in STANAG 4609, single frames taken from an FMV stream may still need to be provided as still images in STANAG 4545 format. It is now mandatory for these images and associated metadata to be stored in the CSD as STANAG 4545 files.

There has also been continuing improvement to how slanted or oblique images can be defined in order to be correctly geo-referenced. Previous guidance provided by MAJIIC was that the SENSRA and ACFTB extensions should be used to populate the STANAG 4545 files for slanted images. It has since been recognised that these extensions could result in unacceptable geo-location errors if the MAJIIC 2 sensor simulators or real systems are unable to comply with the parameter envelope for which these extensions are proven to be accurate. The guidance provided in this document is that MAJIIC 2 systems adopt the SENSRB TRE for the production of slanted imagery.

The SENSRB extension has been published in a new version [NGA STDI-0002 Version 4.0, 2011], which fixes issues contained in the previous version. The current version of this implementation guide provides guidance on how to use this extension for slanted imagery support.

Specifying a nationality when generating release instructions within the STANAG 4545 NSIF format had historically involved filling (xSRELs): file release instructions (FSREL) in the NSIF File Header, Image Releasing Instruction (ISREL) in various NSIF image Sub-headers and Graphic Release Instructions (SSREL) in various Graphic Sub-Headers with values from Processing Standard (FIPS) Publication 10-4 for digraphs or International Organization for Standardization (ISO) Standard 3166 for tri-graphs.

During the MAJIIC 2 project execution it was found that (FIPS) Publication 10-4 is no longer maintained so the guidance switched to requiring the use of tri-graphs as defined in [NATO STANAG 1059 Ed8, 2004]. The tri-graphs in [NATO STANAG 1059 Ed8, 2004] is used to define releasability and required the use of the Releasability Tagged Record Extension (TRE) - RELCCA because it supplements the allowed content for a xSREL field with:

- List(s) of country codes specified by standards other than USA Federal Information Processing Standard (FIPS) Publication 10-4 for digraphs or International Organization for Standardization (ISO) Standard 3166 for tri-graphs.
- List(s) of country codes associated with multilateral entity codes, and
- Listing of organizations to which imagery can be released and provides additional character space when we try to specify a release to many entities.

However, as it was found repeatedly in MAJIIC 2 exercises that the use of correct tri-graphs was not followed by all participants, the MAJIIC 2 implementation started to be "tolerant" to deviations of releasability markings. "Tolerant" means that while most MAJIIC applications were using proper releasability markings according to [NATO STANAG 1059 Ed8, 2004] some MAJIIC 2 applications dealing with exploitation or storage (such as CSD) did accept other releasability markings. The positive side effect is that JISR products with erroneous releasability markings are accepted, they can be stored, retrieved and processed. The negative side effect is that these JISR products are not automatically distributed (e.g. across release servers or boundary protection devices), but they need often interaction with an operator.

Given all that, the situation is now even more complex than it was at the middle of MAJIIC2. We are now hearing of a new NATO agreement on the way forward concerning the use of tri-graphs. We have learned:

- Under guidance of the International Military Staff (IMS), NATO Headquarters C3 Staff will provide a new list of tri-graphs for geographical entities (instead of country codes). This work will be done under Change Proposal 510 for STANAG 7149)
- Under guidance of the International Military Staff (IMS), NATO Headquarters C3 Staff will develop a new approach for security labelling of information.

The cornerstones of the CP 510 agreement are:

1. It is not called a country code list, but a list of geographical entities. The definition of the list is as follows: "Describes countries, independent states, dependent areas and areas of contested jurisdiction or special status."
2. It does not refer to or mention STANAG 1059 or ISO 3166; however the vast majority of codes of course are taken from those standards.
3. Two letter codes are completely removed from the messages; only three letter codes are in the list.
4. For "the former Yugoslav Republic of Macedonia" the usual footnote ("Turkey recognises the Republic of Macedonia with its constitutional name.") is made and the code is FYR – in deviation from MKD in the ISO standard.
5. There is a note at the beginning of the list saying: "Remarks: The inclusion of a data item in these FUDNs does not imply that NATO or one or more member nations recognise those entities."

6. Beyond the obvious list of countries, the list contains entries for NATO, ACT, ACO, UN, EU and NGO (XXN, XXS, XXE, XUN, XEU, NGO) and also the known exercise countries like ORANGELAND, BROWNLAND, LIMELAND, etc. (all starting with XX).

Both developments are assessed to not be finalized before the end of MAJIIC 2 in December 2015; thus future implementations of STANAG 4545 after December 2015 will have to consider these changes.

3.3 EXERCISE LESSONS IDENTIFIED AND IMPLICATIONS FOR GUIDELINES

The major lessons concerning the use of NSIF images that have been learned (and in some cases re-learned) from MAJIIC 2 exercises are:

1. Concerning Imagery, systems must implement mandatory capabilities;
2. Systems shall be able to handle JPEG and JPEG2000 compressed images
3. Production and processing of NSIF Annotated Images using Computer Graphics Metafile (CGM) is desirable;
4. The way MAJIIC 2 currently handles slanted imagery can cause problems;
5. More guidelines need to be provided for metadata.

The technical evaluators have since 2009 recommended that bullets 1, 2, 4 and 5 are of the highest priority and need action. The use of annotated imagery using CGM is desirable; some systems have already implemented this capability and it should be supported by all systems in future exercises. Annotation of NSIF imagery can be accomplished in a number of ways including being burnt into the image. However, the evaluator’s recommendation is that the CGM extension should be used to perform image annotation as this allows annotation to be switched on or off. The critical point is that systems should be able to process NSIF files containing the CGM extension without falling over.

3.4 CURRENT IMPLEMENTATION GUIDELINES

The following development is made to cover the MAJIIC 2 mandate at minimum complexity without imposing undue limitation to the participating sensor capabilities. The authors will consider changes of this document when needs not currently covered will show up.

3.4.1 MAJIIC 2 exchanges using STANAG 4545

The use of the STANAG 4545 is decomposed along the functional needs of MAJIIC 2 in the following way:

1. Exchanges of SAR, EO, IR sensor images from participating systems to the CSD
2. Exchanges of SAR, EO, IR sensor images from CSD to participating systems
3. Other exchanges, e.g. exchanges of exploitation products.

3.4.2 MAJIIC 2 profile of NSIF files for SAR, EO, IR images

A MAJIIC 2 SAR, EO, IR NSIF file shall contain exactly one image segment, with the necessary NSIF approved SDEs at their specified location (file header or segment header). No SDE is currently required for the SAR, EO or IR imagery segment. Currently, MAJIIC 2 expects that the image is made of one single block.

The following NSIF file features are not currently considered for MAJIIC 2:

- All multi/hyper-spectral features,
- All optional features.

The NSIF approved SDEs are described in Annex E of [NATO AEDP-4 Edition 2, 2013], and in [NGA STDI-0002 Version 4.0, 2011].

3.4.3 MAJIIC 2 geo-referencing

A key concern of MAJIIC 2 is proper geo-referencing of images.

Each participating sensor system has its own way of geo-referencing depending upon its proper application field. The existence of MAJIIC 2 might have the effect of extending its application field. There is more than one way to support geo-referencing of an image, depending on the application requirements.

The purpose of the following paragraphs is to develop material for discussing what will be the recommended way to properly support the exploitation stage of MAJIIC 2, initially the input to the exploitation stage. Changes are anticipated.

It has been decided as the MAJIIC 2 geo-referencing requirement to mandate the use of the IGEOLO field and the BLOCKA SDE for ortho-rectified images such as SAR images but to mandate the SENSRB extension for the production of slanted imagery. The EO/IR imagery produced during MAJIIC 2 operations is presented as mostly slanted images, in most cases not ortho-rectified and as a consequence not properly geo-referenced.

The MAJIIC 2 community needs to consider how to handle images that contain the horizon and whose upper corners are in the sky. AEDP-4 has one recommendation for handling these images; an alternative method is proposed in Section 3.4.3.

There are also images that consist mainly of an elevation view of a subject, non-traditional ISTAR images such as those taken from mobile phones come into this category. These images are not likely to be NSIF images but it would be effective for them to be stored and retrieved from the CSD via metadata search.

3.4.4 Imagery Compression

Image compression is a useful method for reducing bandwidth usage and it is important that MAJIIC 2 systems start to support compressed imagery, starting with JPEG and JPEG 2000. As of 2008 the subject matter experts in MAJIIC have recommended that support for compressed imagery should be implemented.

3.4.5 Imagery Chipping

The extraction of image chips from a larger NSIF image is supported by the CSD. The chipping of a relevant area from an image with a large extent, such as a satellite image, is one way of reducing the bandwidth requirements. It may also provide a solution to the problems some national systems had when failing to process massive images. Consequently, the subject matter experts in MAJIIC has recommended that national systems implement the image chipping capability. APPENDIX B provides some guidance for those developing the image chipping capability for the first time.

Warning: the notes in APPENDIX B are for guidance only, other developers may experience other difficulties but the notes are from UK experience of implementing the capability.

3.4.6 Annotated Imagery

The ability to retrieve NSIF images from the CSD and exploit the images is a fundamental task of the image analyst (IA). A frequently used procedure is to annotate the image and send it out as an exploited product. This product could also be stored in the CSD and be accessible to the wider community. Often the annotations are 'burnt into' the image and cannot be removed by another IA who wishes to use the image. STANAG 4545 supports image annotations using the CGM and these annotations could be switched on and off if the applications are capable of doing so. The implications for adopting annotations in MAJIIC 2 are that exploitation stations would need to implement the capability to draw and upload annotated imagery. The subject matter experts in MAJIIC recognises the utility of such a capability. MAJIIC 2 should also consider how to handle Audit Trails for exploited products e.g. addition of a text segment.

3.5 GEO-SPATIAL SUPPORT DATA EXTENSTIONS

Geo-spatial SDEs are NOT REQUIRED currently. They are considered for future use and so are under discussion; they may be present in the NSIF files for experimentation.

3.6 MAJIIC 2 REQUIRED SUPPORT DATA EXTENSTIONS

Currently, the REQUIRED extensions are

- BLOCKA
- ICHIPB
- SENSRB
- RELCCA

3.6.1 BLOCKA

BLOCKA implementation details are provided in Appendix E of [NGA STDI-0002 Version 4.0, 2011].

BLOCKA allows more precise geo-positioning of "image corners" than the ICORDS/IGEOLO fields. The available micro degree resolution is equivalent to a decimetre. Because nothing is said about the Camera Coordinate System (CCS) image plane properties (local projection of the ellipsoid), it is not formally complete for determining the geo-referencing of each image pixel. MAJIIC 2 may have to define the implied default locally referenced projection to be complete. Input from participants and experience learned during Technical Interoperability Experiments suggest that MAJIIC 2 requires the convention that the CCS image plane be the WGS84 latitude-longitude projected coordinate system.

BLOCKA includes the coordinates of the four image corners of the pixel array. From a geometrical point of view, with the above convention, three are enough to fully define an affine transformation between the pixel array coordinates and the World Geodetic System 1984 (WGS84) latitude-longitude coordinates.

The “image corner” expression is coming from the ICORDS/IGEOLO fields and so defines the corner pixel centres (not the intersection of the image borderlines).

Refer to Section 4.6 for information on how to populate BLOCKA in case of images taken from FMV STANAG 4609.

Table 1
MAJIIC 2 Conventions for BLOCKA Fields

Field	MAJIIC 2 Value Convention
CETAG	‘BLOCKA’
CEL	‘00123’
BLOCK_INSTANCE	
N_GRAY	***What is the definition of a gray fill pixel for SAR image? Also, it is TBD if we need to allow ECS Spaces as value, a deviation from the Compendium.***
L_LINES	
LAYOVER_ANGLE	
SHADOW_ANGLE	
(reserved-001)	16 BCS Spaces
FRLC_LOC	MAJIIC 2 prefers decimal degrees representation
LRLC_LOC	MAJIIC 2 prefers decimal degrees representation
LRFC_LOC	MAJIIC 2 prefers decimal degrees representation
FRFC_LOC	MAJIIC 2 prefers decimal degrees representation
(reserved-002)	5 BCS Spaces

3.6.2 ICHIPB

ICHIPB implementation details are provided in Appendix B of [NGA STDI-0002 Version 4.0, 2011]. It is required for chipped images.

Table 2
MAJIIC 2 Conventions for ICHIPB Fields

Field	MAJIIC 2 Value Convention
CETAG	‘ICHIPB’
CEL	‘00224’
…	

3.6.3 SENSRB

SENSRB implementation details are provided in Appendix Z of [NGA STDI-0002 Version 4.0, 2011]. Refer to Section 4.4 in this document for the use of SENSRB to handle slanted imagery.

3.6.4 RELCCA

RELCCA implementation details are provided in Appendix AD of [NGA STDI-0002 Version 4.0, 2011]. It is OPTIONAL for NSIF producers to include this TRE in NSIF files, but it is MANDATORY for NSIF consumers to be able to parse this TRE.

The RELCCA controlled TRE augments the xSREL and supports when:

- The list of codes exceeds the xSREL field capability,
- Applicable policies allow designation of organizations to which imagery can be released, or
- A country code standard other than FIPS 10-4 is used to specify digraph country codes or ISO 3166 for tri-graph country codes

In these cases the associated xSREL fields will contain the letters “RELCCA” and will serve to direct the NSIF decoder to process the RELCCA TRE.

When the RELCCA TRE is present all data (country codes and multilateral entity codes) in the extension’s COALID and RELCCODES fields shall be treated as if they were all in the file header or sub-header xSREL field.

For backward compatibility any list of country and multilateral entity codes meeting the field character limitation should be placed into the xSREL field and the RELCCA TRE shall not be provided.

The following TRE fields are recommended and described for the MAJIIC 2 project.

Table 3
MAJIIC 2 Conventions for RELCCA Fields

Field	MAJIIC 2 Value Convention
CETAG	RELCCA
CEL	11 plus the length in bytes of the subsequent fields: 00063
RELDATE	Date releasability determination was made in the form CCYYMMDD. The RELDATE field will be set to the date the product is created
RELSLNTH	Releasability determination source length. Set to 0003
RELSOURS	Releasability determination source set to XXN (NATO)
RELCCSLNTH	Country code standard length set to 0014
RELCCSTD	Country code standard set to STANAG1059:ED8
RCOLSLNTH	Coalition Code ID Code Standard length. Set to 0000
RCOLSTD	MAJIIC 2 will use the RELCCODES. The Release Coalition Field will not be used
RORGSLNTH	Release Organization Code Standard Length. Set to 0000
RORGSTD	Release Organization code will not be used
COIDLNTH	Coalition ID Field length. Set to 0000
COALID	Coalition Identification providing coalition definition (e.g. AMN, 9EYES, ISAF, KSAF). Coalition Identification will not be used
COALLNTH	Coalition Code Field length. Set to 0000
COALCC	Coalition Nations Country Codes will not be used
RELCNTH	Release Countries Field length. If COALCC is set, release country codes should only be used to augment or list additional countries. For MAJIIC 2 the RELCCODES will list the individual countries to which the NSIF is releasable. This field will be set to 0035
RELCCODES	Country codes to which the NSIF is releasable. The field will conform to the country code standard as specified in RELCCSTD. The country codes will be specified in alphabetical order separated by a single (0x20) space: CAN DEU GBR ESP FRA ITA NLD NOR USA XXN XXN will be used to specify NATO (NCIA) The country code specified in FSCLSY will be excluded from the RELCCODES field. Example, if XN (NATO) is specified in FSCLSY, XXN (NATO) will not be included in the RELCCODES and the RELCCODES field will be defined as: CAN DEU GBR ESP FRA ITA NLD NOR USA
RLORGLNTH	Release Organizational Code Field length. Set to 0000
RELORG	Release Organizational Code will not be used

4. HANDLING OF SLANTED IMAGERY

4.1 PROBLEM DESCRIPTION FOR SLANTED IMAGERY

Normally, air reconnaissance cameras try to look down to the designated targets in vertical or almost vertical angles. With the use of imagery means other than specialised air reconnaissance cameras such as targeting pods, gun cameras or ground-based cameras, the produced images are slanted; this means that the camera is not vertically over the target.

Airborne video cameras (e.g. on-board of unmanned aerial vehicles (UAV)) do not look down vertically during most of their operations. Therefore, images derived from video frames are in most of the cases slanted.

4.1.1 Previous approaches

Depending on the characteristics of the sensor and the processing of the raw image that is performed, it is possible that the image that is produced is not ortho-rectified. Slanted imagery may have all four points on the surface or may have some of the points above the horizon. Up until now the convention among MAJIIC 2 systems is for images with vertices above the horizon (such as some COYOTE images) to have the four location fields in the BLOCKA SDE set to the same value. This has allowed the images to be processed but does not allow any geo-registration of the image on a map. It is possible that an image with these characteristics is calculated to be of zero (or 1 pixel) size. Image viewers may be able to display the image but geo-registration is not possible.

A number of technical approaches have been recommended as solutions to the MAJIIC 2 issues. The STANAG 4545 recommendation in the AEDP-4 document is that the IGEOLO field be used to indicate key points on the image such as the edges of the horizon when some of the vertices are above the horizon. However, this is not sufficient for any kind of geo-positioning except for a rough estimation or for populating the metadata in an image product library (IPL) like the CSD.

The SPOT 123-4-5 Geometry handbook (see [GAEL Consultant GAEL-P135-DOC-001, 2004]) outlines algorithms to locate a position on the ground using the Earth ellipsoid and another one using a digital elevation model (DEM). Refer to chapter 4.7 “Location on Earth model” of [GAEL consultant GAEL-P135-DOC-001, 2004]. The use of a detailed Digital Elevation Model (DEM) for this purpose is mandatory to achieve accurate results. It should be noted that these algorithms are currently not used in MAJIIC 2.

4.2 SENSRB FOR IMAGERY

An evaluation was made by NATO Consultation, Command and Control Agency (NC3A) in the document “Rationale and Method for Creating STANAG 4545 Still Image from STANAG 4609 Motion Imagery” [DOP-MAJIIC-28, 2010]. The document identifies the four capability support categories situational awareness, change detection, geo-positioning, and advanced geo-positioning with a number of operational roles:

- Monitor Situation
- Provide Indications & Warnings
- Support Target Nomination

- Support Target Engagement
- Battle Damage Assessment

The operational roles require different levels of accuracy, which – on the highest level – can only be achieved by using an extensive set of about 80 KLV keys. At present, most of those keys are not defined in [MISB EG 0104.5, 2006] and [MISB STD 0601.5, 2011], which are the commonly used metadata elements provided by current FMV sensors.

At a later point in time a proposal for a pragmatic approach to slanted imagery [MAJIIC2 "A pragmatic approach to slanted imagery", 2011] was presented to the working group in which a multi-level approach was made. This approach utilizes the available metadata elements in [MISB EG 0104.5, 2006] and [MISB STD 0601.5, 2011] and proposes to provide a number of different levels of accuracy in a single SENSRB TRE. As part of the approach, the "80 KLV key" requirement has been analysed against current ICDs from the main camera manufacturers such as WESCAM, FLIR, and Zeiss. Among others, none of the needed error and uncertainty estimates are present in those ICDs. If and when these parameters will become available as part of the raw sensor metadata remains to be seen. Further, sensor calibration would be needed to acquire accurate results. In a rough military environment, this would be hard to guarantee as re-calibration would be necessary in case of rough handling of the equipment, such as a hard landing.

The next chapters describe how to create the multi-level STANAG 4545 images using the SENSRB extension.

Within the research and development efforts of MAJIIC 2, producers of slanted imagery MAJIIC 2 should use the SENSRB TRE.

This requirement to use SENSRB cannot be fulfilled with the current operational systems; therefore, a simplified approach is needed.

4.3 PROCEDURE FOR GEO-RECTIFYING IMAGERY FROM VIDEO

This section describes the procedure to calculate and store parameters to geo-rectify slanted imagery based on metadata extracted from Full Motion Video (FMV). The resulting parameters shall be stored in the SENSRB TRE.

The SENSRB extension is a new extension that allows for additional information required for several applications including accurate geo-positioning. This segment has been designed to support a wider variety of sensors and implementations.

As SENSRB supports a number of different ways to store slanting information, a multi-level approach is taken to store different accuracy levels in the TRE. A SENSRB-aware viewer can then pick the best slanting approach depending on the provided metadata and the display capabilities.

The procedure to warp an image from the extraction of the metadata to the geo-rectified image display can be roughly decomposed into:

1. Extract KLV metadata from video
2. For a pixel p in the video frame, compute the corresponding look vector
3. Compute the intersection between the look vector and the Earth ellipsoid / DEM

4. Compute Ground Control Points (GCPs) for the video frame
5. Store sensor look angles, GCPs etc. in the SENSRB TRE
6. Read SENSRB TRE and pick the best possible slanting approach
7. Use SENSRB TRE information to warp the raster file in the image viewer

The advantage of saving the slanting parameters with the GCPs into the file is that it gives more flexibility as the original frame is kept and a customized warping can be a applied to the image (e.g. n order polynomial, use of thin plate spline, etc.).

Polynomial coefficients can be calculated and saved into the SENSRB TRE extension (up to second degree polynomial).

4.3.1 Virtual Sensor Model

An eight parameter basic sensor camera model is used to geo-slant video frames onto a DEM. These eight parameters are shown in Table 4.

Table 4
Parameters of basic sensor camera model

Sensor Location	Latitude
	Longitude
	Altitude
Sensor Attitude	Yaw
	Pitch
	Roll
Sensor Field of View (FoV)	Horizontal
	Vertical

These values are used to build a generic camera model that is projected onto a specific surface: reference ellipsoid, Digital Elevation Model, Digital Surface Model or any other surface.

Elements needed have the following properties:

- Sensor Latitude and Longitude: both parameters are in geographical coordinates (e.g. WGS84)
- Sensor Altitude: should be in meters and use a “Height Above Sea Level” system, as it integrates better with Global Positioning System (GPS) systems, geoids and digital elevation models
- Sensor Yaw, Pitch and Roll: the sensor’s three attitude angles are to be provided in the correct order
- Sensor Fields of view: camera opening angles are needed for frame aspect ratio and frame on surface calculations.

Using these eight parameters as a starting point, a look-at vector can be calculated.

This can be done by creating a coordinate system on the image frame with values:

Table 5
Image Frame Coordinate System

	X	Y
Top, left	-1	1
Frame Centre	0	0
Bottom, right	1	-1

This coordinate system is used to assign coordinates to the frame's pixels.

The next step is to calculate a normalized look-at vector from the specific pixel, using all eight sensor's parameters.

The intersection between the look-at vector and the underlying surface (DEM, ellipsoid, etc.) is then calculated.

This intersection delivers four important values:

- Point on surface Latitude, Longitude and Altitude.
- Slant-range between sensor and point on surface.

These results can be used to calculate the diverse points of significance:

- Corner Points
- Frame Centre
- Any Ground Control Point

4.3.2 Geospatial Levels

To make efficient use of slanted imagery it is vital for any given system to be able to make use of the available geospatial information. There are various systems with different roles, from fully featured exploitation stations with accurate geospatial capabilities to simple viewers which may just display a centre and/or the corner coordinates of an image. To be able to support all different kinds of images, a multi-step approach to provide the geospatial information is proposed by this document.

Based on the capabilities of a particular system, it can make use of the best available and supported level provided together with a slanted image. This approach proposes to provide **all** of the following information levels for each slanted image. A simple geospatial aware viewer for example may use just the corner coordinates of a slanted image, while an image exploitation system may use either its own slanted image implementation and associated highly accurate elevation model or an accurate geospatial grid, which maps the slanted image precisely to the ground. It should be noted that all levels below the first one can be calculated based on the parameters provided by the first level. The proposed levels to be provided are:

Level 1: “Eight camera model parameters”

Level 2: “Dense coordinate grid”

Level 3: “Cubic polynomial reference”

Level 4: “Footprint and image centre coordinates”

Level 5: “Footprint coordinates”

Figure 1 Original slanted image

4.3.2.1 Level 1: “Eight camera model parameters”

The NSIF metadata provides sensor position, attitude vectors and field of view. Utilizing this information, a capable system can determine pixel locations based on the available elevation data. Systems may be able to utilize highly dense and accurate elevation models which can provide higher accuracy for the geo-positioning of pixels in the image. As the calculation of the coordinates for all following levels are based on these parameters, it is vital to preserve them.

Figure 2 Geo-rectified image using an accurate elevation model

4.3.2.2 Level 2: "Dense coordinate grid"

Systems supporting dense coordinate grids can utilize a grid to warp images and display an accurate mapping to the ground allowing for precise geo-location for any given pixel within the image. The coordinate grid typically takes different elevations within the image into account.

Figure 3 Geo-rectified image using a dense coordinate grid (grid highlighted)

4.3.2.3 Level 3: "Cubic polynomial reference"

Use this transformation when objects in the image are curved.

The higher the order of the polynomial, the better the fit, but the result can contain more curves than the base image.

For a third-order polynomial transformation (2D & 3D):

$$[u, v] = [1, x, y, xy, x^2, y^2, yx^2, x^2, x^3, y^3] \times T^{-1}$$

$$[u, v, w] = [1, x, y, h, xy, xh, yh, x^2, y^2, h^2, xyh, x^3, yx^2, xh^2, x^2y, y^3, yh^2, x^2h, y^2h, h^3] \times T^{-1}$$

Both u and v (and w) are third-order polynomials of x and y (and h). Each third-order polynomial has 10 (3D: 20) terms. To specify all coefficients, T^{-1} has size 10-by-2 (3D: 20-by-3). This approach needs at least 10 (3D: 20) GCP's well distributed over the image. These GCP's will be used to calculate the coefficients by replacing them in the above formula, along with the u, v (and w) coordinates, and then solving the equation. If more than 10 (3D: 20) GCP's are used an adjustment should be made.

Figure 4 Geo-rectified image using cubic polynomial reference

4.3.2.4 Level 4: "Footprint and image centre coordinates"

The five coordinates are the four corner points of the visible area and the centre location of the image assuming it is on the ground and not in the sky. Utilizing this information, the system will be able to compensate for the slant range distortion, moving the centre position of the image closer to the sensor position to its correct spatial coordinate and away from the horizon. This distortion can be considerable depending on the amount of "slanting".

Figure 5 Geo-rectified image using the four corners and the centre point

4.3.2.5 Level 5: "Footprint coordinates"

The four coordinates are the four corner points of the visible area. This information is typically the minimal set geo-aware systems utilize for geo-referencing and is similar to BLOCKA. It should be noted that distortions within the image can be considerable. Note that the centre coordinate as highlighted in the image moves back to the centre of the image. The more slanted the image is, the closer the centre coordinate of the image is towards the origin of the sensor.

While this is the most inaccurate of the five levels, this level might still be sufficient for situation awareness and reporting capabilities.

Figure 6 Geo-rectified image using only the four corners

4.4 SENSRB

The SENSRB TRE extension offers a number of possibilities to store slanting image information. The information contained in this TRE can be used to map still images, snapshots from videos or moving imagery onto projected maps with or without terrain models.

The following table indicates which SENSRB modules are needed to transport the information for the five different geospatial levels. It should be noted that this specification does not exclude the other modules from being transmitted. Instead it is highly recommended to provide as much information as possible in the various SENSRB modules.

Note that the SENSRB specification defines Module 1 “General Data” as mandatory for the first instance of a SENSRB TRE in an image segment. As all the spatial levels as proposed by this implementation guide can be transported within a single SENSRB TRE, this module must be provided.

Module 4 “Image Formation Data” is optional according to the SENSRB specification. For the extraction of video frames from a Full Motion Video sensor (“framing sensor”), all fields can be set to their default values. Thus the only parameters which are used from this module are row and column count. Those two parameters are identical to the values provided in the image segment header (fields NROWS and NCOLS) for framing sensors. As a result, this module may be omitted and is optional. However, it is recommended to provide those parameters in the SENSRB TRE as it would make the processing of the SENRSB TRE independent from external parameters.

Further, SENSRB defines two mandatory modules: Module 5 “Reference Time/Pixel” and Module 6 “Sensor Position Data”.

As the sensor will typically provide the **eight camera model parameters** and those values are the source for all other geospatial levels, it is **highly recommended to provide this geospatial level** whenever possible. Thus, image exploitation systems and appropriate viewers can make use of this information and may create better spatial accuracy by utilizing a higher resolution elevation model, for example. Less capable viewers can gracefully downgrade to the best supported geospatial level.

Table 6 shows a matrix of the SENSRB Modules and the different Geospatial levels. The letter “M” indicates that it is mandatory to use the field, the letter “O” that it is optional to use the field for a particular Geospatial Level. An empty field indicates that those fields are not used.

Table 6
SENSRB Modules and the Geospatial Levels

	#1: Eight camera model parameters	#2: Dense coordinate grid	#3: Cubic polynomial reference[1]	#4: Footprint & image centre coordinates	#5: Footprint coordinates
Module 01	M	M	M	M	M
Module 02	M	-	-	-	-
Module 03	-	-	-	-	-
Module 04	O	O	O	O	O
Module 05	M	M	M	M	M
Module 06	M	M	M	M	M
Module 07	M	-	-	-	-
Module 08	-	-	-	-	-
Module 09	-	-	-	-	-
Module 10	-	-	-	-	-
Module 11	-	M	-	M	M
Module 12	-	-	-	-	-
Module 13	-	-	-	-	-
Module 14	-	-	-	-	-
Module 15	-	-	M[2]	-	-

<u>Notes (with reference to Table 6):</u>

1. Currently SENSRB does not provide the means to transport all needed parameters for a cubic polynomial. Thus, this geo-reference is not supported at the moment.
2. Module 15 “Additional Parameter Data” could be used to store the cubic polynomial coefficients. The approach should be harmonized with the NSIF/SENRB community. In the current version of this implementation guide the cubic polynomial reference is not used.

Table 7 lists the SENSRB modules needed to support the different combinations of the geospatial levels. Note that the geospatial levels #2, #4 and #5 use Module 11 in different ways. The SENSRB specification allows for different point set types, which can be transmitted in a single Module 11.

Table 7
Spatial Levels and needed SENSRB

Geospatial Level					SENSRB Module															Content level[3]
#1	#2	#3	#4	#5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
	X				M			O	M	M					M					1
			X		M			O	M	M					M					1
	X		X		M			O	M	M					M					1
				X	M			O	M	M					M					1
	X			X	M			O	M	M					M					1
			X	X	M			O	M	M					M					1
	X		X	X	M			O	M	M					M					1
X					M	M		O	M	M	M									4
X	X				M	M		O	M	M	M				M					5
X			X		M	M		O	M	M	M				M					5
X	X		X		M	M		O	M	M	M				M					5
X				X	M	M		O	M	M	M				M					5
X	X			X	M	M		O	M	M	M				M					5
X			X	X	M	M		O	M	M	M				M					5
X	X		X	X	M	M		O	M	M	M				M					5

Notes (with reference to the top-rightmost cell in Table 7):

3. Currently SENSRB does not provide the means to transport all needed parameters for a cubic polynomial. Thus, this geo-reference is not supported at the moment.

Table 7 shows for the various geospatial levels (left section of the table) the required SENSRB modules, including Content Level mapping for Module 1. The letter “M” indicates that it is mandatory to use the field, the letter “O” indicates that it is optional to use the field. An empty field in “SENSRB Module” indicates that those fields are not used.

4.4.1 Complete Module description

Note that this implementation guide provides guidance to utilize SENSRB for the different approaches to cover the slanting imagery. The required fields for the slanting are highlighted. Fields marked in **bold** are populated from sensor metadata (the eight parameters and related fields). Other non-slanting related fields like sensor name and other operational relevant information should be populated as accurate as possible.

The “Description/Value” column contains the description of the field in the context of the use for slanted imagery. Values enclosed in quotes (“”) are the proposed fixed values for the respective field. Values marked as “to be defined” should be filled according to the specification and the available metadata within the limits of the particular field on a “best effort” basis. Those fields will not affect the geo-slanting.

It should be noted that the SENSRB does not specify null-values for most of the fields in case the real content is unknown.

It should be noted that the metadata registry as mentioned in the SENSRB specification (http://jitc.fhu.disa.mil/cgi/nitf/registers/trereg.aspx) does not provide proper values at the time of this writing for the fields as indicated in the specification. The fields affected by this are: 01a, 01c, 01e, 01g, 02a, 04a, 04b, 11a, 15a.

Default Values: It should be noted that "*the SENSRB specification allows that certain fields from each of the three field types be given a default value when meaningful data is not available or when the field is not applicable. **These fields are indicated with square brackets around the type indicator ([R], [C], or [L]). Basic Character Set (BCS) hyphens (minus signs) (code 0x2D) will be used as the default value for all such fields***".

For the detailed description and types of the individual fields refer to the SENSRB specification.

Table 8
Default SENSRB field values

Index	Field	Description/Value
	CETAG	"SENSRB"
	CEL	The total length of SENSRB in bytes **excluding** CETAG and CEL

4.4.1.1 General Data

This module is mandatory for all geospatial levels.

Table 9
SENSRB Module 1: General Data

Index	Field	Description/Value
01	GENERAL_DATA	“Y”
01a	SENSOR	From metadata as appropriate
01b	SENSOR_URI	Set according to specification. Default is all “-“, if not known.
01c	PLATFORM	From metadata as appropriate
01d	PLATFORM_URI	Set according to specification. Default is all “-“, if not known.
01e	OPERATION_DOMAIN	From metadata as appropriate
01f	CONTENT_LEVEL	See Table 7
01g	GEODETIC_SYSTEM	“WGS84”
01h	GEODETIC_TYPE	“G” As the sensor metadata for framing sensors is typically geographic, it is highly recommended to use geographic / geodetic coordinates.
01i	ELEVATION_DATUM	“HAE” or “MSL” (see notes in chapter 4.5.2.1)
01j	LENGTH_UNIT	“SI”
01k	ANGULAR_UNIT	“DEG”
01l	START_DATE	UTC Date according to metadata
01m	START_TIME	UTC Seconds since start of the day according to metadata
01n	END_DATE	Same as 01l for a single frame
01o	END_TIME	Same as 01m for a single frame
01p	GENERATION_COUNT	“00”
01q	GENERATION_DATE	“--------” Default is all “-“, if not known.
01r	GENERATION_TIME	“----------” Default is all “-“, if not known.

4.4.1.2 *Sensor Array Data*

This module is mandatory for geospatial level “#1: Eight camera model parameters”.

The SENSRB specification states for fields 2de, 2f, and 2fg: "*At least two of the three sets of data (ROW/COLUMN_METRIC—indices 02d and 02e, FOCAL_LENGTH—index 02f, and ROW/COLUMN_FOV—indices 02g and 02h) must contain meaningful values (not be default filled) to provide the photogrammetric data typically required for geo-positioning*". This is true to calculate the optical distortions in the frame. However, for the basic geo-slanting the two field-of-view values are sufficient. For the typical UAV based sensor, the relatively small field-of-view values will result in only minimal distortions. Further, some sensors do provide the focal length only as a per cent value of the real range, in which the latter is unknown.

Table 10
SENSRB Module 2: Sensor Array Data

Index	Field	Description/Value
02	SENSOR_ARRAY_DATA	"Y"
02a	DETECTION	Currently the National Imagery Transmission Format Standard (NITFS) Board (NTB) registry does not provide any values for this field. It is recommended to populate this field on a best effort basis from metadata.
02b	ROW_DETECTORS	Number of detectors used in the row-aligned dimension. Set according to specification or to the image width. Typically this should be set to the video coded width.
02c	COLUMN_DETECTORS	Number of detectors used in the column-aligned dimension. Set according to specification or to the image height. Typically this should be set to the video coded height.
02d	ROW_METRIC	Set according to specification. (Default is all "–", if not known)
02e	COLUMN_METRIC	Set according to specification. (Default is all "–", if not known)
02f	FOCAL_LENGTH	Set according to specification. (Default is all "–", if not known)
02g	**ROW_FOV**	**Row field of view from metadata**
02h	**COLUMN_FOV**	**Column field of view from metadata**
02i	CALIBRATED	Set according to specification.

In case the geospatial level "#1: Eight camera model parameters" is not provided Module 2 can be omitted.

Table 11
Module 2 Values in the Case of Geospatial Level #1

Index	Field	Description/Value
02	SENSOR_ARRAY_DATA	“N”

4.4.1.3 Sensor Calibration Data

This module is not used.

Table 12
SENSRB Module 3: Sensor Calibration Data

Index	Field	Description/Value
03	SENSOR_CALIBRATION_DATA	“N”

4.4.1.4 Image Formation Data

This module is optional (recommended) for all geospatial levels.

Table 13
SENSRB Module 4: Image Formation Data

Index	Field	Description/Value
04	IMAGE_FORMATION_DATA	“Y”
04a	METHOD	Currently the NTB registry does not provide any values for this field. It is recommended to populate this field on a best effort basis from metadata.
04b	MODE	Currently the NTB registry does not provide any values for this field. It is recommended to populate this field on a best effort basis from metadata. The ACFTB.MPLAN definitions might not be usable here.
04c	ROW_COUNT	Image row count. For framing sensors equal to NROWS from the image segment header.
04d	COLUMN_COUNT	Image column count. For framing sensors equal to NCOLS from the image segment header.
04e	ROW_SET	Same as 04c
04f	COLUMN_SET	Same as 04d
04g	ROW_RATE	“0000000000”
04h	COLUMN_RATE	“0000000000”
04i	FIRST_PIXEL_ROW	“00000001”
04j	FIRST_PIXEL_COLUMN	“00000001”
04k	TRANSFORM_PARAMS	“0”: In this case fields 04l to 04s are omitted.

4.4.1.5 Reference Time or Pixel

This module is mandatory.

The use of this module is unclear according to the SENSRB specification. For framing sensors, there will be neither a reference time nor a reference row/column. The use of this module needs to be investigated further for framing sensors. Currently, the reference row and column is set to the image coordinate (0, 0).

Table 14
SENSRB Module 5: Reference Time or Pixel

Index	Field	Description/Value
05	REFERENCE TIME/PIXEL	
05a	REFERENCE_TIME	"------------"
05b	REFERENCE_ROW	"00000000"
05c	REFERENCE_COLUMN	"00000000"

4.4.1.6 *Sensor Position Data*

This module is mandatory.

Table 15
SENSRB Module 6: Sensor Position Data

Index	Field	Description/Value
06	SENSOR POSITION DATA	
06a	**LATITUDE_OR_X**	**Sensor or platform latitude from metadata**
06b	**LONGITUDE_OR_Y**	**Sensor or platform longitude from metadata**
06c	**ALTITUDE_OR_Z**	**Sensor or platform altitude from metadata**
06d	**SENSOR_X_OFFSET**	**Sensor X offset if known else "00000000"**
06e	**SENSOR_Y_OFFSET**	**Sensor Y offset if known else "00000000"**
06f	**SENSOR_Z_OFFSET**	**Sensor Z offset if known else "00000000"**

4.4.1.7 *Attitude – Euler Angles*

This module is mandatory for geospatial level "#1: Eight camera model parameters".

Table 16
SENSRB Module 7: Attitude – Euler Angles

Index	Field	Description/Value
07	ATTITUDE_EULER_ANGLES	"Y"
07a	**SENSOR_ANGLE_MODEL**	**"1"**
07b	**SENSOR_ANGLE_1**	**Sensor angle 1 from metadata**
07c	**SENSOR_ANGLE_2**	**Sensor angle 2 from metadata**
07d	**SENSOR_ANGLE_3**	**Sensor angle 3 from metadata**
07e	**PLATFORM_RELATIVE**	**"Y" or "N" depending on metadata**
07f	**PLATFORM_HEADING**	**Platform heading from metadata if 07e is "Y" else "---------"**
07g	**PLATFORM_PITCH**	**Platform pitch from metadata if 07e is "Y" else "---------"**
07h	**PLATFORM_ROLL**	**Platform roll from metadata if 07e is "Y" else "----------"**

In case the geospatial level "#1: Eight camera model parameters" is not provided Module 7 can be omitted.

Table 17
Module 7 Values in the Case of Geospatial Level #1

Index	Field	Description/Value
07	ATTITUDE_EULER_ANGLES	"N"

4.4.1.8 Attitude – Unit Vectors

This module is not used.

Table 18
SENSRB Module 8: Attitude – Unit Vectors

Index	Field	Description/Value
08	ATTITUDE_UNIT_VECTORS	"N"

4.4.1.9 *Attitude – Quaternions*

This module is not used.

Table 19
SENSRB Module 9: Attitude - Quaternions

Index	Field	Description/Value
09	ATTITUDE_QUATERNION	"N"

4.4.1.10 *Sensor Velocity Data*

This module is not used.

Table 20
SENSRB Module 10: Sensor Velocity Data

Index	Field	Description/Value
10	SENSOR_VELOCITY_DATA	"N"

4.4.1.11 *Point Data Sets*

In case only geospatial level "#1: Eight camera model parameters" is provided, this module is not used. In case one or more of the geospatial levels "#2: Dense coordinate grid", "#4: Footprint & image centre coordinates", or "#5: Footprint coordinates" is provided, **one or more** point sets need to be provided in Module 11 "Point Set Data".

Table 21
Module 11 Values in the Case of Geospatial Level #1

Index	Field	Description/Value
11	POINT_SET_DATA	Set to the number of provided point sets.

Table 22 describes the use of a single point in a point set. It is a reference or tie point, which binds a geo-location in 3d space to a pixel coordinate (x, y).

Table 22
SENSRB Module 11: Point Data Sets for other Geospatial Levels

Index	Field	Description/Value
11c	P_ROW_NNN	y-coordinate of the reference point
11d	P_COLUMN_NNN	x-coordinate of the reference point
11e	P_LATITUDE_NNN	Latitude of the reference point
11f	P_LONGITUDE_NNN	Longitude of the reference point
11g	P_ELEVATION_NNN	Elevation of the reference point
11h	P_RANGE_NNN	Slant range (line-of-sight distance from sensor to point) of the reference point. The SENSRB specification states “measured range”. However, in case the value is available from the calculation it should be provided. If not know, the field shall be default filled “--------”.

4.4.1.11.1 #2: Dense coordinate grid

The number of reference points should be high enough to be able to drag the image with sufficient accuracy across the landscape. It is recommended to use a regular n*m grid. Good results have been achieved with grids of the size 16*16 with 256 points. This is the recommended grid size.

Table 23
Module 11 Values in the Case of Geospatial Level #1

Index	Field	Description/Value
11a	POINT_SET_TYPE_MM	“Ground Points”
11b	POINT_COUNT_MM	As needed. n = “256” recommended
11c-h	Reference point #1	
…		
11c-h	Reference point #n	

4.4.1.11.2 #4: Footprint & image centre coordinates

This geospatial level requires two point set instances: “Image Footprint” and “Image Center”. The sequence for the reference points of the image footprint should be either clockwise or counter-clockwise (i.e. when drawing lines sequentially from point 1 to 4, the lines should not cross). It is recommended to use the same sequence as used in the BLOCKA extension.

Table 24
Module 11 Values in the Case of Geospatial Level #4 – Image Footprint

Index	Field	Description/Value
11a	POINT_SET_TYPE_MM	“Image Footprint”
11b	POINT_COUNT_MM	“004”
11c-h	Reference point Corner 1	
11c-h	Reference point Corner 2	
11c-h	Reference point Corner 3	
11c-h	Reference point Corner 4	

Table 25
Module 11 Values in the Case of Geospatial Level #4 – Image Center

Index	Field	Description/Value
11a	POINT_SET_TYPE_MM	“Image Center”
11b	POINT_COUNT_MM	”001”
11c-h	Reference point image centre	

4.4.1.11.3 #5: Footprint coordinates

The footprint coordinates are a subset of the previous geospatial level. In case only the footprint shall be submitted, see the “Image Footprint” table in the previous chapter.

4.4.1.12 Time-Stamped Data Sets

This module is not used.

Table 26
SENSRB Module 12: Time-Stamped Data Sets

Index	Field	Description/Value
12	TIME_STAMP_DATA_SETS	“00”

4.4.1.13 Pixel-Referenced Data Sets

This module is not used.

Table 27
SENSRB Module 13: Pixel-Referenced Data Sets

Index	Field	Description/Value
13	PIXEL_REFERENCED_DATA_SETS	“00”

4.4.1.14 Uncertainty Data

This module is not used.

Table 28
SENSRB Module 14: Uncertainty Data

Index	Field	Description/Value
14	UNCERTAINTY_DATA	“000”

4.4.1.15 Additional Parameter Data

This module is not used.

Table 29
SENSRB Module 15: Additional Parameter Data

Index	Field	Description/Value
15	ADDITIONAL_PARAMETER_DATA	“000”

4.5 EXTRACTING METADATA FROM STANAG 4609 FOR SENSRB

The following chapters provide the details for the needed KLV keys for [MISB STD 0601.5, 2011] and [MISB EG 0104.5, 2006]. In case the keys are directly mapped from [MISB EG 0104.5, 2006] to [MISB STD 0601.5, 2011] (according to [MISB STD 0601.5, 2011], Table 1 “UAS Datalink Local Metadata Set data elements”) the values appear on the same line.

For [MISB STD 0601.5, 2011], all necessary tags as outlined below are required according to [MISB STD 0902.1, 2011].

4.5.1 Platform and Sensor Angles

The platform angle model (yaw, pitch, roll) used by [MISB STD 0601.5, 2011] and [MISB EG 0104.5, 2006] is identical to the one used in SENSRB. Thus no conversion is needed.

The attitude angle model for the sensor is in both [MISB STD 0601.5, 2011] and [MISB EG 0104.5, 2006] identical to SENSRB Sensor Angle Model "1" as shown below.

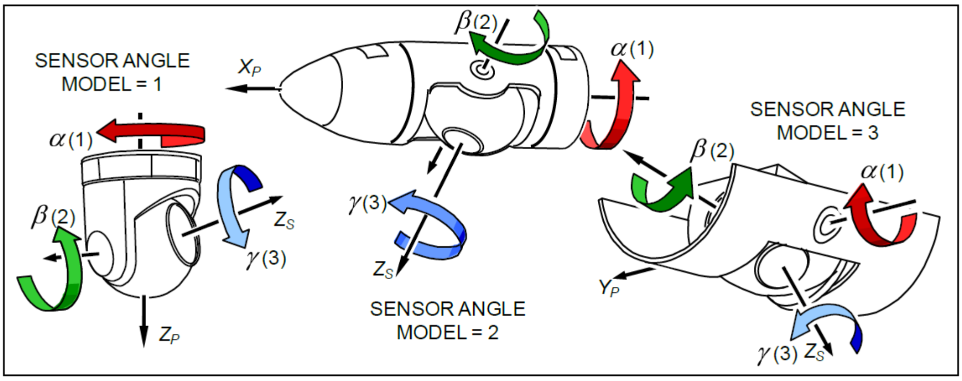

Figure 7 Attitude Angle Model

4.5.2 Parameter Groups

The Eight-Parameters can be separated into three groups:

1. Sensor Location
2. Sensor Attitude
3. Sensor Field of View

It should be noted that all three groups are required to perform the slanting calculations.

4.5.2.1 Sensor Location

The sensor or platform location or device position is the origin of the coordinate system. All three values are required. SENSRB allows specifying an offset from the platform to the real sensor position. However, neither [MISB EG 0104.5, 2006] nor [MISB STD 0601.5, 2011] define keys to specify such an offset.

In case of [MISB EG 0104.5, 2006]: Set field 01i "Elevation Datum" to "MSL".

In case of [MISB STD 0601.5, 2011]: If key 15 is present, set field 01i "Elevation Datum" to "MSL". In case key 75 is present, set field 01i "Elevation Datum" to "HAE".

Table 30
Sensor Location Mapping from KLV to SENSRB

EG 0104.5		EG 0601		SENSRB	
KLV Key	KLV Name	Key	LDS Name	Field	Name/Value
060e2b34010101030701020102040200	Device Latitude	13	Sensor Latitude	06a	LATITUDE_OR_X
060e2b34010101030701020102060200	Device Longitude	14	Sensor Longitude	06b	LONGITUDE_OR_Y
060e2b34010101010701020102020000	Device Altitude	15	Sensor True Altitude	01i	"MSL"
				06c	ALTITUDE_OR_Z
	n/a	75	Sensor Ellipsoid Height **(Preferred)**	01i	"HAE"
				06c	ALTITUDE_OR_Z

4.5.2.2 Sensor Attitude

The sensor attitude may be provided by [MISB STD 0601.5, 2011] and [MISB EG 0104.5, 2006] in different ways. The term "device" might be used as a synonym both for platform and for sensor, depending on the available metadata. The following combinations have been encountered:

1. Absolute sensor attitude ([MISB EG 0104.5, 2006])
2. Absolute platform and relative sensor attitude ([MISB STD 0601.5, 2011], [MISB EG 0104.5, 2006])
3. Absolute platform and absolute sensor attitude ([MISB EG 0104.5, 2006])

At least one of three sets must be provided.

SENSRB allows for either:

- Absolute sensor attitude vectors, or
- Relative sensor attitude in combination with absolute platform attitude vectors.

See the description for Module 07 "Attitude Euler Angles" in SENSRB.

While for case number 3 (absolute platform and absolute sensor attitude) it would be sufficient for the slanting calculations to ignore the absolute platform attitude and provide only the absolute sensor attitude, it is strongly recommended to calculate the relative sensor attitude from the two absolute attitude vectors and provide both sets of angles in SENSRB (case 2). This will preserve the platform attitude for additional calculations and for display purposes. Note that it is not sufficient to simply subtract the angles. Typically this calculation is done using quaternions.

4.5.2.2.1 Absolute Sensor Attitude

In case absolute sensor attitude vectors are provided together with absolute platform attitude vectors, it is recommended to calculate the relative sensor attitude vectors and provide those as outlined below. This will preserve the platform attitude for further processing as stated above.

In case no absolute platform attitude vectors are provided, the absolute sensor attitude vectors can be directly used as shown in Table 31. Note that in this case field 07e must be set to "N" and fields 07f, 07g and 07h must be defaulted.

Note: [MISB EG 0104.5, 2006], chapter 4.4 "Obliquity Angle Notes" clarifies the use of the obliquity angle: "*The definition, derived from the SMPTE KLV dictionary, states "Obliquity angle of image expressed in degrees. The inverse of sensor depression angle.*"

To use the obliquity angle as "sensor angle 2", it must be calculated:

SENSOR_ANGLE_2 = 180 – Obliquity Angle

Note that a range correction might be needed after this calculation.

Table 31
Sensor Angle Mapping between KLV and SENSRB

EG 0104.5		EG 0601		SENSRB	
KLV Key	KLV Name	Key	LDS Name	Field	Name
060e2b34010101010701100102000000	Angle to North		n/a	07b	SENSOR_ANGLE_1
060e2b34010101010701100103000000	Obliquity Angle		n/a	07c	SENSOR_ANGLE_2
060e2b34010101010701100101000000	Sensor Roll Angle		n/a	07d	SENSOR_ANGLE_3

4.5.2.2.2 Relative Sensor Attitude

In case relative sensor attitude vectors are provided, field 07e must be set to "Y" and fields 07f, 07g and 07h must be set to the absolute platform attitude as shown in Table 32.

Table 32
Relative Sensor Attitude Mapping between KLV and SENSRB

EG 0104.5		EG 0601		SENSRB	
KLV Key	KLV Name	Key	LDS Name	Field	Name
060e2b34010101010e01010204000000	Sensor Relative Azimuth Angle	18	Sensor Relative Azimuth Angle	07b	SENSOR_ANGLE_1
060e2b34010101010e01010205000000	Sensor Relative Elevation Angle	19	Sensor Relative Elevation Angle	07c	SENSOR_ANGLE_2
060e2b34010101010e01010206000000	Sensor Relative Roll Angle	20	Sensor Relative Roll Angle	07d	SENSOR_ANGLE_3

4.5.2.2.3 Absolute Platform Attitude

The absolute platform attitude vectors are required in case relative sensor attitude vectors are provided (see previous chapters).

Note that in case relative sensor attitude vectors are used, absolute platform attitude vectors must be provided and in this case field 07e must be set to "Y".

In case no sensor attitude vectors are provided at all, slanting calculations are not possible.

Table 33
Absolute Platform Attitude Mapping between KLV and SENSRB

EG 0104.5		EG 0601		SENSRB	
KLV Key	KLV Name	Key	LDS Name	Field	Name
060e2b34010101010707011001060000000	Platform Heading Angle	5	Platform Heading Angle	07f	PLATFORM_HEADING
060e2b34010101010707011001050000000	Platform Pitch Angle	6	Platform Pitch Angle	07g	PLATFORM_PITCH
		90	Platform Pitch Angle (Full) (**Preferred**)		
060e2b34010101010707011001040000000	Platform Roll Angle	7	Platform Roll Angle	07h	PLATFORM_ROLL
		91	Platform Roll Angle (Full) (**Preferred**)		

4.5.2.3 Sensor Field of View

Table 34
Sensor Field of View Mapping between KLV and SENSRB

EG 0104.5		EG 0601		SENSRB	
KLV Key	KLV Name	Key	LDS Name	Field	Name
060e2b34010101010204200201010800000	Field of View (FOV-Horizontal)	16	Sensor Horizontal Field of View	02h	ROW_FOV
060e2b340101010103042002010100a0100	Field of View (Vertical)		n/a	02g	COLUMN_FOV
060e2b340101010107042002010100a0100	Field of View (FOV-Vertical FP-4)	17	Sensor Vertical Field of View		

4.6 EXTRACTING METADATA FROM STANAG 4609 FOR BLOCKA

As stated in Chapter 3.6.1 BLOCKA allows for precise geo-positioning of "image corners". In the case where SENSRB is present, it should take precedence over any BLOCKA information for the image. However, some systems might not be able to process the SENSRB extension. To be able to support those systems, BLOCKA should be populated according to the following rules:

- In case the sensor metadata contains the four corner coordinates, BLOCKA should be populated with the values from the metadata.
- Otherwise, in case the four corners can be calculated from the eight parameters, BLOCKA should be populated with the calculated values.
- Otherwise, BLOCKA should not be populated and only IGEOLO should be filled with a meaningful value, for example the image centre coordinates, if available.

Table 35 specifies the recommended mapping from [MISB EG 0104.5, 2006] and [MISB STD 0601.5, 2011] to BLOCKA.

Table 35
Recommended Mapping from EG 0104.5 and STD 0601.5 to BLOCKA

EG 0104.5		EG 0601		BLOCKA
KLV Key	KLV Name	Key	LDS Name	Field Name
060e2b3401010101030701020103080100	Corner Latitude Point 2 (Decimal Degrees)	26	Offset Corner Latitude Point 2 (in combination with key 23)	FRLC_LOC
		84	Corner Latitude Point 2 (Full)	
060e2b34010101010307010201030C0100	Corner Longitude Point 2 (Decimal Degrees)	27	Offset Corner Longitude Point 2 (in combination with key 24)	
		85	Corner Longitude Point 2 (Full)	
060e2b3401010101030701020103090100	Corner Latitude Point 3 (Decimal Degrees)	28	Offset Corner Latitude Point 3 (in combination with key 23)	LRLC_LOC
		86	Corner Latitude Point 3 (Full)	
060e2b34010101010307010201030d0100	Corner Longitude Point 3 (Decimal Degrees)	29	Offset Corner Longitude Point 3 (in combination with key 24)	
		87	Corner Longitude Point 3 (Full)	
060e2b34010101010307010201030a0100	Corner Latitude Point 4 (Decimal Degrees)	30	Offset Corner Latitude Point 4 (in combination with key 23)	LRFC_LOC
		88	Corner Latitude Point 4 (Full)	
060e2b34010101010307010201030e0100	Corner Longitude Point 4 (Decimal Degrees)	31	Offset Corner Longitude Point 4 (in combination with key 24)	
		89	Corner Longitude Point 4 (Full)	
060e2b3401010101030701020103070100	Corner Latitude Point 1 (Decimal Degrees)	26	Offset Corner Latitude Point 1 (in combination with key 23)	FRFC_LOC
		82	Corner Latitude Point 1 (Full)	
060e2b34010101010307010201030b0100	Corner Longitude Point 1 (Decimal Degrees)	27	Offset Corner Longitude Point 1 (in combination with key 24)	
		83	Corner Longitude Point 1 (Full)	
		23	Frame Center Latitude	
		24	Frame Center Longitude	

5. POSTING A STANAG 4545 IMAGE TO A CSD

The MAJIIC 2 requirement is for a national system to post an NSIF file into a CSD. A critical issue for systems that post imagery onto the CSD is the correct use of CSD metadata. If the metadata is not consistent then posted imagery may be undiscoverable. Advice for the content of the CSD metadata can be found in the MAJIIC 2 Business Rules & Use Case document [DOP-MAJIIC2-026, 2015] and from documented mission or exercise network metadata requirements.

5.1 CSD SERVER

The requirements for CSD servers when chipping images are:

- Use of the BLOCKA TRE for improved precision compared to the IGEOLO field,
- Use of the ICHIPB for image chips to map pixel coordinates back to the pixel coordinates in the original image, and
- Transparent copy other TREs in the generated file from original data.

5.2 MAJIIC 2 USE OF NSIF FIELDS FOR SENSOR IMAGES

This section describes the use of STANAG 4545 for the dissemination of the MAJIIC 2 sensor output before exploitation. For exploitation products see next section.

The subsequent tables give the information needed for MAJIIC 2 interoperability. Specific NSIF metadata requirements will be defined in the exercise plan. They follow the STANAG 4545 description of fields. Refer to the STANAG to get a normative description.

If the line is absent or void, the STANAG applies. The values are given between quotes. Implementers shall check padding.

5.2.1 NSIF file header – MAJIIC 2 conventions

5.2.1.1 Identification and Origination Group

Table 36
NSIF File Header – Identification and Origination Group

Field	MAJIIC 2 Value Convention
FHDR	'NSIF'
FVER	'02.00'
CLEVEL	
STYPE	'BF01'
OSTAID	The identifier syntax is: JU:EK267
FDT	Time of the File's origination, that is when the File was generated by OSTAID
FTITLE	Not yet defined, preferred value: default (filled with ECS Spaces)

5.2.1.2 Others Group

Table 37
NSIF File Header – Other Group

Field	MAJIIC 2 Value Convention
FBKGC	Preferred colour is black, that is 0x00, 0x00, 0x00
ONAME	
OPHONE	

5.2.1.3 Length and Extension Group

Table 38
NSIF File Header – Length and Extension Group

Field	**MAJIIC 2 Value Convention**
FL	
HL	
NUMI	‘1’
LISH001	
LI001	
NUMS	‘000’
NUMX	‘000’
NUMT	‘000’
NUMDES	‘000’
NUMRES	‘000’
UDHDL	‘000’
XHDL	‘00000’
XHDLOFL	‘000’,
XHD	Void

5.2.2 NSIF image sub-header – MAJIIC 2 conventions

5.2.2.1 Identification Group

Table 39
NSIF image sub-header – Identification Group

Field	**MAJIIC 2 Value Convention**
IM	‘IM’
IID1	Not yet defined, filled by BCS spaces
IDATIM	
TGTID	Filled by BCS spaces currently
IID2	Not yet defined, filled by BCS spaces

5.2.2.2 Security Group

Table 40
Image sub-header – Security Group

Field	**MAJIIC 2 Value Convention**
ISCLAS	
ISCLSY	
ISCODE	
ISCTLH	
ISREL	
ISDCTP	
ISDCDT	
ISDCXM	
ISDG	
ISDGDT	
ISCLTX	
ISCATP	
ISCAUT	
ISCRSN	
ISSRDT	
ISCTLN	
ENCRYP	
ISORCE	The identifier syntax is: JU:EK267

5.2.2.3 Others

Fields related to image encoding description are omitted with exceptions.

Table 41
Image sub-header – Other Fields

Field	MAJIIC 2 Value Convention
…	
PVTYPE	Expected value is ‘INT’
IREP	Expected value is ‘MONO’, ‘RGB’, ‘RGB/LUT’
ICAT	Expected values are ‘EO’, ‘SAR’, ‘IR’, ‘VIS’ Caveat: TI products shall be named ‘EO’ or ‘IR’ because of our TORs
…	
ICORDS	MAJIIC 2 requires D or G representation, with D preferred
IGEOLO	
…	
NICOM	
ICOMn	
IC	For FINEX’08, the handling of JPEG or JPEG2000 compressed files is a recommendation. If a compressed file is downloaded from the CSD it is the obligation of the EWS system to decompress it for display.
...	
NBPP	Limited to ‘08’ or ‘16’
IDLVL	‘1’
IALVL	‘0’
ILOC	‘0000000000’
IMAG	From sensor to CSD, the expected value is ‘1.0’. ICHIPB must be used if IMAG is insufficient to specify the exact reduction ratio of the image.
UDIDL	As user data is not coalition shareable, recommended value is ‘00000’
IXSHDL	‘134’, or ‘369’, depending on the used SDE, see below
IXSOFL	‘000’, no Image Extended sub-header Overflow
IXSHD	BLOCKA (134 bytes), or BLOCKA (134 bytes) + ICHIPB (235 bytes)

6. NSIF TEST AND EVALUATION (T&E) CONSIDERATIONS

6.1 INTRODUCTION

It has been shown since 2007 that a comprehensive test and evaluation regime provides great benefit to a MAJIIC 2 exercise and experiment. Tools available for allowing the generation and testing of STANAG 4545 data allow producers to produce and check the format and presentation of the STANAG 4545 they produce. Exploiters of STANAG 4545 data receive early data samples from producers and can highlight any issues with the data. All of this activity is performed offline prior to an exercise and means that time is not wasted when the systems come together for an exercise or experiment. This regime is not limited to simulated data, it is even more critical to the success of an exercise that data samples from any live systems participating in an exercise. A basic set of requirements for enabling a test regime are shown below. A brief description of each of the detailed requirements for each bullet follows:

- Live or simulated STANAG 4545 imagery
- Automatic Format Checkers
- Commercial off the shelf (COTS) Test Tools
- Shared Reporting Portal
- Dedicated T&E team

6.2 LIVE OR SIMULATED STANAG 4545 IMAGERY

It is critical that sample data is made available to consumers of STANAG 4545 imagery prior to an experiment or exercise. It is equally critical that this data exhibits the characteristics of the data that the systems will see during the exercise and experiments. Characteristics that would have prevented some incompatibilities arising during Trial Quest 2007 include image size, use of data compression, inappropriate metadata fields, BLOCKA use for slanted images. Artificial NSIF image data files such as test patterns can also be used to look at things such as geo-registration of imagery.

6.3 COTS TEST TOOLS

Along with the NSIF automatic format checker there are a number of existing tools that could be used to check NSIF files and that can itemise errors or observations in a file. Tools used during Trial Quest 2007 were CIVA, SNIPER and GeoView. GeoView also provides a viewer so that the NSIF file image may be viewed. These tools are extremely useful in that the contents of the metadata can be viewed and problems diagnosed.

6.4 CDTE PRETESTING

In order to make the testing regime work it is important that all participants have access to the MAJIIC 2 Collaborative Development and Test Environment (CDTE) T&E test area. New users are encouraged to get access and get familiar with the MAJIIC 2 Portal and Pretesting Test areas. Access to the portal and CDTE should be requested through your National Project Officer (NPO).

6.5 DEDICATED T&E TEAM

The founding of the Test & Evaluation sub group prior to 2007 was fundamental to the successes in the following exercises. A stringent pre-test regime meant that systems were well prepared prior to arrival at the NCI Agency and the benefit was quickly illustrated by reduced integration time and in a reduction of fundamental data areas between systems.

APPENDIX A
AUTHOR'S NOTES

A.1 INTRODUCTION

This introduction includes an historical and contextual overview of the MAJIIC project starting from the initial Conference of National Armaments Directors (CNAD) decision in 1995 until the date of this issue of this document before focusing on the use of the STANAG 4545 in the MAJIIC 2 test bed.

A.1.1 Background

Following the statement of the initial CNAD decision on Alliance Ground Surveillance (AGS), the AGS interoperability is seen as the interoperability of a system of systems, the participating systems being the NATO AGS Core and national systems, the external systems being the NATO C3I and national C3Is, all linked by a data sharing system build upon the Nations/NATO C3I networking resources.

For the MAJIIC 2 project the name of the shared data is Coalition Shared Data (CSD).

[Note: some rationale to go from initial statement to here might be useful; suggestions for materials are welcome.]

A.1.2 History

In November 1995, CNAD decided that NATO should procure an AGS capability based on the concept of a NATO-owned and operated core capability supplemented by interoperable national assets. The NATO Alliance Ground Surveillance Capability Test bed (NACT) was established at NC3A, The Hague (NL), in 1996 to provide scientific and engineering support to the ongoing NATO efforts to determine and assess technical and operational aspects of the NATO AGS system [16].

An EX Format was initially developed from 1996 to 1998 for use in the NACT in order to meet an identified shortfall in capability in the area of surveillance and reconnaissance data and imagery. The EX format addressed this shortfall by providing formats for synthetic aperture radar (SAR), moving target indicator (MTI), electronic warfare support measures (ESM), Sensor Service Requests (SSR) and other related AGS required data types. It is important to point out that the EX format is not a STANAG. It was supposed that the proposed formats and the collected experience from using the EX format could be incorporated into a number of STANAGS. The formats contained in the EX format have been developed by NC3A in conjunction with all of the major producers of AGS sensor and exploitation systems. The EX formats for MTI, Attached MTI, Group, SAR, SSR, Free Text have been rigorously tested in the laboratory and with actual platforms in the field. It has demonstrated its usability and has allowed the participants to collect experience about AGS interoperability. The EX Format was the interoperable format which allowed pre-CAESAR experiments such as the Paris Interoperability Experiment (PIE) to take place in 1997 and the CAESAR coalition to take part in many exercises and experiments during the period of the CAESAR program and CAESAR extension. However, with the emphasis in MAJIIC and in NATO on the use of STANAGSs and because the STANAGs offered a way to alleviate the bandwidth consumption problem that surfaced during CAESAR, it was felt that it would be appropriate for MAJIIC systems to use the STANAG 4545 to support imagery needs within the MAJIIC project and consequently the EX format will be obsolete for MAJIIC imagery.

The use of the NSIF was initiated during the CAESAR project as part of the development of the CSD concept. Its first deployment by NC3A was made during the 2003 TIE experiment when SAR images streamed on the network in EX format was automatically converted to NSIF files and published in CSDs.

A.1.3 Testing

Conceptually MAJIIC testing consists of three components: a scenario generation capability; a number of radar/motion imagery/EO sensor simulation capabilities; and various ground and airborne exploitation capabilities. The scenario generation capability JCATS (Joint Conflict and Tactical Simulation) provides methods for the scripting and playing of scenarios so that all sensor simulations are driven synchronously. The sensor simulators' output data, in turn, are synchronous and representative of the scenario as "seen" by the various sensors. The output data is capable of being shared between any of the MAJIIC 2 coalition ground stations, either by broadcast means or by accessing the data from a shared database. The CAESAR program looked at interoperability of ground moving target indicator (GMTI) and SAR sensor data; MAJIIC 2 has extended the sensor types to include EO/IR and motion imagery, and ESM.

APPENDIX B
IMAGE CHIPPING NOTES

The capability to retrieve image chips has long been supported by the MAJIIC 2 CSD. Some MAJIIC 2 systems have implemented the capability to request image chips in their CSD clients however in Trial Quest 2007 the majority of systems could not request image chips from the CSD. As Image Chipping is one key way of reducing bandwidth usage the ability to request image chips will be mandatory in MAJIIC 2 from MAJEX08 onwards.

An NSIF image chip does not have all of the information available if mensuration of the image chip is required. Some of the necessary information is embedded in the original image. The ICHIPB Support Data Extension is 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.

In order to assist the developer in implementing Image Chipping capability some notes from a UK development of the capability are added here:

The main difficulty with chipping is creating an order as there are a number of elements, including the Tailoring Spec, Packaging Spec, Image Spec, Alteration Spec, Product Details, Delivery Details, and so on. Further confusion is caused by there being geo-region fields in both the Image Spec and the Alteration Spec. Counter-intuitively it is the geo-region within the Image Spec that is actually used to specify the chip's geo-region, rather than the one in the Alteration Spec (which can be populated with (0,0) for both corners and a region type of 'NULL REGION').

OrderMgr does provide a validate message that checks the contents of the order, but it only checks to see if the order is well-formed and not whether the contents actually make sense. The geo-region is not checked until the order is placed by sending the order to the OrderMgr and the Delivery Details are not checked until the order has been completed and is ready to be FTPed back to the client. So, it is perfectly possible for an order to appear valid but not be completed.

One thing we picked up on while testing the chipping is that the geo-region of a NITF image must match the metadata field or chipping will not work as the CSD server does a validity check of the chipping area against the product metadata and will raise a ProcessingFault if the chip area is not inside the region specified in the metadata for the image. As this fault is raised on the OrderRequest object, it is easy to assume that the problem with the order is in the Delivery Details rather than with the order itself (it passed validation after all). If using the NC3A CSD server it is possible to see what caused the ProcessingFault by checking the CSD server log file in the Apache log directory.

One final thing to watch for is that the OrderRequest 'complete' message, which blocks until the order is ready, can unblock before the FTP of the order results is completed, and so the client should set a watch on the directory where the file is expected to arrive, rather than assuming that if it isn't there when the order is expected to be complete that there is a problem.

APPENDIX C
SLANTED IMAGERY NOTES

The following discussion thread is derived from an e-Mail exchange between Arnaud MARTIN (THALES Communications, FR) and Christian COMAN (NCI Agency) with the agreement of the two participants. It gives some perspective about the geo-referencing process and the existing NCI Agency (formerly NC3A) implementation:

[Arnaud MARTIN] (Initial message):

I am not sure if the SENSRA and ACFTB segments convey absolutely all the information which is required to properly geo-reference slanted images. It depends strongly on sensors' specifics.

This means that inside the SENSRA segment, we do not have access to the optical imaging parameters such as the lens position and the orientation of the focal plane array about the optical axis. But these are not conveyed either inside the ACFTB segment.

So the concern is:

- *Can we assume that the lens position coincides with the sensor position?*
- *Can we assume that the image is centered around the optical axis in the image plane?*
- *ROW_SPACING and COL_SPACING (ACFTB) should be delivered in angular unit, because this way FOCAL_LENGTH (ACFTB) is not required for computing the look vector at each pixel.*

if ROW_SPACING and COL_SPACING are delivered in distance unit, FOCAL_LENGTH should be filled and it should be assumed that the focal plane is perpendicular to the optical axis.

[Christian COMAN] (Responding to message above)

I was looking at your proposal and I think this is a very good start for solving the problem of slanted images. Last year we had a student implementing a geo-location algorithm for slant images.

Our algorithm for geo-referencing slant images is similar to the one suggested in your document. On short, the algorithm reads:

1) *use the orientation of the platform and the orientation of the sensor to define the optical axis in the Geocentric reference frame. The axis is assumed to be in the center of the image.*
2) *use the field of view (or alternatively the ROW_SPACING and COL_SPACING) to find the direction of an image pixel (four corners of the image were used).*
3) *intersect the direction of the relevant pixel with the Earth ellipsoid (in the Geocentric reference frame)*

The specific information that we use in the algorithm is the field of view of the camera. However, this is just because we played with MetaVR images for test purposes. As a consequence, it was assumed that the image corners intersect a circular cone associated with the camera field of view. The camera field of view and the additional assumption are not necessary if the ACFTB is provided.

There are a few things, which we didn't manage to solve within that project. The relevant ones are related to the accuracy of the geo-location for directions tangential to the Earth and the use of Replacement Sensor Models.

[Arnaud MARTIN] (Responding to message above)

If I sum up, in the case of a frame sensor (e.g. video camera), we would have the following conditions:

- *the optical axis position is the same as the sensor position*
- *the optical axis is at the center of the image*
- *the ROW_SPACING and COL_SPACING are given as angles*
- *so one may compute the look vector for a pixel by knowing the two angles of the line which joins the optical center and the pixel, from the optical axis*

Additional questions:

- *What if the optical axis is not exactly at the center of the image*
- *What if the optical center position is not exactly the same as the sensor's position (the only one I know from SENSRA)*
- *What if ROW_SPACING and COL_SPACING are given as distances and FOCAL_LENGTH is not supplied?*

[Christian COMAN] (Responding to message above)

I think the summary you presented is correct and we can use this as recommendations for MAJIIC.

Regarding the additional questions, here are some comments:

- in general, it is safe considering that an image collected by an sensor has the optical axis at the centre of the image. This is not longer valid if the image is exploited and clipped in an asymmetrical manner.

- if the optical centre and sensor position are not collocated a systematical error will be added to the location of the image pixels. To circumvent this kind of errors it would be useful to ask MAJIIC cameras to produce and send an calibration image with a clear defined target (location known) in the center of the image.

- I'm not sure if I understood correctly the use of the FOCAL_LENGTH. Reading the STDI-0002 it seems that this information is used when the ROW_SPACING and COL_SPACING is provided in radians. Besides, in order to estimate the angular distance between the optical axis and the look axis of a pixel in the image, it is necessary to have either the distance between the lens and the object (pixel) on the ground or to know the size of the CCD detector and the resolution.

[Arnaud MARTIN] (Responding to message above)

On the last point, the fact is I am not sure either how to deal with the FOCAL_LENGTH field.

My guess is that when ROW_SPACING and COL_SPACING are given as distances, these correspond to the size of the CCD detector in the corresponding direction.

So if you know FOCAL_LENGTH, you should have enough information to retrieve the two angles of the look axis. But FOCAL_LENGTH is not delivered in this case according to STDI-0002, so I am lost on this.

Do you have additional information on how to handle this particular case? I believe that in case of a push-broom sensor, one of the two XXX_SPACING is given as a distance, which might be a problem…

[Christian COMAN] (Responding to message above)

Indeed, the STDI documentation is not very clear in this case. The confusion is amplified by the fact that the ROW_SPACING and COL_SPACING distances are given in meter (feet) and not in mm or inch. For example, common CCD cameras can have sizes of the pixel in order of 5.6 micrometers (http://www.theimagingsource.com/en/resources/whitepapers/download/flenparawp.en.pdf). These small sizes cannot be recorded using the ROW_SPACING and COL_SPACING format, which are limited to fractions of millimeters. In addition the spacing in the CCD detector should be uniform and does not make sense to specify that the parameters are defined at the centre of the image. Based on these observations, I supposed that the ROW_SPACING and the COL_SPACING represent distances in the object plane.

On the other hand, the FOCAL_LENGTH is provided in cm with the range [0.1mm, 9m). Consequently, this parameter cannot be used to represent the distance between the sensor and the object, which in many cases is in order of hundreds/ thousands of meters.

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ABBREVIATIONS

AEDP	Allied engineering documentation publication
AGS	Alliance ground surveillance
ASTOR	airborne stand-off radar
ATWG	Architecture and Technical Working Group
AWG	Architecture Working Group
BCS	Basic Character Set
C3	command, control and communications
C3I	command, control, communication and intelligence
CAESAR	Coalition Aerial Surveillance and Reconnaissance
CAN	ISO 3166-1 alpha-3 country code for Canada
CCS	Camera Coordinate System
CDF	Common Data Format
CDTE	Collaborative Development & Test Environment
CGM	Computer Graphics Metafile
CNAD	Conference of National Armaments Directors
COTS	commercial off-the-shelf
CSD	Coalition Shared Data
DEM	Digital Elevation Model
DES	Data Extension Segments
DEU	ISO 3166-1 alpha-3 country code for Germany
DIGEST	digital geographic information exchange standard
EG	Engineering Guideline
EO	electro-optical
ESM	electronic warfare support measures
ESP	ISO 3166-1 alpha-3 country code for Spain
EX	exercise
FIPS	Federal Information Processing Standard
FMV	full motion video
FoV	field of view
FRA	ISO 3166-1 alpha-3 country code for France
GBR	United Kingdom, by ISO 3166-1 code
GCP	Ground Control Point
GMTI	ground moving target indicator
GPS	global positioning system
HAE	Height Above Ellipsoid
IPL	ISR Product Library
IR	infrared
ISO	International Organization for Standardization

ISR	intelligence, surveillance, and reconnaissance
ISTAR	Intelligence, Surveillance, Target Acquisition and Reconnaissance
ITA	ISO 3166-1 alpha-3 country code for Italy
JCATS	Joint Conflict and Tactical Simulation
JISR	joint intelligence, surveillance and reconnaissance
JPEG	Joint Photographic Experts Group
JSTARS	Joint Surveillance Target Attack Radar System
KLV	Key-Length-Value
MAJIIC	Multi-sensor Aerospace-ground Joint ISR Interoperability Coalition
MAJIIC 2	Multi-Intelligence All-Source Joint Intelligence, Surveillance and Reconnaissance (ISR) Interoperability Coalition
MISB	Motion Imagery Standards Board
MSL	mean sea level
MTI	moving target indicator
NC3A	NATO Consultation, Command and Control Agency
NACT	NATO Alliance Ground Surveillance Capability Testbed
NCIA	NATO Communications & Information Agency
NITFS	National Imagery Transmission Format Standard
NLD	ISO 3166-1 alpha-3 country code for the Netherlands
NOR	ISO 3166-1 alpha-3 country code for Norway
NPO	National Project Officer
NSIF	NATO Secondary Imagery Format
NTB	NITFS Board
OSWG	Operational Support Working Group
OWG	Operational Working Group
PIE	Paris Interoperability Experiment
SAR	synthetic aperture radar
SDE	support data extension
SMPTE	Society of Motion Picture and Television Engineers
SSR	Sensor Service Requests
STANAG	NATO standardization agreement
T&E	test and evaluation
TIE	Technical Interoperability Experiment
TRE	tagged record extension
TWG	Technical Working Group
UAS	unmanned aircraft system
UAV	unmanned aerial vehicle
UK	United Kingdom
USA	United States of America
WGS84	World Geodetic System 1984