MISB MOTION IMAGERY STANDARDS BOARD	MISB ST 1107.1
STANDARD	
Metric Geopositioning Metadata Set	**27 February 2014**

1 Scope

This Standard (ST) defines threshold and objective metadata elements for photogrammetric applications. This ST defines a new Local Set (LS) with metadata elements selected from MISB ST 0801[1], MISB ST 1010[2], and MISB ST 1202[3]The metadata elements specific to metric sensing are a subset of ST 0801 photogrammetric metadata elements. This ST supersedes MISB EG 0810[10].

2 References

2.1 Normative Reference

The following references and the references contained therein are normative.

[1] MISB ST 0801.5 Photogrammetry Metadata Set for Digital Motion Imagery, Feb 2014
[2] MISB ST 1010.1 Generalized Standard Deviation and Correlation Coefficient Metadata, Feb 2014
[3] MISB ST 1202.1 Generalized Transformation Parameters, Feb 2014
[4] SMPTE RP 210v13:2012 Metadata Element Dictionary
[5] MISB ST 0807.13 MISB KLV Metadata Dictionary, Feb 2014
[6] MISB ST 0603.2 Common Time Reference for Digital Motion Imagery using Coordinated Universal Time (UTC), Feb 2014
[7] MISB RP 0701 Common Metadata System: Structure, Aug 2007
[8] MISB ST 0107.2 Bit and Byte Order for Metadata in Motion Imagery Files and Streams, Feb 2014
[9] MISB ST 1201.1 Floating Point to Integer Mapping, Feb 2014

2.2 Informative References

[10] MISB EG 0810.2 Profile 2: KLV for LVSD Applications

3 Abbreviations and Acronyms

CE	Circular Error
CSM	Community Sensor Model
DGMS	Direct Geopositioning Metric Sensor

EG	Engineering Guideline
FFOV	Full Field-of-View
FLP	Floating Length Pack
KLV	Key-Length-Value
LS	Local Set
LE	Linear Error
LRF	Laser Range Finder
MISB	Motion Imagery Standards Board
NITF	National Imagery Transmission Format
PED	Processing, Exploitation, and Dissemination
RP	Recommended Practice
SACP	Single Aimpoint Center Pixel
SET	Sensor Exploitation Tool
SMPTE	Society of Motion Picture and Television Engineers
ST	Standard
TLE	Target Location Error
TRE	Tagged Reference Extension
UL	Universal Label

4 Introduction

A metric sensor collects sufficient metadata to support the computation of a target coordinate (latitude, longitude, and height-above-ellipsoid), and its uncertainty (TLE or CE/LE). A metric sensor that enables the computation of the target coordinate(s) and uncertainties from a single image is a Direct Geopositioning Metric Sensor (DGMS). A DGMS integrates a Laser Range Finder (LRF) or a framing LIDAR sensor into the sensor system. The value of a DGMS is the ability to generate target coordinates (latitude, longitude, and elevation) and an error estimate (TLE or CE/LE) for those coordinates with a known level of confidence as a result of direct calculation.

Two critical elements are required to exploit a metric sensor and a DGMS: (1) a rigorous sensor model; and (2) a complete set of metadata describing the sensor state and the measurement uncertainties of that state. These elements enable a myriad of down-stream Processing, Exploitation, and Dissemination (PED), such as allowing imagery to be combined with other imagery or data sources (i.e. data fusion). The sensor model is managed by the GWG/Community Sensor Model Working Group; however, the metadata elements to describe the sensor state and the measurement uncertainties is the intent of this ST.

Integrating metric capability with motion imagery is increasingly important as motion imagery plays a more significant role in fulfilling ISR mission needs. The photogrammetric metadata defined in MISB ST 0801[1] provides all of the required elements to describe a sensor with sufficient content to compute precision geolocations. The variance-covariance information about the parameters in ST 0801 may be conveyed through MISB ST 1010[2]. The first 31 elements of the LS defined in this ST are the elements in ST 0801 that have uncertainty information (consistent with the order required in ST 1010). The Standard Deviation and Correlation FLP per ST 1010 for these elements immediately follows. The remaining elements of the LS lists elements in ST 0801 that do not have an uncertainty model.

5 Revision History

Revision	Date	Summary of Changes
ST 1107.1	02/27/2014	• Promoted to Standard

6 Accuracy and Metricity

The terms “accuracy” and “metricity” have two different but related definitions. Accuracy is a measure of how well a system is able to calculate the location of a point of interest compared to its actual location in the real world. A more accurate sensor can produce target coordinates closer to the true location of a coordinate (i.e. the missed distance is small) than a less accurate sensor. Accuracy is usually stated as a system requirement, and is dependent on how well a system measures its state when an image is collected. A system may improve its accuracy by using higher quality system components (e.g. improved IMU or GPS solution). Understanding the accuracy of a sensor’s metadata requires the measurement uncertainties (errors); this refers to the metricity.

Metricity provides confidence in the calculated location of a point of interest. This confidence is expressed in terms of predicted uncertainties for various components of the geopositioning result, and therefore, is dependent on how well the system knows the uncertainties (errors) associated with the measured system parameters for each image. A metric sensor reports the metadata elements as dynamic information available about the system at the time the imagery is captured by the system. Even when values have large uncertainties and inaccurate data, the sensor is metric. On the other hand, a system that does not provide current error estimates for dynamic system values may not be considered metric.

Figure 1 illustrates this relationship between accuracy and metricity. The lower left quadrant represents a less accurate, non-metric system. The calculated target location shows a large displacement when compared to the actual geolocation of the target. By improving the system components, the system may become more accurate and move into the lower right quadrant. For both of these non-metric cases, the confidence in the calculated target location is unknown.

If, however, the less accurate, non-metric system of the lower left quadrant provided error estimates for the dynamic system parameters, it becomes a metric sensor and moves to the upper left quadrant. While such a system may not improve in accuracy, the confidence in the calculated target location is known and may be used for engagement, collateral damage assessment, weapons effect calculations or other precision based tasks. The ideal case is where the system components are of sufficient high quality for accuracy and produce error estimates for the dynamic system parameters. This is the case shown in the upper right quadrant, and such a system is able to provide actionable target information.

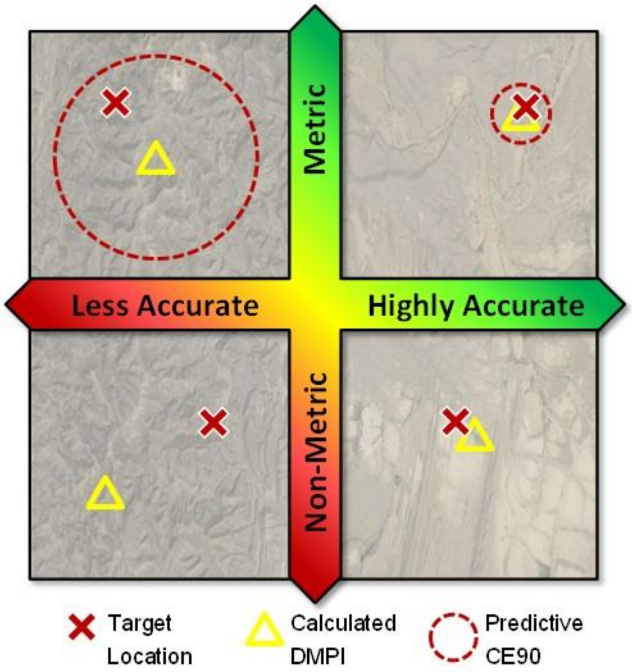

Figure 1: Relationship between accuracy and metricity

7 Metadata Timing

Metric sensors require more than just populated system parameters and error estimates. The system timing architecture must be understood and accounted for in the system design. The local set includes a metadata element to record the time for when the set of metadata elements are valid. Uncertainties and misalignments in the timing architecture can cause large increases in the uncertainty of calculated target coordinates. It is recommended that systems implementing this ST have the capability to capture and time tag the metadata at the same time the corresponding image is captured. Any timing differences between the metadata elements themselves, or between the metadata elements and the image capture must be understood and accounted for in the uncertainty (error) estimates.

8 Bandwidth Considerations

The MISB ST 1107 local set offers a significant reduction in the amount of information transmitted as compared to the Truncation Packs endorsed by version 3 or prior of ST 0801. This efficiency is realized for several reasons: (1) combining metadata elements from various ST/RP's into a single LS replaces the 16-byte UL key required for each element to be represented by a one-byte tag; (2) the variance-covariance information is contained in one location (the ST 1010 tag), eliminating the need for that information in the ST 0801 Truncation Packs; and (3) a single time tag is recorded in the LS for all data elements, eliminating the need for time in the ST 0801 Truncation Packs.

9 Metric Geopositioning Local Set (LS)

The Local Set for Metric sensors is listed in Table 1. The documents from which these metadata elements are defined contain more detail regarding the data type, size, and integer mapping, if applicable. "Type" indicates a priority of element, where Threshold elements are mandatory, and Objective elements are desired.

Table 1: Metric Geopositioning Local Set (LS)

Local Set Key				**Local Set Name**		
06.0E.2B.34.02.0B.01.01.0E.01.03.03.22.00.00.00 (CRC 13780)				**Geopositioning LS**		
Tag	**Size (bytes)**	**Name**	**Key**	**Type**	**Uncertainty Information Applicable (Type and Size)**	**Originating Document**
1	5	Sensor ECEF Position Component X	06.0E.2B.34.01.01.01.01.0E.01.02.01.25.00.00.00 (CRC 25208)	**THRESHOLD**	YES (IMAPB(0, 650, 2)	ST 0801[1]
2	5	Sensor ECEF Position Component Y	06.0E.2B.34.01.01.01.01.0E.01.02.01.26.00.00.00 (CRC 63908)	**THRESHOLD**	YES (IMAPB(0, 650, 2)	ST 0801[1]
3	5	Sensor ECEF Position Component Z	06.0E.2B.34.01.01.01.01.0E.01.02.01.27.00.00.00 (CRC 36624)	**THRESHOLD**	YES (IMAPB(0, 650, 2)	ST 0801[1]
4	3	Sensor ECEF Velocity Component X	06.0E.2B.34.01.01.01.01.0E.01.02.01.2E.00.00.00 (CRC 31847)	OBJECTIVE	YES (IMAPB(-900, 900, 2)	ST 0801[1]
5	3	Sensor ECEF Velocity Component Y	06.0E.2B.34.01.01.01.01.0E.01.02.01.2F.00.00.00 (CRC 2771)	OBJECTIVE	YES (IMAPB(-900, 900, 2)	ST 0801[1]
6	3	Sensor ECEF Velocity Component Z	06.0E.2B.34.01.01.01.01.0E.01.02.01.30.00.00.00 (CRC 50586)	OBJECTIVE	YES (IMAPB(-900, 900, 2)	ST 0801[1]
7	4	Sensor Absolute Heading	06.0E.2B.34.01.01.01.01.0E.01.02.01.37.00.00.00 (CRC 38071)	**THRESHOLD**	YES (IMAPB(0, 0.2, 2)	ST 0801[1]
8	4	Sensor Absolute Pitch	06.0E.2B.34.01.01.01.01.0E.01.02.01.38.00.00.00 (CRC 16473)	**THRESHOLD**	YES (IMAPB(0, 0.2, 2)	ST 0801[1]
9	4	Sensor Absolute Roll	06.0E.2B.34.01.01.01.01.0E.01.02.01.39.00.00.00 (CRC 14061)	**THRESHOLD**	YES (IMAPB(0, 0.2, 2)	ST 0801[1]
10	2	Sensor Absolute Heading Rate	06.0E.2B.34.01.01.01.01.0E.01.02.01.40.00.00.00 (CRC 34799)	OBJECTIVE	YES (IMAPB(0, 70, 2)	ST 0801[1]
11	2	Sensor Absolute Pitch Rate	06.0E.2B.34.01.01.01.01.0E.01.02.01.41.00.00.00 (CRC 61787)	OBJECTIVE	YES (IMAPB(0, 70, 2)	ST 0801[1]
12	2	Sensor Absolute Roll Rate	06.0E.2B.34.01.01.01.01.0E.01.02.01.42.00.00.00 (CRC 27271)	OBJECTIVE	YES (IMAPB(0, 70, 2)	ST 0801[1]

Local Set Key				**Local Set Name**		
06.0E.2B.34.02.0B.01.01.0E.01.03.03.22.00.00.00 (CRC 13780)				**Geopositioning LS**		
Tag	**Size (bytes)**	**Name**	**Key**	**Type**	**Uncertainty Information Applicable (Type and Size)**	**Originating Document**
13	2	Boresight Offset Delta X	06.0E.2B.34.01.01.01.01.0E.01.02.02.18.00.00.00 (CRC 39365)	OBJECTIVE	YES (IMAPB(0, 650, 5)	ST 0801[1]
14	2	Boresight Offset Delta Y	06.0E.2B.34.01.01.01.01.0E.01.02.02.19.00.00.00 (CRC 61297)	OBJECTIVE	YES (IMAPB(0, 650, 5)	ST 0801[1]
15	2	Boresight Offset Delta Z	06.0E.2B.34.01.01.01.01.0E.01.02.02.1A.00.00.00 (CRC 29869)	OBJECTIVE	YES (IMAPB(0, 650, 5)	ST 0801[1]
16	4	Boresight Delta Angle 1	06.0E.2B.34.01.01.01.01.0E.01.02.02.1B.00.00.00 (CRC 00537)	OBJECTIVE	YES (IMAPB(0, 2, 3)	ST 0801[1]
17	4	Boresight Delta Angle 2	06.0E.2B.34.01.01.01.01.0E.01.02.02.1C.00.00.00 (CRC 21300)	OBJECTIVE	YES (IMAPB(0, 2, 3)	ST 0801[1]
18	4	Boresight Delta Angle 3	06.0E.2B.34.01.01.01.01.0E.01.02.02.1D.00.00.00 (CRC 09600)	OBJECTIVE	YES (IMAPB(0, 2, 3)	ST 0801[1]
19	2	Focal Plane Line Principal Point Offset	06.0E.2B.34.01.01.01.01.0E.01.02.02.03.00.00.00 (CRC 40061)	**THRESHOLD**	YES (IMAPB(0, 1, 2)	ST 0801[1]
20	2	Focal Plane Sample Principal Point Offset	06.0E.2B.34.01.01.01.01.0E.01.02.02.04.00.00.00 (CRC 52560)	**THRESHOLD**	YES (IMAPB(0, 1, 2)	ST 0801[1]
21	4	Sensor Calibrated / Effective Focal Length	06.0E.2B.34.01.01.01.01.0E.01.02.02.05.00.00.00 (CRC 48100)	**THRESHOLD**	YES (IMAPB(0, 350, 2)	ST 0801[1]
22	4	Radial Distortion Constant Parameter	06.0E.2B.34.01.01.01.01.0E.01.02.02.6A.00.00.00 (CRC 14040)	OBJECTIVE	YES (FLOAT(4))	ST 0801[1]
23	4	First Radial Distortion Parameter	06.0E.2B.34.01.01.01.01.0E.01.02.02.0A.00.00.00 (CRC 28426)	OBJECTIVE	YES (FLOAT(4))	ST 0801[1]
24	4	Second Radial Distortion Parameter	06.0E.2B.34.01.01.01.01.0E.01.02.02.0B.00.00.00 (CRC 06590)	OBJECTIVE	YES (FLOAT(4))	ST 0801[1]
25	4	Third Radial Distortion Parameter	06.0E.2B.34.01.01.01.01.0E.01.02.02.0C.00.00.00 (CRC 18579)	OBJECTIVE	YES (FLOAT(4))	ST 0801[1]
26	4	First Tangential / Decentering Parameter	06.0E.2B.34.01.01.01.01.0E.01.02.02.0D.00.00.00 (CRC 15911)	OBJECTIVE	YES (FLOAT(4))	ST 0801[1]
27	4	Second Tangential / Decentering Parameter	06.0E.2B.34.01.01.01.01.0E.01.02.02.0E.00.00.00 (CRC 42491)	OBJECTIVE	YES (FLOAT(4))	ST 0801[1]

Local Set Key				Local Set Name		
06.0E.2B.34.02.0B.01.01.0E.01.03.03.22.00.00.00 (CRC 13780)				**Geopositioning LS**		
Tag	**Size (bytes)**	**Name**	**Key**	**Type**	**Uncertainty Information Applicable (Type and Size)**	**Originating Document**
28	4	Third Tangential / Decentering Parameter	06.0E.2B.34.01.01.01.01. 0E.01.02.02.83.00.00.00 (CRC 16709)	OBJECTIVE	YES (FLOAT(4))	ST 0801[1]
29	4	Differential Scale Affine Parameter	06.0E.2B.34.01.01.01.01. 0E.01.02.02.0F.00.00.00 (CRC 54095)	OBJECTIVE	YES (FLOAT(4))	ST 0801[1]
30	4	Skewness Affine Parameter	06.0E.2B.34.01.01.01.01. 0E.01.02.02.10.00.00.00 (CRC 07174)	OBJECTIVE	YES (FLOAT(4))	ST 0801[1]
31	4	Slant Range	06.0E.2B.34.01.01.01.01. 07.01.08.01.01.00.00.00 (CRC 16588)	OBJECTIVE	YES (IMAPB(0, 650, 2)	SMPTE RP 210[4]
32	V	Standard Deviation and Correlation Coefficient FLP	06.0E.2B.34.02.05.01.01. 0E.01.03.03.21.00.00.00 (CRC 64882)	**THRESHOLD**	N/A	ST 1010[2]
33	V	Generalized Transformation LS	06.0E.2B.34.02.0B.01.01 .0E.01.03.05.05.00.00.00 (CRC 40498)	OBJECTIVE	YES (Variable)	ST 1202[3]
34	2	Image Rows	06.0E.2B.34.01.01.01.01. 0E.01.02.02.06.00.00.00 (CRC 08248)	**THRESHOLD**	NO	ST 0801[1]
35	2	Image Columns	06.0E.2B.34.01.01.01.01. 0E.01.02.02.07.00.00.00 (CRC 22156)	**THRESHOLD**	NO	ST 0801[1]
36	2	Pixel Size X	06.0E.2B.34.01.01.01.01. 0E.01.02.02.82.00.00.00 (CRC 14321)	**THRESHOLD**	NO	ST 0801[1]
37	2	Pixel Size Y	06.0E.2B.34.01.01.01.01. 0E.01.02.02.82.01.00.00 (CRC 00193)	**THRESHOLD**	NO	ST 0801[1]
38	1	Slant Range Pedigree	06.0E.2B.34.01.01.01.01. 0E.01.02.02.87.00.00.00 (CRC 35764)	OBJECTIVE	NO	ST 0801[1]
39	4	Measured Line Coordinate for Range	06.0E.2B.34.01.01.01.01. 0E.01.02.05.07.00.00.00 (CRC 12632)	OBJECTIVE	NO	ST 0801[1]
40	4	Measured Sample Coordinate for Range	06.0E.2B.34.01.01.01.01. 0E.01.02.05.08.00.00.00 (CRC 58806)	OBJECTIVE	NO	ST 0801[1]
41	4	LRF Divergence	06.0E.2B.34.01.01.01.01. 0E.01.02.05.09.00.00.00 (CRC 37634)	OBJECTIVE	NO	ST 0801[1]
42	4	Valid Range of Radial Distortion	06.0E.2B.34.01.01.01.01. 0E.01.02.02.69.00.00.00 (CRC 44292)	OBJECTIVE	NO	ST 0801[1]

Local Set Key				Local Set Name		
06.0E.2B.34.02.0B.01.01.0E.01.03.03.22.00.00.00 (CRC 13780)				**Geopositioning LS**		
Tag	**Size (bytes)**	**Name**	**Key**	**Type**	**Uncertainty Information Applicable (Type and Size)**	**Originating Document**
43	8	Precision Time Stamp (POSIX Microseconds)	06.0E.2B.34.01.01.01.03.07.02.01.01.01.05.00.00 (CRC 64827)	**THRESHOLD**	NO	ST 0603[6]
44	1	Document Version	06.0E.2B.34.01.01.01.01 0E.01.02.05.05.00.00.00 (CRC 56368)	**THRESHOLD**	NO	ST 0807[5]
45	2	CRC-16-CCITT	06.0E.2B.34.01.01.01.01.0E.01 02.03.5E.00.00 00 (CRC 31377)	**THRESHOLD**	NO	RP 0701[7]

10 Metadata Requirements

Requirement	
ST 1107.1-01	All metadata shall be expressed in accordance with MISB ST 0107[8].
ST 1107.1-02	All metadata elements indicated as THRESHOLD in MISB ST 1107 Table 1 shall be populated and transmitted in the Metric Geopositioning LS.

To help detect erroneous metadata after transmission, a 2-byte CRC is included in every LS as the last item. The CRC is computed across the entire LS packet starting with the 16-byte LS key and ending with the length field of the CRC data element. Figure 2 illustrates the data range the checksum is performed over. If the calculated CRC of the received LS packet does not match the CRC stored in the packet, the packet is discarded as being invalid.

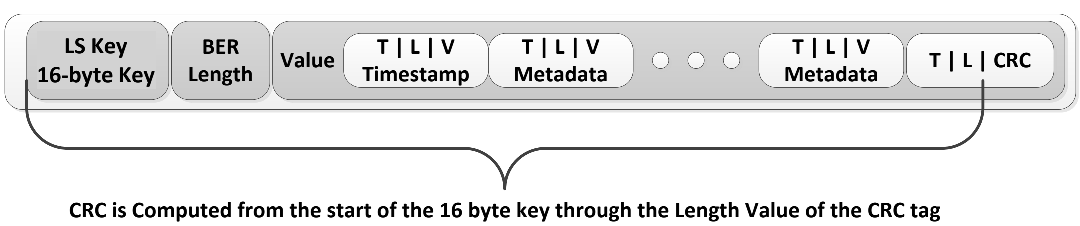

Figure 2: CRC Representation

The "Threshold" elements represent the core elements required for data exploitation. The additional "Objective" elements complete an ideal set of elements for a DGMS that may yield results with the highest fidelity. The Objective elements are also required for Single Aim Center Pixel (SACP) or Full Field of View (FFOV) exploitation.

The column labeled "Uncertainty Information Applicable" further denotes whether Standard Deviation and Correlation Coefficient metricity information is applicable. Elements labeled with "YES" have Standard Deviation and Correlation Coefficient information that may be applied;

these elements are followed by the recommended data type and size in parentheses. The elements labeled “No” do not require Standard Deviation and Correlation Coefficient information.

The last column identifies the originating document where the individual element is defined, which provides a more detailed description of the data element.

Requirement	
ST 1107.1-03	The program office shall select from the “Objective” elements in MISB ST 1107 Table 1 to produce a data population plan that enables the full capability for their system.
ST 1107.1-04	When transmitting a Metric Geopositioning LS either the airborne platform elements or the spaceborne platform elements shall be used, but not both.
ST 1107.1-05	When the Metric Geopositioning LS is used for airborne DGMS application, real-time position ECEF values as represented by LS Tags 1, 2 and 3 shall be present.
ST 1107.1-06	When the Metric Geopositioning LS is used for spaceborne DGMS application, real-time ECEF values as represented by LS Tags 7, 8 and 9 shall be present.
ST 1107.1-07	Only one value of position information shall be transmitted in the stream.
ST 1107.1-08	Position information shall be transmitted only once per stream.
ST 1107.1-09	Only one value of velocity information shall be transmitted in the stream.
ST 1107.1-10	Velocity information shall be transmitted only once per stream.
ST 1107.1-11	Standard Deviation and Correlation Coefficient metricity information of a data element shall be conveyed in accordance with MISB ST 1010[2].

11 Invoking MISB ST 1010

For a detailed description of how to invoke ST 1010 for conveying Standard Deviation and Correlation Coefficient uncertainty information, please consult MISB ST 1010[2]. The five elements required to invoke ST 1010 are listed below.

11.1 Matrix Size N

The first element is the matrix size N that describes uncertainty information for N corresponding elements in Table 1. A given value of N indicates that Standard Deviation and Correlation Coefficient uncertainty information, corresponding to the selected N elements in Table 1, is provided in a Standard Deviation and Correlation Coefficient FLP.

The index of Standard Deviation is associated with its corresponding Tag Number in Table 1. The Correlation Coefficient index is represented by the combination of two non-equal Tag Numbers in Table 1.

11.2 Parse Control Byte

The second element is the Parse Control Byte, which indicates whether the correlation values are sparsely represented, and also provides the number of bytes used for both the standard deviation (sigma) and correlation (rho) values. The recommended data type and size is listed in parentheses after the “YES” for all applicable elements in the Uncertainty Information

Applicable column in Table 1. Rho values are mapped integers using IMAPB(-1.0,1.0,C_{Length}) (see MISB ST 1201[9]). The recommended value for C_{Length} is two (2) bytes for all correlation coefficients related to the parameters in Table 1, although this does not limit the use of additional bytes if a system requires greater precision.

11.3 Bit Vector

The third element in the Standard Deviation and Correlation FPL is a Bit Vector mask, where a “1” indicates that a value is present and a “0” that a value is not.

11.4 Standard Deviation and Correlation Coefficient Values

The final two elements in the Standard Deviation and Correlation FLP are the standard deviation elements and correlation coefficient elements respectively, first sorted by row index and second by column index.

Only the upper triangle elements on the Standard Deviation and Correlation Coefficient matrix are used when invoking ST 1010.

The following subsections define the uncertainty parameters that will be populated into MISB ST 1010[2]. The following subsections do not list all the possible correlation coefficients combinations but there is a possibility they may exists in the data. In their existence they will be transmitted in accordance with MISB ST 1010.

11.4.1 Sensor Position

The ECEF position uncertainties (i.e. standard deviation or sigma, σ) are recorded as uncertainties about the individual X, Y, and Z components, and the correlation coefficients (rho, ρ) describe the correlation between the X, Y, and Z components.

11.4.2 Sensor Velocity

The ECEF velocity uncertainties (sigma, σ) are recorded as uncertainties about the individual X, Y, and Z velocity components, and the correlation coefficients (rho, ρ) describe the correlation between the X, Y, and Z velocity components.

11.4.3 Sensor Orientation

The sensor orientation standard deviations (sigma, σ) of the angular uncertainties are recorded about the Line-of-Sight (LOS) axis, and the correlation coefficients (rho, ρ) describe the correlation between the angular components of the LOS axis.

11.4.4 Sensor Orientation Rate

The sensor orientation rate standard deviations (sigma, σ) of the angular rate uncertainties are recorded about the LOS axis, and the correlation coefficients (rho, ρ) describe the correlation between the angular rate components of the LOS axis.

11.4.5 Boresight

The boresight Delta X, Delta Y, and Delta Z position uncertainties (sigma, σ) are recorded as uncertainties about the sensor's local frame, and the correlation coefficients (rho, ρ) describe the correlation between the Delta X, Delta Y, and Delta Z components.

The boresight Delta Angle 1, Delta Angle 2, and Delta Angle 3 standard deviations (sigma, σ) of the angular boresight uncertainties are recorded about the principal axis, and the correlation coefficients (rho, ρ) describe the correlation between the angular boresight components of the principal axis.

11.4.6 Focal Plane

The line and sample principal point offset standard deviations (sigma, σ) are recorded as the uncertainties about the principal point offset parameters, and the correlation coefficients (rho, ρ) describe the correlation between the line and sample principal point offset components.

The sensor's focal length standard deviation (sigma, σ) is recorded as the uncertainties about the sensor focal length parameter.

11.4.7 Radial Distortion

The radial distortion standard deviations (sigma, σ) are recorded as the uncertainties about the radial distortion parameters, and the correlation coefficients (rho, ρ) describe the correlation between the radial distortion components.

11.4.8 Tangential Decentering

The tangential-decentering standard deviations (sigma, σ) are recorded as the uncertainties about the tangential-decentering parameters, and the correlation coefficients (rho, ρ) describe the correlation between the tangential-decentering components.

11.4.9 Affine

The affine correction standard deviations (sigma, σ) are recorded as the uncertainties about the affine correction parameters, and the correlation coefficients (rho, ρ) describe the correlation between the affine correction components.

11.4.10 Slant Range

The standard deviation (sigma, σ) of the Slant Range is in meters along the Slant Range vector.

12 Image Coordinate Frame

The definition of the image coordinate system is critical in these Standards. The focus of this metadata is to support a Community Sensor Model (CSM) compliant sensor models for geopositioning activities. The CSM Technical Requirements Document (TRD) has a defined image coordinate system used in all of the computations.

The default transformation from the pixel-space (shown in Figure 3) to the “virtual” image-space coordinate system is shown in Figure 4.

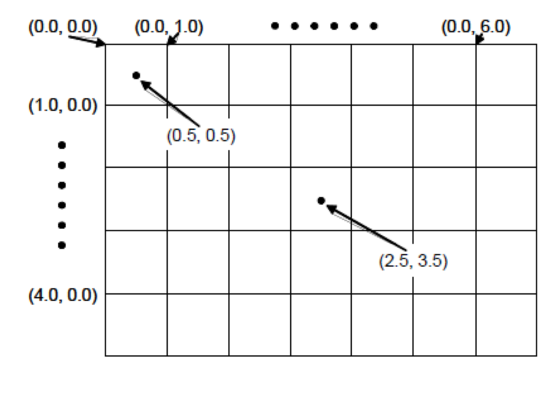

Figure 3: Pixel Coordinate System per CSM TRD

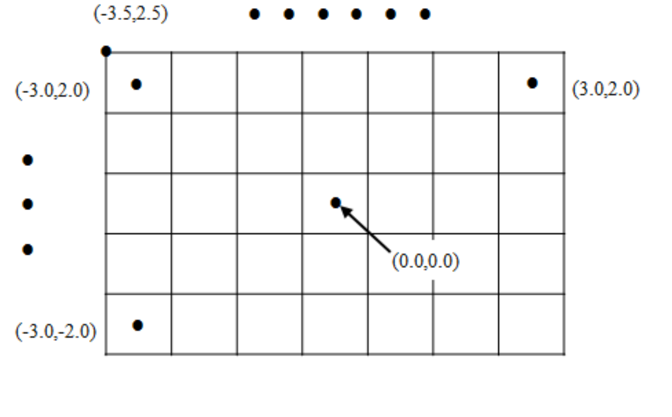

Figure 4: Virtual Image Coordinate System

If the image requires the default transformation and additional transformations to relate the pixel-space to the “virtual” image-space, then use of MISB ST 1202 is required. ST 1202 provides additional transformations to define the relationship between the pixel-space and the “virtual” image space. The full definition of these additional transformations is given in ST 1202.

13 Appendix - Informative

13.1 Parameter Information – ST 0801

MISB ST 0801 defines metadata elements that supports metric geo-location for a single sensor. A complete description of the parameters is provided in ST 0801 and should be consulted for reference. The following subsections provide a brief description of the parameters and justification for classification as “Threshold” or “Objective” elements in Table 1.

13.1.1 Sensor Position

The sensor position is captured in Tag 1 through Tag 3. These tags are mandatory. Uncertainties (sigmas) and correlation coefficients (rhos) are placed into the Standard Deviation and Correlation Coefficient FLP. These establish sensor position for each image. Further description of the sensor position parameters are contained in ST 0801.

13.1.2 Sensor Velocity

The external sensor velocity is captured in Tag 4 through Tag 6.These tags are optional. If implemented, they represent real-time sensor ECEF velocity values. Uncertainties (sigmas) and correlation coefficients (rhos) are placed into the Standard Deviation and Correlation Coefficient FLP. These establish sensor velocity for each image. Further description of the sensor velocity parameters are contained in ST 0801.

13.1.3 Sensor Orientation

The sensor orientation is captured in Tag 7 through Tag 9. Uncertainties (sigmas) and correlation coefficients (rhos) are placed into the Standard Deviation and Correlation Coefficient FLP. The correlation coefficients (rhos) are optional but should be provided if known. These establish sensor pointing attitude for each image. Further description of the sensor orientation parameters are contained in ST 0801.

13.1.4 Sensor Orientation Rate

The external sensor orientation rate is captured in Tag 10 through Tag 12. These Tags are optional. If implemented, they represent real time sensor ECEF velocity values. Uncertainties (sigmas) and correlation coefficients (rhos) are placed into the Standard Deviation and Correlation Coefficient FLP. These establish sensor attitude rates for each image. Further description of the sensor orientation rate parameters are contained in ST 0801.

13.1.5 Boresight

The six elements of the boresighting information, Tag 13 through Tag 18, are optional for the DGMS sensor data. Further description of this information is given in ST 0801. Uncertainties (sigmas) and correlation coefficients (rhos) are placed into the Standard Deviation and Correlation Coefficient FLP. Further description of the boresight parameters are contained in ST 0801.

13.1.6 Focal Plane

The focal plane is captured in Tag 19 through Tag 21. These tags are mandatory. The system contains principal point offset values and the effective focal length of the sensor. Uncertainties (sigmas) and correlation coefficients (rhos) are placed into the Standard Deviation and Correlation Coefficient FLP. This information establishes the principal point offset for each image. Further description of the focal plane parameters are contained in ST 0801.

13.1.7 Radial Distortion

The Internal Parameters Radial Distortion tags are optional. If used, this information is captured in Tag 22 through Tag 25 and Tag 42. Further description of these parameters is found in ST 0801. Uncertainties (sigmas) and correlation coefficients (rhos) are placed into the Standard Deviation and Correlation Coefficient FLP. Further description of the radial distortion parameters are contained in ST 0801.

13.1.8 Tangential Decentering

The Internal Tangential/Decentering tags are optional. This system contains the tangential/decentering distortion parameters values in Tag 26 through Tag 28. Further description of these parameters is found in ST 0801. Uncertainties (sigmas) and correlation coefficients (rhos) are placed into the Standard Deviation and Correlation Coefficient FLP. Further descriptions of the tangential decentering parameters are contained in ST 0801.

13.1.9 Affine

The Internal Parameters Affine Correction tags are optional. This information is captured in Tag 29 and Tag 30. Further description of these parameters is found in ST 0801. Uncertainties (sigmas) and correlation coefficients (rhos) are placed into the Standard Deviation and Correlation Coefficient FLP. Further descriptions of the affine parameters are contained in ST 0801.

13.1.10 Slant Range

The Slant Range is optional; however, any system capable of measuring slant range should provide slant range and slant range uncertainty in order to be metric. If used, Slant Range is captured in Tag 31. Slant Range is defined in SMPTE RP 210[4] as, "The distance from the sensor to the center point on the ground of the framed subject (image) depicted in the captured essence, (default meters)." Use of the ST 0801 Slant Range has a range pedigree, Tag 38, that describes if the slant range is a physically measured range (such as via laser range finder) or computed through inference or intersection with an elevation model. Also accompanied by the use of the ST 0801 Slant Range is the measured line and sample for the Slant Range, Tag 39 and 40, and a Laser Range Finder (LRF) Divergence value, Tag 41. The corresponding uncertainty (sigma) is placed into the Standard Deviation and Correlation Coefficient FLP. Further description of the slant range parameters are contained in ST 0801.

13.1.11 Standard Deviation and Correlation Coefficient FLP

The standard deviation and correlation coefficient information is captured in the mandatory Tag 32. Please refer to MISB ST 1010[2] for further description of the Standard Deviation and Correlation Coefficient FLP.

Two instances of the standard deviation and correlation coefficient information may exist within this Local Set: (1) one instance for the ST 0801 data; and (2) one instance for the Generalized Transformation LS. Each instance contains an enumerated value that describes which group of data elements it represents; therefore, each instance is self-describing and uncorrelated to the other instances.

13.1.12 Generalized Transformation LS

The Generalized Transformation Local Set is an optional set of data captured in Tag 33 used to relate the virtual image coordinate system to the distorted image coordinate system. The Generalized Transformation LS may appear up to four times in the Metric Geopositioning LS to account for all the enumerations defined in ST 1202. The full definition of the Generalized Transformation LS is given in ST 1202.

13.1.13 Image Size

The image size is captured in Tag 34 through Tag 37. These mandatory tags contain the number of image rows and image columns and the x and y pixel size on the actively illuminated FPA. These establish image size for each image. Further description of the image size parameters are contained in ST 0801.