MISB MOTION IMAGERY STANDARDS BOARD	MISB ST 1601.1
STANDARD	
Geo-Registration Local Set	**1 November 2018**

1 Scope

This standard defines metadata to support the identification of a geo-registration algorithm and various outputs from a geo-registration process. The intent is to use this standard's Local Set in conjunction with the KLV construct Amend Local Set as defined in MISB ST 1607. Only include the Geo-Registration Local Set within an existing Local Set that contains items describing a sensor model.

2 References

[1] MISB ST 0601.14 UAS Datalink Local Set, Nov 2018.

[2] MISB ST 0902.8 Motion Imagery Sensor Minimum Metadata Set, Nov 2018.

[3] MISB ST 1607 Constructs to Amend/Segment KLV Metadata, Oct 2016.

[4] MISB MISP-2019.1: Motion Imagery Handbook, Nov 2018.

[5] MISB ST 0107.3 KLV Metadata in Motion Imagery, Nov 2018.

[6] SMPTE ST 336:2017 Data Encoding Protocol Using Key-Length-Value.

[7] MISB ST 0807.22 MISB KLV Metadata Registry, Jun 2018.

[8] MISB ST 1303.1 Multi-Dimensional Array Pack, Nov 2018.

[9] ISO/IEC 9834-8:2014 Information technology - Procedures for the Operation of Object Identifier Registration Authorities - Part 8: Generation of Universally Unique Identifiers (UUIDs) and their use in Object Identifiers.

[10] IETF RFC 4122 A Universally Unique IDentifier (UUID) URN Namespace, Jul 2005.

[11] NGA.RP.0001_1.0.0 NGA Recommended Practice for Universally Unique Identifiers, Jan 2013.

3 Revision History

Revision	Date	Summary of Changes
ST 1601.1	11/01/2018	• Added Requirement -03 (Note: requirement number out of typical sequence as it was skipped in initial document release but reused here)

		• Modified MISB ST 1303 invoking statements for Correspondence Points – Row / Column & Correspondence Points – Latitude / Longitude to correct dimension & size errors • Updated References & revised ST to use term ”item” when referring to individual KLV for clarity as opposed to “element” • Added Tag 8 to support Height Above Ellipsoid (HAE) values for the correspondence points • Added Tag 9 to support Standard Deviation and Cross Correlation values for image-to-image correspondences. • Added Tag 10 to support Standard Deviations and Cross Correlations values for image-to-geographic correspondences. • Modified Key mapped to Tags 4 & 5 to be the generic MDARRAY Key defined by CRC 39697 for consistency of guidance.

4 Acronyms

KLV	Key Length Value
LS	Local Set
MDARRAY	Multi-Dimensional Array
SDCC-FLP	Standard Deviation and Correlation Coefficient Floating Length Pack
SMPTE	Society of Motion Picture & Television Engineers

5 Introduction

Geo-registration, generically defined and as used in this document, is the process of revising sensor model metadata through a mathematical process. For example, a First Image may be geo-registered to a “known good” Second Image, and the mathematical process “transfers” the accuracy of the Second Image to the First Image by adjusting the sensor model metadata of the First Image. In another use case, typical in mosaic generation, two images “float” and adjustments to both sensor model’s metadata produce best alignment.

The basic metadata parameters needed for a sensor model are contained in an existing Local Set (e.g. MISB ST 0601 [1]) and profiled in MISB ST 0902 [2]. Through the KLV construct of the Amend Local Set defined in MISB ST 1607 [3] the basic sensor model parameter values revised through the geo-registration process are “amended” within the KLV construct. The Motion Imagery Handbook [4] provides more information on amending data.

The Geo-Registration Local Set provides the additional metadata necessary to identify geo-registration algorithms and additional geo-registration process output data not contained in the original Local Set.

6 Geo-Registration Local Set

The Geo-Registration Local Set is a KLV Local Set whose items provide information specific to a geo-registration algorithm, such as name and version, and additional geo-registration output, such as correspondence points.

6.1 Conventions

Requirement(s)	
ST 1601-01	All metadata shall be expressed in accordance with MISB ST 0107 [5].
ST 1601-02	Formatting of Geo-Registration metadata shall be compliant with SMPTE ST 336 [6] encoding rules for Universal Labels and Local Sets.

6.2 Geo-Registration Local Set

The Geo-Registration Local Set 16-Byte Universal Label registered in MISB ST 0807 [7] is:

06.0E.2B.34.02.0B.01.01.0E.01.03.03.01.00.00.00 (CRC 39238)

Table 1 summarizes the Geo-Registration Local Set. The columns are defined as:

- **Tag ID** indicates the Tag to use when specifying the item in the Geo-Registration Local Set.
- **Name** is the name of the dictionary item.
- **Key** is the KLV registry Universal Label associated with the item.
- **Units** specifies the units of an item's value; a value of N/A means Not Applicable.
- **Type** specifies the data type (binary format) when encoding the value into binary. Note: The Type uint is a generalization to allow the application to define the number of bytes needed for an items value representation.
- **Rules** indicates if the item is Mandatory or Optional. The Local Set must include items listed as Mandatory, while those listed as Optional are at the implementer's discretion.

Table 1: Geo-Registration Local Set Items

Local Set Key			Name		
06.0E.2B.34.02.0B.01.01.0E.01.03.03.01.00.00.00 (CRC 39238)			Geo-Registration Local Set		
Constituent Items					
Tag ID	**Name**	**Key**	**Units**	**Type[1]**	**Rules**
1	Document Version	06.0E.2B.34.01.01.01.01. 0E.01.02.05.05.00.00.00 (CRC 56368)	N/A	uint	Mandatory
2	Algorithm Name	06.0E.2B.34.01.01.01.01. 0E.01.04.03.03.00.00.00 (CRC 48077)	N/A	utf8	Mandatory
3	Algorithm Version	06.0E.2B.34.01.01.01.01. 0E.01.04.03.03.00.00.00 (CRC 48077)	N/A	utf8	Mandatory
4	Correspondence Points – Row / Column	06.0E.2B.34.02.05.01.01. 0E.01.03.03.06.00.00.00 (CRC 39697)	pixels	MDARRAY	Optional
5	Correspondence Points – Latitude / Longitude	06.0E.2B.34.02.05.01.01. 0E.01.03.03.06.00.00.00 (CRC 39697)	degrees	MDARRAY	Optional
6	Second Image Name	06.0E.2B.34.01.01.01.01. 0E.01.04.03.03.00.00.00 (CRC 48077)	N/A	utf8	Optional
7	Algorithm Configuration Identifier	06.0E.2B.34.01.01.01.01. 0E.01.04.03.04.00.00.00 (CRC 60128)	N/A	UUID	Optional
8	Correspondence Points – Elevation	06.0E.2B.34.02.05.01.01. 0E.01.03.03.06.00.00.00 (CRC 39697)	meters	MDARRAY	Optional
9	Correspondence Points – Row / Column Standard Deviation & Correlation Coefficients	06.0E.2B.34.02.05.01.01. 0E.01.03.03.06.00.00.00 (CRC 39697)	variable	MDARRAY	Optional
10	Correspondence Points – Latitude / Longitude / Elevation Standard Deviation & Correlation Coefficients	06.0E.2B.34.02.05.01.01. 0E.01.03.03.06.00.00.00 (CRC 39697)	variable	MDARRAY	Optional

[1]Note on Lengths: Length computation occurs when the complete size of values is known at "run-time". (E.g. The number of characters in the string determines the length of a utf8 string; likewise, the number of elements in the array determines the size of an MDARRAY. See the Motion Imagery Handbook [4] for more information on data types and lengths.)

Tags 4, 5, 8, 9 and 10 all contain information about a common list of tie points; therefore, the MDARRAYs for these tags must have the same number of tie point elements.

Requirement	
ST 1601.1-03	Where Geo-Registration Local Set Items 4, 5, 8, 9, or 10 are included in the Local Set, all the included items shall use the same number of tie points in their arrays.

6.3 Geo-Registration Local Set Items

6.3.1 Tag 1: Document Version

The *Document Version* item identifies the version of MISB ST 1601 used in the implementation.

Requirement	
ST 1601-04	A Geo-Registration Local Set shall include the Document Version metadata item.

6.3.2 Tag 2: Algorithm Name

The *Algorithm Name* item uniquely identifies the algorithm used to geo-register the imagery data to produce revised sensor model parameter values.

Requirement	
ST 1601-05	A Geo-Registration Local Set shall include the Algorithm Name metadata item.

6.3.3 Tag 3: Algorithm Version

The *Algorithm Version* item is an alphanumeric that uniquely identifies the specific version of the Algorithm Name used to geo-register the imagery data.

Requirement	
ST 1601-06	A Geo-Registration Local Set shall include the Algorithm Version metadata item.

6.3.4 Tag 4: Correspondence Points – Row/Column

A geo-registration algorithm uses the *Correspondence Points – Row/Column* MDARRAY item to define an extensible list of tie points represented in pixel space for two Images, or a single Image and a set of geographic points defined in Tag 5 (Latitude/Longitude) and Tag 8 (Height above Elevation).

Figure 1 illustrates the first case of having correspondence or tie points between two Images: Image 1 and Image 2. The circles in Image 1 correspond to the triangles in Image 2. The MDARRAY stores each tie point's row and column.

Figure 1: Illustration of Correspondence Points between two Images

Table 2 shows the list of tie points for Figure 1, which becomes the MDARRAY.

Table 2: Example Tie Points for Figure 1

		Tie Points			
		0	**1**	**2**	**3**
Image 1	**Row**	133	128	97	69
	Column	31	91	122	129
Image 2	**Row**	89	82	52	27
	Column	125	176	204	210

MISB ST 1303 [8] defines the MDARRAY KLV Pack construct.

The parameters for this Multi-Dimensional Array are: MDARRAY($Note_A$, 2, 4, $Note_B$) where

- $Note_A$: Array(0, tp) = 06.0E.2B.34.01.01.01.01.0E.01.01.03.3F.01.00.00 (CRC 44071)[a]

  Array(1, tp) = 06.0E.2B.34.01.01.01.01.0E.01.01.03.3F.02.00.00 (CRC 62839)[b]

  Array(2, tp) = 06.0E.2B.34.01.01.01.01.0E.01.01.03.3F.01.00.00 (CRC 44071)[c]

  Array(3, tp) = 06.0E.2B.34.01.01.01.01.0E.01.01.03.3F.02.00.00 (CRC 62839)[d]

  tp = denotes a specific tie point

  [a]This KLV key represents the row value of the tie point for the First Image.

  [b]This KLV key represents the column value of the tie point for the First Image.

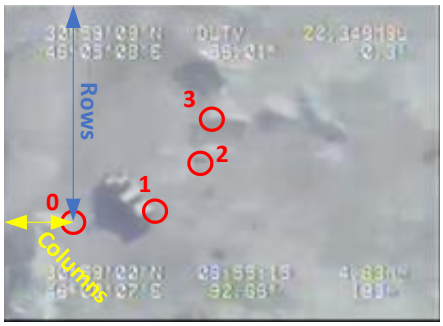
  [c]This KLV key represents the row value of the tie point for the Second Image.

  [d]This KLV key represents the column value of the tie point for the Second Image.

- $Note_B$: This value is dependent upon the number of tie points produced between two Images.

This specifies a two-dimensional Array with dimensions of four (4) by that given by $Note_B$.

When specifying tie points in pixel space to geographic points, use only one Image and specify the tie points in Tag 5 for the latitude/longitude and Tag 8 for the height above ellipsoid. Figure 2 illustrates a single Image with correspondences to geographic tie points.



Geo Point	Latitude	Longitude	HAE
0	32.98416	48.08388	1500
1	32.98417	48.08389	1501
2	32.98418	48.08390	1500
3	32.98419	48.08390	1499

Figure 2: Illustration of Correspondence Points between an Image and geographic points.

Table 3 shows the list of tie points for Figure 2, which becomes three MDARRAYs. Tag 4 specifies the Row/Column. Tag 5 specifies the Latitude/Longitude. Tag 8 specifies the Height Above Ellipsoid.

Table 3: Example Tie Points for Figure 1

		Tie Points			
		0	**1**	**2**	**3**
Tag 4	**Row**	133	128	97	69
	Column	31	91	122	129
Tag 5	**Latitude**	32.98416	32.98417	32.98418	32.98419
	Longitude	48.08388	48.08389	48.08390	48.08391
Tag 6	**HAE**	1500	1501	1500	1499

6.3.5 Tag 5: Correspondence Points – Latitude / Longitude

A geo-registration algorithm uses the *Correspondence Points – Latitude/Longitude* MDARRAY item to define an extensible list of tie points represented in geographic space for two Images. MISB ST 1303 [8] defines the MDARRAY KLV Pack construct.

The parameters for this Multi-Dimensional Array are: MDARRAY($Note_A$, 2, 2, $Note_B$) where

- $Note_A$: Array(0, tp) = 06.0E.2B.34.01.01.01.01.0E.01.01.03.28.00.00.00 (CRC 53661)[a]

  Array(1, tp) = 06.0E.2B.34.01.01.01.01.0E.01.01.03.29.00.00.00 (CRC 42793)[b]

  tp = denotes a specific tie point

  [a]This KLV key represents the latitude value of the tie point.

  [b]This KLV key represents the longitude value of the tie point.

- $Note_B$: This value is dependent upon the number of tie points produced between the two images.

This specifies a two-dimensional Array with dimensions of two (2) by that given by $Note_B$.

6.3.6 Tag 6: Second Image Name

The *Second Image Name* item uniquely identifies the second Image used in the geo-registration process.

6.3.7 Tag 7: Algorithm Configuration Identifier

The *Algorithm Configuration Identifier* item is a generic identification system based on a Universal Unique Identifier (UUID) to differentiate configurations or set of parameters for a specific Algorithm Name and Algorithm Version. It is up to the algorithm vendor to identify the set of variable configuration parameters and values for each algorithm to form the basis of the UUID.

Multiple techniques to generate a UUID are available as discussed in ISO 9834 [9] and RFC 4122 [10]. NGA Recommended Practice [11] discusses which UUID versions may be used.

This Standard recommends constructing UUIDs from unique configuration information through UUID Version 4 leveraging random numbers or UUID Version 5 leveraging Secure Hash Algorithm (SHA) coding process. For example, combine minimization thresholds, minimum number of tie points, correlation settings, etc. and use either truly random numbers or the SHA hash function to generate the UUID.

6.3.8 Tag 8: Correspondence Points – Elevation

A geo-registration algorithm uses the *Correspondence Points – Elevation* MDARRAY item to define an extensible list of elevation values for geographic space tie points for two Images. MISB ST 1303 [8] defines the MDARRAY KLV Pack construct.

The parameters for this Multi-Dimensional Array are: MDARRAY($Note_A$, 1, $Note_B$) where

- $Note_A$: Array(0, tp) = 06.0E.2B.34.01.01.01.01.0E.01.01.03.2A.00.00.00 (CRC 15605)[a]

  tp = denotes a specific tie point

  [a]This KLV key represents the elevation value of the tie point.

- $Note_B$: This value is dependent upon the number of tie points produced between two Images.

This specifies a one-dimensional Array with a dimension of one (1) by that given by $Note_B$.

6.3.9 Tag 9: Correspondence Points – Row / Column Standard Deviation & Correlation Coefficients

A geo-registration algorithm uses the *Correspondence Points – Row/Column Standard Deviation & Correlation Coefficients* MDARRAY item to define an extensible list of standard deviations and correlations coefficients for tie points represented in pixel space for two Images. MISB ST 1303 [8] defines the MDARRAY KLV Pack construct.

The value of Tag 9 is a two-dimensional Array with dimensions of six (6) by the number of tie points (tp) defined in the value of Tag 4, i.e. one sigma value for each value in Tag 4's array and one rho value for each row/value pair.

The parameters for the Multi-Dimensional Array are: MDARRAY($Note_A$, 2, 6, $Note_B$, E_{Bytes} see $Note_C$) where

- $Note_A$:

  Array(0, tp) = Sigma value for Item 4's Array(0, tp), the First Image Row for tie point tp. Value is a floating point using IMAPB(0, 100, E_{Bytes})

  Array(1, tp) = Sigma value for Item 4's Array(1, tp), the First Image Column for tie point tp. Value is a floating point using IMAPB(0, 100, E_{Bytes})

  Array(2, tp) = Rho value for the cross correlation between the First Image row and column values for tie point tp. Value is a floating point using IMAPB(-1, 1, E_{Bytes})

  Array(3, tp) = Sigma value for Item 4's Array(2, tp), the Second Image Row for tie point tp. Value is a floating point using IMAPB(0, 100, E_{Bytes})

  Array(4, tp) = Sigma value for Item 4's Array(3, tp), the Second Image Column for tie point tp. Value is a floating point using IMAPB(0, 100, E_{Bytes})

  Array(5, tp) = Rho value for the cross correlation between the Second Image row and column values for tie point tp. Value is a floating point using IMAPB(-1, 1, E_{Bytes})

  tp = denotes a specific tie point

- $Note_B$: This value is dependent upon the number of tie points produced between two Images.

- $Note_C$: Compute the E_{Bytes} value at runtime based on the given precision of the sigma and rho values. The E_{Bytes} value is the maximum length across all IMAP'ed sigma and row values. For example, if a sigma values requires 3 bytes and the rho requires only 2 bytes then the rho values have their IMAP values computed with 3 bytes.

6.3.10 Tag 10: Correspondence Points – Latitude / Longitude / Elevation Standard Deviation & Correlation Coefficients

A geo-registration algorithm uses the *Correspondence Points – Latitude / Longitude / Elevation Standard Deviation & Correlation Coefficients* MDARRAY item to define an extensible list of standard deviations & correlations coefficients for tie points represented in geographic space for two Images. MISB ST 1303 [8] defines the MDARRAY KLV Pack construct.

The Value of Tag 10 is a two-dimensional Array with dimensions of up to six (6) by the number of tie points (tp) defined in Tag 5's value, i.e. one sigma value for each value in Tag 5's array and optionally Tag 8's array, along with one rho value for each latitude/longitude pair in Tag 5's array and rho values for the correlations between latitude/elevation and longitude/elevation.

The parameters for the Multi-Dimensional Array are: MDARRAY($Note_A$, 2, $Note_B$, $Note_C$, $Note_D$) where

- $Note_A$:

  Array(0, tp) = Sigma value in meters for Item 5's Array(0, tp), the latitude for tie point tp. Value is a floating point using IMAPB(0, 650, E_{Bytes}). Note: Although the latitude is in degrees, in this standard measure the sigma value in meters.

  Array(1, tp) = Sigma value in meters for Item 5's Array(1, tp), the longitude for tie point tp. Value is a floating point using IMAPB(0, 650, E_{Bytes}). Note: Although the longitude is in degrees, in this standard measure the sigma value in meters.

  Array(2, tp) = Rho value for the latitude and longitude cross correlation for tie point tp. Value is a floating point using IMAPB(-1, 1, E_{Bytes})

  Array(3, tp) = Sigma value for Item 8's Array(0, tp), the elevation for tie point tp. Value is a floating point using IMAPB(0, 1000, E_{Bytes})

  Array(4, tp) = Rho value for the latitude and elevation cross correlation for tie point tp. Value is a floating point using IMAPB(-1, 1, E_{Bytes})

  Array(5, tp) = Rho value for the longitude and elevation cross correlation for tie point tp. Value is a floating point using IMAPB(-1, 1, E_{Bytes})

  tp = denotes a specific tie point

- $Note_B$: This value is three (3) if providing only latitudes / longitudes and is six (6) if providing latitudes / longitudes / elevations.
- $Note_C$: This value is dependent upon the number of tie points produced between two Images.
- $Note_D$: Compute the E_{Bytes} value at runtime based on the given precision of the sigma and rho values. The E_{Bytes} value is the maximum length across all IMAP'ed sigma and row values. For example, if a sigma values requires 3 bytes and the rho requires only 2 bytes then the rho values have their IMAP values computed with 3 bytes.

Appendix A – Example: Geo-Registration incorporated into MISB ST 0601 – Informative

In this example, a generic sensor model represented by 11 dynamic items from MISB ST 0601 define the imaging ray. Figure 3 illustrates the concept of how to leverage MISB ST 0601 Tag 101: Amend Local Set.

Note Tag 101 reuses the MISB ST 0601 Tags 5, 90, 91, 13, 14, 75, 16, 17, 18, 19 & 20 with their values defined in the base ST 0601 Local Set. These same 11 tags, with possibly revised values, and with the addition of Tag 102 (SDCC-FLP) reflect the results of a geo-registration process. Although the illustration only shows 11 metadata items, the Amend Local Set Tag 101 permits other MISB ST 0601 items, such as the SDCC-FLP tag as shown. A receiver is free to select items with their corresponding values from the base set or the substituted set.

In this illustration, Tag 98 Geo-Registration Local Set (indicated as GEOR LS) is the final element within the Amend Local Set Tag 101, which includes specific attributes of the geo-registration process. Including multiple Tag 101 Amend Local Sets within the MISB ST0601 Local Set enables the inclusion of multiple results from different geo-registration algorithms.

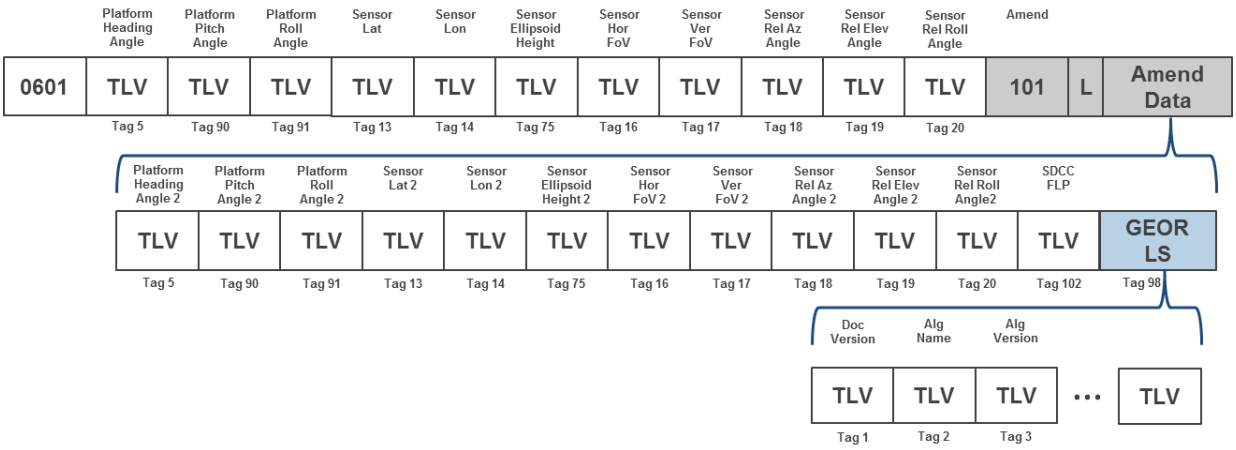


Figure 3: Use of ST 0601 Tag 101 – Amend Local Set to embed a Geo-Registration LS.