MISB MOTION IMAGERY STANDARDS BOARD	MISB ST 1907.1
STANDARD **Motion Imagery Metadata (MIMD): Payload**	**25 June 2020**

1 Scope

The Motion Imagery Metadata (MIMD) Model [1] includes information about Payloads hosted by Platforms (see MISB ST 1905 [2]). A Payload is a device or system of devices attached to a Platform for accomplishing the objectives of the system. Devices include general purpose intelligence gathering systems such as visible light cameras, infrared cameras, SAR, ESM, LIDAR, HSI, MSI, and acoustical devices, for example, a Motion Imagery system with its lenses, filters, and sensor arrays. The Payload model currently does not include weapon systems. The scope of this standard describes the modeling information about payloads with an initial focus on Geo-Intelligence Sensors. Other payload types, e.g., acoustical devices, are future extensions.

2 References

[1] MISB ST 1901.1 Motion Imagery Metadata (MIMD): Modeling Rules, Jun 2020.

[2] MISB ST 1905.1 Motion Imagery Metadata (MIMD): Platform, Jun 2020.

[3] MISB MISP-2020.1: Motion Imagery Handbook, Oct 2019.

[4] MISB ST 1906.1 Motion Imagery Metadata (MIMD): Staging System, Jun 2020.

[5] MISB ST 1904.1 Motion Imagery Metadata (MIMD): Base Attributes, Oct 2019.

[6] MISB ST 0601.16 UAS Datalink Local Set, Oct 2019.

3 Revision History

Revision	Date	Summary of Changes
ST 1907.1	6/25/2020	• Restructured to enable auto-generation of Model Class and Model Enumeration sections • Added CorrespondenceGroup Class and its supporting classes • Removed attribute Correspondence Point “type” attribute (replaced with type in CorrespondenceGroup); renumbered attributes in Correspondence Point class • Retained corrType enumeration for future use • Added Track class and its supporting classes

		• Added warnings and error enumerations to Payload and GeoIntelligenceSesenor classes. • Moved some of the DeviceStatus enumeration values to warnings and errors enumerations.

4 Acronyms, Terms, Definitions

GSCPO	Geo-Intelligence Sensor Common Pointing Orientation
HAE	Height Above Ellipsoid
LRF	Laser Range Finder
MISB	Motion Imagery Standards Board
MISP	Motion Imagery Standards Profile
ROC_Unknown	Report-on-Change Unknown state
ST	Standard
UML	Unified Modeling Language

5 Introduction

Several types of Payloads hosted on Platforms provide distinct functions to achieve system and mission objectives. One subset of Payload types are sensors that gather Geographical based Intelligence data on an image scene (see MISB Motion Imagery Handbook [3] for background on Sensors and Scene). A Geo-Intelligence Sensor is a device which measures active or passive Scene energy with a defined correspondence between the sensed data and the Scene.

While Payload devices share common attributes, each Payload device also defines specific metadata for their phenomenologies and methods of data collection. This standard includes the model for frame imagers (visible light and infrared), and Laser Range Finder (LRF); future revisions will include models for other Payload devices.

6 Overview

The Payload model is the combination of the physical Payload description and the resulting operational results in the form of Correspondences, Correspondence Groups and Tracks.

6.1 Payload Description

A Payload is a self-contained set of one or more devices along with its supporting hardware and software. The Payload is a physical component attached to (or riding on) a Platform (defined in MISB ST 1905) and may or may not need external power, communications, or controls. The MIMD Model provides a list of Payloads for a Platform, where each Payload may have one or more devices. Currently, the Payload only supports Geo-Intelligence devices. The Payload may define a reference point and orientation using Stages (defined in MISB ST 1906 [4]), which may provide the basis for the positioning and orientation information in each Payload device. The Payload position and orientation may be absolute or relative to the Platform position and orientation.

Figure 1 shows several images of potential Payloads. Image (a) is a Payload consisting of a single sensor ball with multiple sensors (e.g., Visible light, Infrared, Laser Range Finder). Image (b) is a combination of sensors and gun system. Currently, the Payload model only supports metadata for the sensor component of this system and not the guns. Image (c) and (d) is a ground-based tracking system where each sensor may be a separate Payload attached to a turreted Platform.

(a)
(Approved by USN for public release)

(b)
(Approved by USN for public release)

(c)
(Photo credit White Sands Missile Range)

(d)
(Photo credit White Sands Missile Range)

Figure 1: Example Payloads

6.1.1 Geo-Intelligence Sensor Orientation

A Geo-Intelligence Sensor is a conceptual sensor which may be directional or "point" to a Scene or point-target, for example an imaging sensor or an LRF. For this model there are two types of pointing sensors: Single Point sensors and Multi-Point sensors. Single point sensors only collect one data value in the sensor's pointing direction (e.g., LRF). Multi-Point sensors collect more than one point at a time in the pointing direction; the result is either a one- or two-dimensional array of data (e.g., imaging sensor).

When specifying the Staging (see MISB ST 1906) orientation of any Single Point or Multi-Point Geo-Intelligence Sensor the MIMD Model defines a **Geo-Intelligence Sensor Common Pointing Orientation (GSCPO)** for the final or terminal stage. In all cases (Single Point or Multi-Point) the GSCPO has the positive x-axis pointing in the direction from the sensor to the Scene or point-target. The x-axis aligns with the boresight of the pointing sensor for the given sensor. With Multi-Point Sensors an array of samples is available (either one or two dimensional), so there is enough information to define a Scene and therefore the y and z axes orientations. The positive y-axis points to the right side of the Scene or in the direction of

increasing column numbers. The positive z-axis points downward towards the bottom of the Scene or in the direction of increasing row numbers.

6.1.1.1 Sample Array

The Geo-Intelligence Sensor models its output as an array of samples, which may be a single point, one dimensional, or two dimensional. The GeoIntelligenceSensor class uses attributes nCols and nRows to define the sizes of the dimensions. If both are greater than one (1) the array is two-dimensional with the given nCols and nRow dimension sizes. If either is one (1) and the other value is greater than one the array is a single dimension. If both are one (1) then the array is a single point.

The coordinates of the array are zero based, so the upper left of the array has (row, col) coordinate (0,0) and the lower right of the array is (nRows-1, nCols-1). These coordinates match the y-axis and z-axis orientation from Section 6.1.1, therefore rows correlate with the y-axis and columns correlate with the z-axis.

6.2 Operational Results

In addition to the visual aspect of Motion Imagery, a major component of usability is the resulting operational metadata. This metadata describes items of interest in the Motion Imagery at three levels. The first level is single points of information which may be in the image, in the "Scene" or both; this first level of information is the Correspondence Point (Section 6.2.1). The second level is a conceptual area either in the image or in the scene, a conceptual area may or may not include a list of Correspondence Points; the second level of information is the Correspondence Group (Section 6.2.2). The third level is temporal tracking of Correspondence Groups in the image, the Scene or both; the third level of information is the Track (Section 6.2.3).

6.2.1 Correspondence Point

Correspondence is a relationship between the Scene and the measured data. The relationship may be measurable, e.g., a geographical location (any 3-space on, above, or below the reference ellipsoid), or non-measurable, e.g., an object of interest clearly in the Scene but with an unknown geographical location. An example of a measurable correspondence is an LRF distance measurement between the LRF system and a point on the ground or object in the air, along the laser pointing direction. Figure 2 illustrates an LRF ranging a point on a Scene target (the arrow). The Range value is the distance between the LRFs position and a point in the direction the LRF is oriented, in this case the point on the arrow.

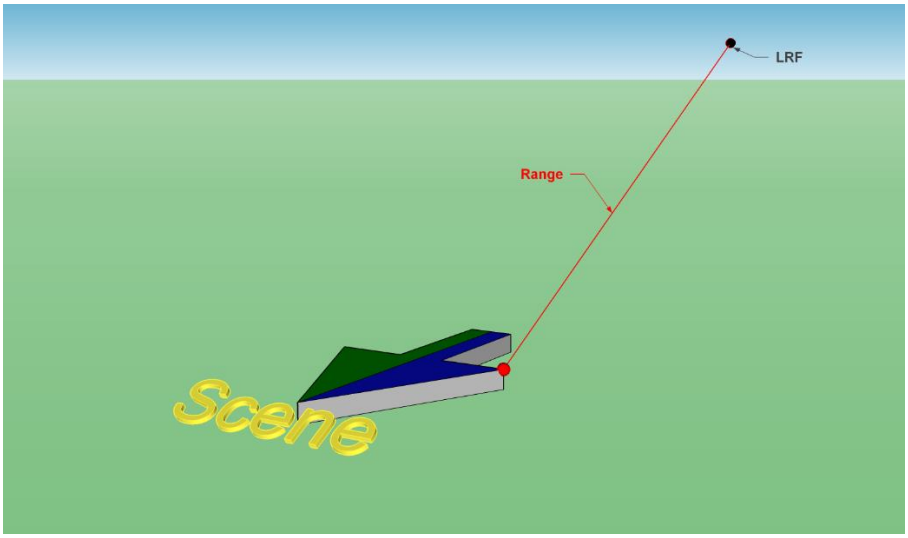

Figure 2: Example LRF Correspondence

Another example of a measurable correspondence is a pixel location in an image corresponding to a geographical point in the Scene (e.g., a point on the ground, or a missile). Figure 3 illustrates a measurable Image Point to Target Point correspondence. The Image Point's pixel location corresponds to the Target Points position (e.g., latitude, longitude, HAE). The Target Point's position is typically algorithmically determined. The Geo-Intelligence sensor information provides the position and orientation of the Perspective Center and Image.

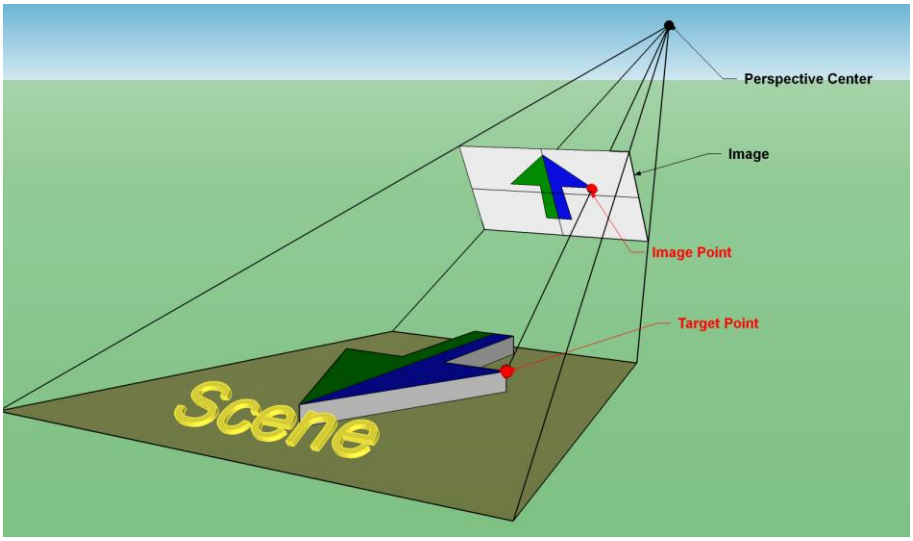

Figure 3: Example Measurable Image Correspondence

Figure 4 illustrates an example of a non-measurable correspondence. The pixel locations of the arrow are known but the Target Point position is unknown. Subsequent image processing may determine presence of an object with the correspondence between the pixel location and the arrow object.

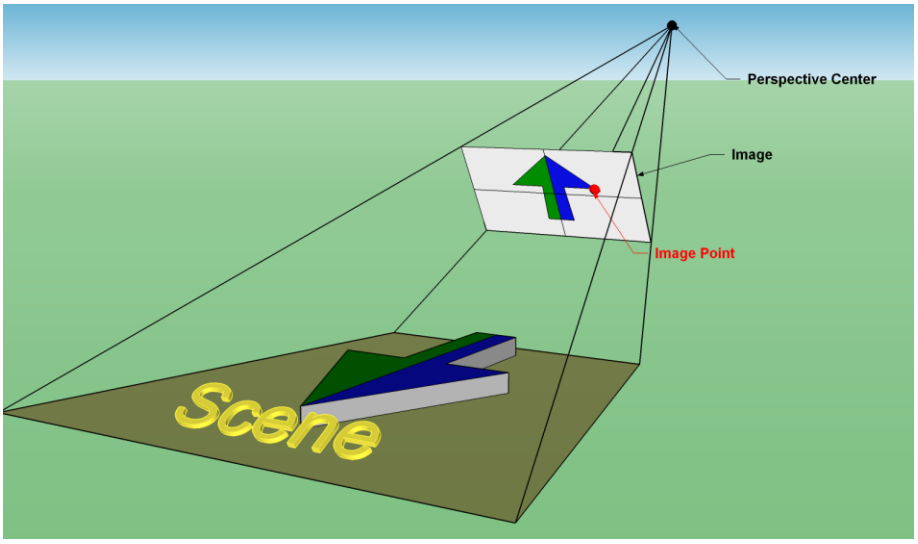

Figure 4: Example Non-Measurable Image Correspondence

There are two types of correspondences: Intra and Inter. Intra-correspondences are within a single sensor as illustrated in the previous figures above. Inter-correspondences are cross references between two or more sensors, such as an Imager and LRF, or two Imagers. Inter-correspondences may occur between sensors within a single Payload or between sensors in different payloads. Figure 5 illustrates a cross reference between a non-measurable image correspondence and a measured LRF correspondence. This illustration shows the Image's Perspective Center and the LRF are not co-located and therefore not bore sighted. The staging data for the Perspective Center and LRF are very important modeling items to complete the geometry for target positioning.

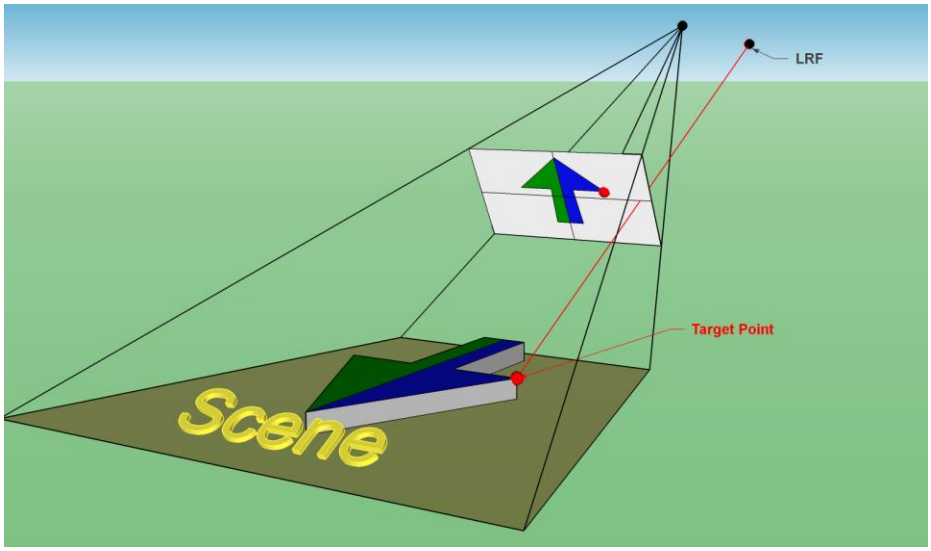

Figure 5: Example Inter-Correspondence between an Image and LRF

A useful set of default Image Intra-Correspondences are the image center point and four corners. Figure 6 illustrates these five default Image correspondences. The red line intersects the image

center and corresponds to the scene point in the middle of the image. The four corners of the image correspond to four points on the ground if the sensor is pointing downward. Additional points are the horizon line, if the Scene consists of ground and sky, and the corners of an arbitrary bounding box.

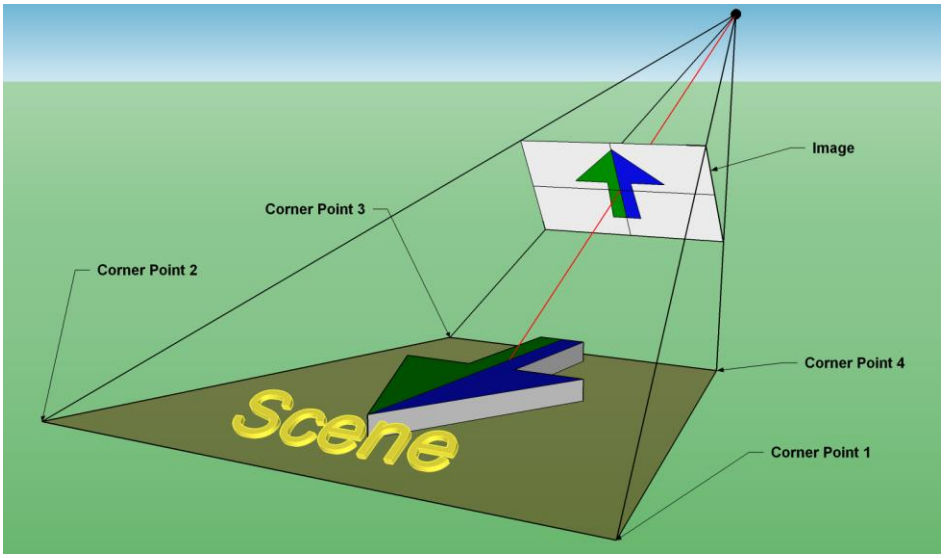

Figure 6: Default Image Correspondences

6.2.2 Correspondence Group

A Correspondence Group is a defined region-of-interest within the imagery. For example, a Correspondence Group may define the points for a moving or still object in the Motion Imagery, define a "tripwire" region (e.g., something which does not necessarily have a visual representation in the Motion Imagery), or describe the four corners of the imagery (e.g., footprint trapezoid).

There are three methods for defining a Correspondence Group: **correspondence point array**, **boundary definition**, and **pixel mask**. Any of the three or combination of the three methods define the group. A **correspondence point array** is a list of correspondence points which defines a group. The **boundary definition** is either a boundary polygon (of correspondence points), or a bounding rectangle (two correspondence points). A **pixel mask** is an area within the image selected pixel-by-pixel.

A Correspondence Group has a set of assignable properties applicable to the whole group, for example color or intensity. Additionally, Correspondence Groups may define their centroid, bounding rectangle, and boundary properties as needed.

Machine learning algorithms create Correspondence Groups, therefore attributes to support confidence measures of the group definition and identification of an object (along with confidence of the object identity) are integral for a group.

6.2.3 Track

A Track is the management of an object over time. Correspondence points and correspondence groups only exist in the scope of the current Motion Imagery frame; they are valid for one instant of time. In subsequent frames the Correspondence points and groups may shift within the frame but their history, frame to frame, is not managed. In effect, a track provides a history of one or more Correspondence Groups over time.

7 Model Classes

Figure 7 shows the UML class diagram for the MIMD Payload. The Payload class includes attributes about the Payload and a list of Geographical Intelligence Sensors (GeoIntelligenceSensor), where each Sensor class includes a list of Correspondence classes.

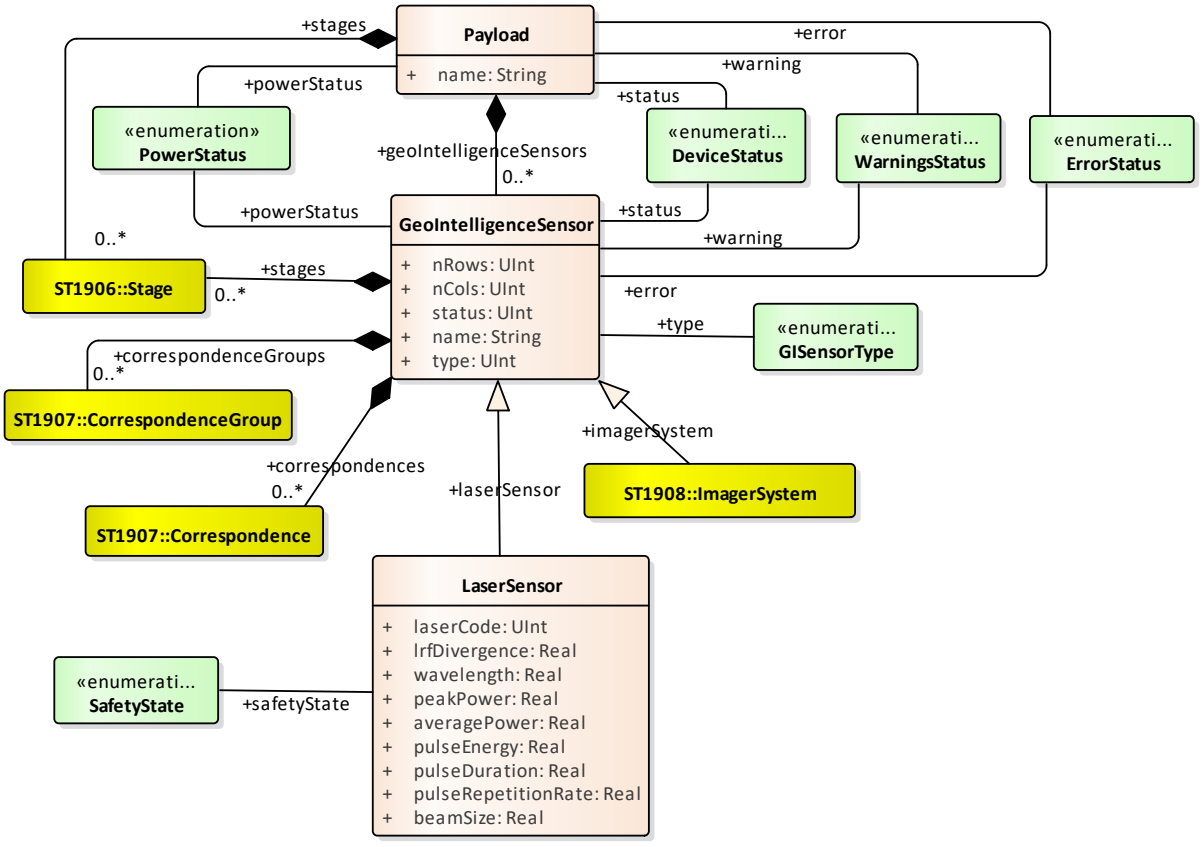

Figure 7: Payload Class Model

Per discussion in MISB ST 1901, MIMD classes support the Report-On-Change (reference the Motion Imagery Handbook) and include MIMD Base Attributes (MISB ST 1904 [5]), which use attribute identifiers 1-32.

7.1 Payload Class

Table 1 lists the attributes for the Payload class.

Table 1: Payload Class Attributes

Id	Name	Type	Min	Max	Res	MLen	Units	Ref
33	status	DeviceStatus	N/A	N/A	N/A	N/A	None	7.1.1
34	powerStatus	PowerStatus	N/A	N/A	N/A	N/A	None	7.1.2
35	name	String	N/A	N/A	N/A	100	None	7.1.3
36	stages	LIST<Stage>	--	--	N/A	N/A	None	7.1.4
37	geoIntelligenceSensors	LIST<GeoIntelligenceSensor>	--	--	N/A	N/A	None	7.1.5
38	warning	DeviceWarning	N/A	N/A	N/A	N/A	None	7.1.6
39	error	DeviceError	N/A	N/A	N/A	N/A	None	7.1.7

7.1.1 Attribute 33 – status

This attribute is an enumeration. Section 8.1 defines the DeviceStatus enumeration.

7.1.2 Attribute 34 – powerStatus

This attribute is an enumeration. Section 8.2 defines the PowerStatus enumeration.

7.1.3 Attribute 35 – name

The *name* attribute is an identifier for the payload system. The procurement officer, vendor, or integrator defines the formatting of the name, which may include versioning information.

7.1.4 Attribute 36 – stages

This attribute is a list of Stage classes. MISB ST 1906 defines the Stage class.

The Payload Stage is the position and orientation of a Payload reference point. Geo-Intelligence Sensors may use the Payload reference point to describe their stage's position and orientation. MISB ST 1906 defines the Stage class and all its child classes.

7.1.5 Attribute 37 – geoIntelligenceSensors

This attribute is a list of GeoIntelligenceSensor classes. Section 7.2 defines the GeoIntelligenceSensor class.

7.1.6 Attribute 38 – warning

This attribute is an enumeration. Section 8.3 defines the DeviceWarning enumeration.

7.1.7 Attribute 39 – error

This attribute is an enumeration. Section 8.4 defines the DeviceError enumeration.

7.2 GeoIntelligenceSensor Class

Table 2 lists the attributes for the GeoIntelligenceSensor class.

Table 2: GeoIntelligenceSensor Class Attributes

Id	Name	Type	Min	Max	Res	MLen	Units	Ref
33	nCols	UInt	--	--	N/A	N/A	Columns	7.2.1
34	nRows	UInt	--	--	N/A	N/A	Rows	7.2.2
35	name	String	N/A	N/A	N/A	100	None	7.2.3
36	type	GISensorType	N/A	N/A	N/A	N/A	None	7.2.4
37	status	DeviceStatus	N/A	N/A	N/A	N/A	None	7.2.5
38	stages	LIST<Stage>	--	--	N/A	N/A	None	7.2.6
39	correspondences	LIST<Correspondence>	--	--	N/A	N/A	None	7.2.7
40	imagerSystem	ImagerSystem	N/A	N/A	N/A	N/A	None	7.2.8
41	laserSensor	LaserSensor	N/A	N/A	N/A	N/A	None	7.2.9
42	correspondenceGroups	LIST<CorrespondenceGroup>	--	--	N/A	N/A	None	7.2.10
43	warning	DeviceWarning	N/A	N/A	N/A	N/A	None	7.2.11
44	error	DeviceError	N/A	N/A	N/A	N/A	None	7.2.12

7.2.1 Attribute 33 – nCols

The *nCols* and *nRows* attributes specify the size of the sensor's output data in columns and rows. If both nCols and nRows are equal to one, the GeoIntelligenceSensor is a point source (e.g., LRF) sensor. If both are greater than one (1) the array is two-dimensional with the given nCols and nRow dimension sizes. If either attribute is one (1) and the other value is greater than one the array is a single dimension.

7.2.2 Attribute 34 – nRows

Refer to the description of attribute 33, *nCols*, for the details of this attribute.

7.2.3 Attribute 35 – name

The *name* attribute is a descriptive name of the payload defined by the producer. Examples are: "VIS Nose Camera", "ACME IR Model 456".

7.2.4 Attribute 36 – type

This attribute is an enumeration. Section 8.5 defines the GISensorType enumeration.

7.2.5 Attribute 37 – status

This attribute is an enumeration. Section 8.1 defines the DeviceStatus enumeration.

7.2.6 Attribute 38 – stages

This attribute is a list of Stage classes. MISB ST 1906 defines the Stage class.

The *stages* attribute defines the pointing vector of the GeoIntelligenceSensor using the definition and orientation of the GSCPO in Section 6.1.1. MISB ST 1906 defines the Stage class and all its child classes.

Requirement	
ST 1907-01	Where the GeoIntelligenceSensor Stage attribute list is set, the terminal stage shall match the definition and orientation of the GSCPO.

7.2.7 Attribute 39 – correspondences

This attribute is a list of Correspondence classes. Section 7.6 defines the Correspondence class.

7.2.8 Attribute 40 – ImagerSystem

This attribute is a specialization relationship to the GeoIntelligenceSensor class. MISB ST 1908 defines the ImagerSystem class.

7.2.9 Attribute 41 – laserSensor

This attribute is a specialization relationship to the GeoIntelligenceSensor class. Section 7.3 defines the LaserSensor class.

7.2.10 Attribute 42 – correspondenceGroups

This attribute is a list of CorrespondenceGroup classes. Section 7.4 defines the CorrespondenceGroup class.

7.2.11 Attribute 43 – warning

This attribute is an enumeration. Section 8.3 defines the DeviceWarning enumeration.

7.2.12 Attribute 44 – error

This attribute is an enumeration. Section 8.4 defines the DeviceError enumeration.

7.3 LaserSensor Class

Table 3 lists the attributes for the Laser Sensor class. The LaserSensor Class supports all potential Laser sensors including Laser Range Finders (LRF), Laser illuminators, and LIDAR sensors (future).

Table 3: LaserSensor Class Attributes (extends GeoIntelligenceSensor)

Id	Name	Type	Min	Max	Res	MLen	Units	Ref
33	laserCode	UInt	0	65 535	N/A	N/A	None	7.3.1
34	lrfDivergence	Real	0.0	785.0	0.1	N/A	mrad	7.3.2
35	wavelength	Real	0.0	1 000.0	0.001	N/A	µm	7.3.3
36	peakPower	Real	0.0	1 000.0	0.001	N/A	MW	7.3.4
37	averagePower	Real	0.0	1 000.0	0.001	N/A	KW	7.3.5
38	pulseEnergy	Real	0.0	1 000.0	0.001	N/A	J	7.3.6
39	pulseDuration	Real	0.0	100.0	1.00E -09	N/A	s	7.3.7
40	pulseRepetitionRate	Real	0.0	500 000.0	0.1	N/A	Hz	7.3.8
41	beamSize	Real	0.0	1.0	0.001	N/A	mm	7.3.9
42	safetyState	SafetyState	N/A	N/A	N/A	N/A	None	7.3.10

7.3.1 Attribute 33 – laserCode

The *laserCode* attribute is the same as the UAS Datalink LS Item 62, in MISB ST 0601 [6], which defines the Pulse Repetition Frequency (PRF) code.

7.3.2 Attribute 34 – lrfDivergence

The *lrfDivergence* is the Full Width at Half-Maximum (FWHM) angular measurement of the laser beam divergence.

7.3.3 Attribute 35 – wavelength

The *wavelength* attribute is the wavelength of the laser transmission.

7.3.4 Attribute 36 – peakPower

The *peak*P*ower* attribute is the instantaneous power at the laser sensor's output aperture. (e.g., 10 ns pulse at 10 mJ, peakPower = $\frac{10\ mJ}{10\ ns}$=1 MW)

7.3.5 Attribute 37 – averagePower

The *averagePower* attribute is the continuous power at the laser sensor's output aperture averaged over period of one second.

7.3.6 Attribute 38 – pulseEnergy

The *pulseEnergy* attribute is the power of a pulse.

7.3.7 Attribute 39 – pulseDuration

The *pulseDuration* attribute is length of time the laser is on during one pulse.

7.3.8 Attribute 40 – pulseRepetitionRate

The *pulseRepetitionRate* attribute defines the number of times the laser signal repeats per second.

7.3.9 Attribute 41 – beamSize

The *beamSize* attribute is the beam's diameter, at the exit aperture, where the power is at $1/e^2$ times the maximum power of the laser beam.

7.3.10 Attribute 42 – safetyState

This attribute is an enumeration. Section 8.6 defines the SafetyState enumeration.

7.4 CorrespondenceGroup Class

The CorrespondenceGroup class is a collection of related correspondence points, see Section 6.2.2 for background.

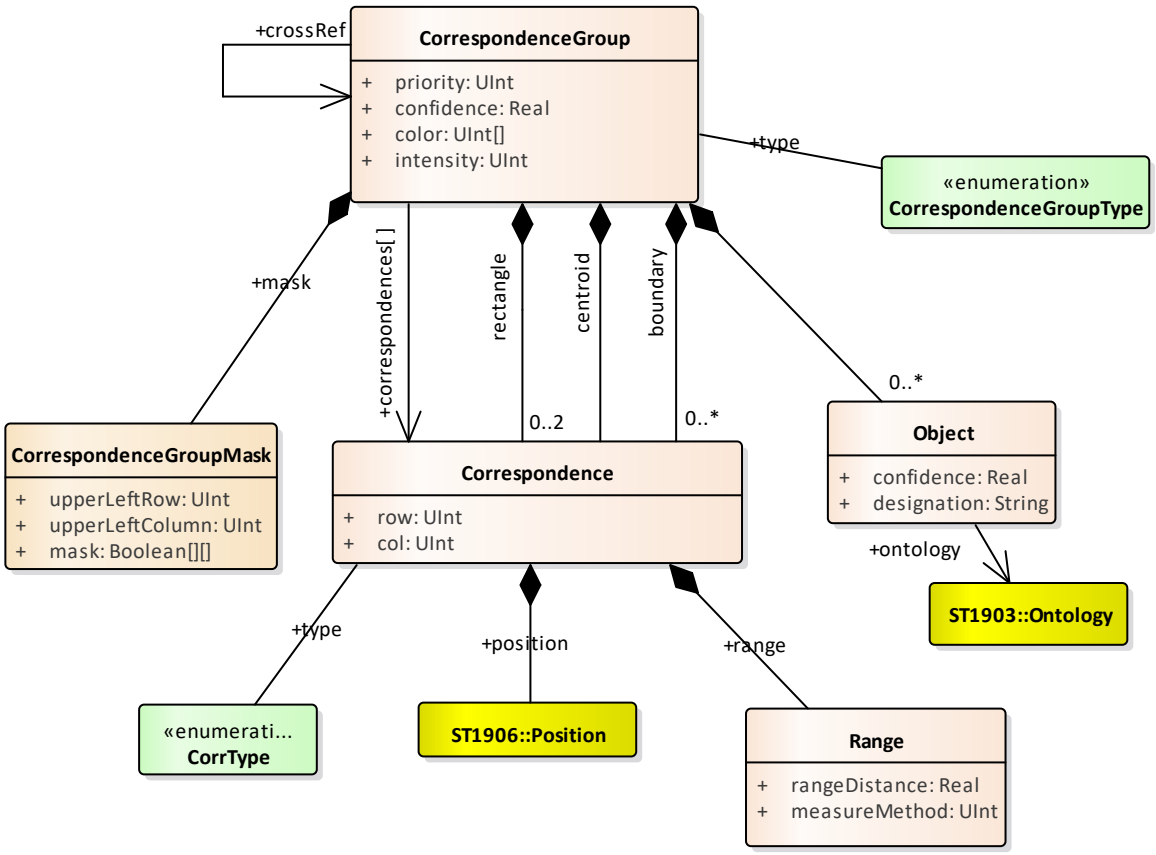

Figure 8: Correspondence Group Model

Table 4: CorrespondenceGroup Class Attributes

Id	Name	Type	Min	Max	Res	MLen	Units	Ref
33	priority	UInt	--	--	N/A	N/A	None	7.4.1
34	confidence	Real	0.0	100.0	0.1	N/A	%	7.4.2
35	color	UInt[]	--	--	N/A	N/A	None	7.4.3
36	crossRef	REF<CorrespondenceGroup>	N/A	N/A	N/A	N/A	None	7.4.4
37	type	CorrespondenceGroupType	N/A	N/A	N/A	N/A	None	7.4.5
38	object	REF<Object>	N/A	N/A	N/A	N/A	None	7.4.6
39	mask	CorrespondenceGroupMask	N/A	N/A	N/A	N/A	None	7.4.7
40	rectangle	LIST<Correspondence>	0	2	N/A	N/A	None	7.4.8
41	centroid	Correspondence	N/A	N/A	N/A	N/A	None	7.4.9
42	boundary	LIST<Correspondence>	--	--	N/A	N/A	None	7.4.10
43	algorithm	REF<Algorithm>	N/A	N/A	N/A	N/A	None	7.4.11
44	correspondences	REF<Correspondence>[]	N/A	N/A	N/A	N/A	None	7.4.12

7.4.1 Attribute 33 – priority

The *priority* attribute defines the priority of the CorrespondenceGroup, where 1 is the highest priority. Zero (0) represents an unknown priority and is the default value if the priority attribute is ROC_Unknown.

7.4.2 Attribute 34 – confidence

The *confidence* attribute is the measure of CorrespondenceGroup confidence. For systems which use algorithmic methods to define a group of Correspondence Points as an "object" the confidence value provides a means of labeling how confident the points are the correct points. A value of 0.0 is essentially no confidence and a value of 100.0 is the highest confidence.

7.4.3 Attribute 35 – color

The *color* attribute defines the representative "color" of the group of points. The color attribute is an array of UInt values, where each value represents a color band. For monochrome images (e.g., Infrared), there is only one band and one value. For color imagery, the color attribute uses three bands, with the first element being the red value, second the green value, and the third the blue value (i.e., RGB). Systems using additional bands increase the length of the color array. The color band wavelengths match the second dimension of the wavelengths attribute of the DetectorFilters class (see MISB ST 1908). The bitdepth attribute in the DetectorElement class (see MISB ST 1908) defines the range for the color measurements.

The method for determining the representative color is implementation dependent (e.g., average color of all points).

7.4.4 Attribute 36 – crossRef

This attribute is a directed association (or reference) to Class CorrespondenceGroup. Section 7.4 defines the CorrespondenceGroup class.

7.4.5 Attribute 37 – type

This attribute is an enumeration. Section 8.7 defines the CorrespondenceGroupType enumeration.

7.4.6 Attribute 38 – object

This attribute is a directed association (or reference) to Class Object. Section 7.8 defines the Object class.

7.4.7 Attribute 39 – mask

This attribute is a composite relationship to the Class CorrespondenceGroupMask. Section 7.5 defines the CorrespondenceGroupMask class.

The *mask* attribute provides a means to specify exact pixel locations that form the Correspondence Group.

7.4.8 Attribute 40 – rectangle

This attribute is a list of Correspondence classes. Section 7.6 defines the Correspondence class.

The *rectangle* attribute defines two corners of a Correspondence Group. When the correspondence points or mask attributes are set the rectangle is the bounding box of all points in the Correspondence Group. When the boundary attribute is set the bounding box contains all points within the boundary.

Requirement(s)	
ST 1907.1-02	Where the CorrespondenceGroup's *rectangle* attribute list is set, the list shall contain two correspondences defining a rectangle.
ST 1907.1-03	Where the CorrespondenceGroup's *rectangle* attribute list is set, the rectangle shall be a bounding rectangle of all data within the CorrespondenceGroup (i.e., boundary of attributes: mask, correspondences, boundary, and centroid.)

7.4.9 Attribute 41 – centroid

This attribute is a composite relationship to the Class Correspondence. Section 7.6 defines the Correspondence class.

The *centroid* attribute is the point within a group that represents the whole group. Typically, this value is at the center of the boundary polygon; however, this is not required.

7.4.10 Attribute 42 – boundary

This attribute is a list of Correspondence classes. Section 7.6 defines the Correspondence class.

The *boundary* attribute is a list of Correspondences that are the outer perimeter of the conceptual CorrespondenceGroup. If the correspondence points or mask attributes are set, the boundary

encompasses all the points in the Correspondence Group. If both correspondence points and mask are set, the boundary encompasses the union.

Requirement	
ST 1907.1-04	Where the CorrespondenceGroup's *boundary* attribute list is set, the list shall define a closed boundary of all data within the CorrespondenceGroup (i.e., boundary of attributes: mask, correspondences, and centroid.)

7.4.11 Attribute 43 – algorithm

This attribute is a directed association (or reference) to Class Algorithm. MISB ST 1903 defines the Algorithm class.

The *algorithm* attribute enables systems to state the algorithm that created the CorrespondenceGroup.

7.4.12 Attribute 44 – correspondences

This attribute is a directed association (or reference) to Class Correspondence. Section 7.6 defines the Correspondence class.

The *correspondences* attribute is an array of references to any of the GeoIntelligence classes correspondences list.

7.5 CorrespondenceGroupMask Class

The CorrespondenceGroupMask class defines a bit mask which identifies exact pixel locations to include in the Correspondence Group. The masking process first defines a set of pixels (e.g., an object) in an image, then computes a bounding box. The mask sets all the pixels-of-interest to true and all other pixels to false. Figure 9 illustrates the mask process with the pixels-of-interest being the vehicle (and its shadow). The masking algorithm computes the bounding box of the pixels-of-interest shown in red. The Image Chip is the same region enlarged for illustrative purposes. The Object Mask forms the mask array where its values are set to true for pixels-of-interest and false elsewhere. The Upper Left Corner row and column denote where, in the original image, the mask is located.

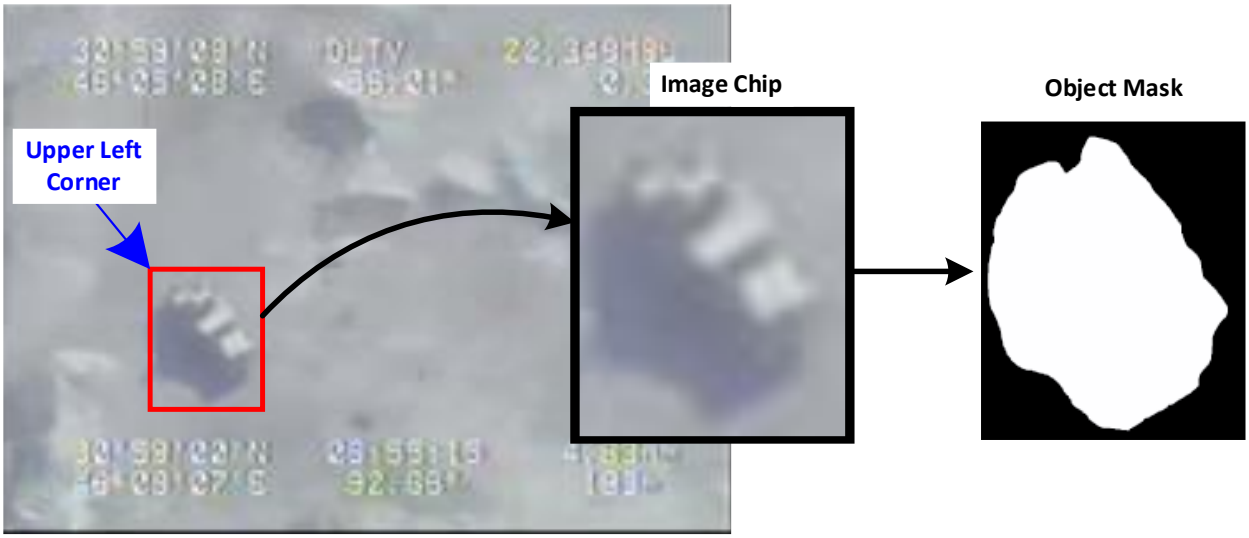

Figure 9:Illustration of Mask

Table 5: CorrespondenceGroupMask Class Attributes

Id	Name	Type	Min	Max	Res	MLen	Units	Ref
33	upperLeftRow	UInt	--	--	N/A	N/A	None	7.5.1
34	upperLeftCol	UInt	--	--	N/A	N/A	None	7.5.2
35	mask	Boolean[][]	N/A	N/A	N/A	N/A	None	7.5.3

7.5.1 Attribute 33 – upperLeftRow

The *upperLeftRow* and *upperLeftCol* attributes state where in the image the mask is located. The values are in the range from zero to the nRows-1 and zero to nCols-1 for upperLeftRow and upperLeftCol respectively; nRows and nCols are attributes of the GeoIntelligenceSensor class.

7.5.2 Attribute 34 – upperLeftCol

Please refer to the description of attribute 33, *upperLeftRow*, for information about this attribute.

7.5.3 Attribute 35 – mask

The *mask* attribute is an array depicting the points-of-interest in a raster format. A value of true indicates a point-of-interest and a value of false indicates the point is not a point-of-interest.

7.6 Correspondence Class

Table 6 lists the attributes for the Correspondence class.

Table 6: Correspondence Class Attributes

Id	Name	Type	Min	Max	Res	MLen	Units	Ref
33	col	Real	0.0	--	--	N/A	Columns	7.6.1
34	row	Real	0.0	--	--	N/A	Rows	7.6.2
35	type	CorrType	N/A	N/A	N/A	N/A	None	7.6.3
36	crossRef	REF<Correspondence>	N/A	N/A	N/A	N/A	None	7.6.4
37	position	Position	N/A	N/A	N/A	N/A	None	7.6.5
38	range	Range	N/A	N/A	N/A	N/A	None	7.6.6

7.6.1 Attribute 33 – col

The *col* and *row* attributes together specify the correspondence position in the sensor data.

7.6.2 Attribute 34 – row

Refer to the description of attribute 33, *col*, for the details of this attribute.

7.6.3 Attribute 35 – type

This attribute is an enumeration. Section 8.9 defines the CorrType enumeration.

The *type* attribute provides meaning to the correspondence point. With the addition of CorrespondenceGroup class most of the CorrType enumeration values have been removed; however, the type attribute is maintained for future use.

7.6.4 Attribute 36 – crossRef

This attribute is a directed association (or reference) to Class Correspondence. Section 7.6 defines the Correspondence class.

The *crossRef* attribute is an Inter-Correspondence reference (to another correspondence), see Section 6.1.1 for overview of Inter-Correspondences.

7.6.5 Attribute 37 – position

This attribute is a composite relationship to the Class Position. MISB ST 1906 defines the Position class.

7.6.6 Attribute 38 – range

This attribute is a composite relationship to the Class Range. Section 7.7 defines the Range class.

7.7 Range Class

Table 7 lists the attributes for the Range class.

Table 7: Range Class Attributes

Id	Name	Type	Min	Max	Res	MLen	Units	Ref
33	rangeDistance	Real	0.0	5 000 000.0	0.01	N/A	m	7.7.1
34	measureMethod	MeasureMethod	N/A	N/A	N/A	N/A	None	7.7.2

7.7.1 Attribute 33 – rangeDistance

The *rangeDistance* attribute is the reported distance from the geo-intelligence sensor's terminal stage origin to the target point.

7.7.2 Attribute 34 – measureMethod

This attribute is an enumeration. Section 8.10 defines the MeasureMethod enumeration.

The *measureMethod* attribute defines the method for determining the rangeDistance attribute.

7.8 Object Class

The Object class records the results of an object classification process.

Table 8: Object Class Attributes

Id	Name	Type	Min	Max	Res	MLen	Units	Ref
33	confidence	Real	0.0	100.0	0.1	N/A	%	7.8.1
34	ontology	REF<Ontology>	N/A	N/A	N/A	N/A	None	7.8.2
35	designation	String	N/A	N/A	N/A	100	None	7.8.3

7.8.1 Attribute 33 – confidence

The *confidence* attribute is the measure of object classification confidence. The confidence value provides a means of labeling how confident the classification method is that the object is the identified object. A value of 0.0 is essentially no confidence and a value of 100.0 is the highest confidence.

7.8.2 Attribute 34 – ontology

This attribute is a directed association (or reference) to Class Ontology. MISB ST 1903 defines the Ontology class.

7.8.3 Attribute 35 – designation

The *designation* attribute is the result of the object classification. This value uses the syntax defined by the ontology attribute. For example, "Dismount/Non-combatant/Female/Child".

7.9 Track Class

Figure 10 shows the UML model for the Track Class. The Track class "tracks" Correspondence Groups over time providing a track history.

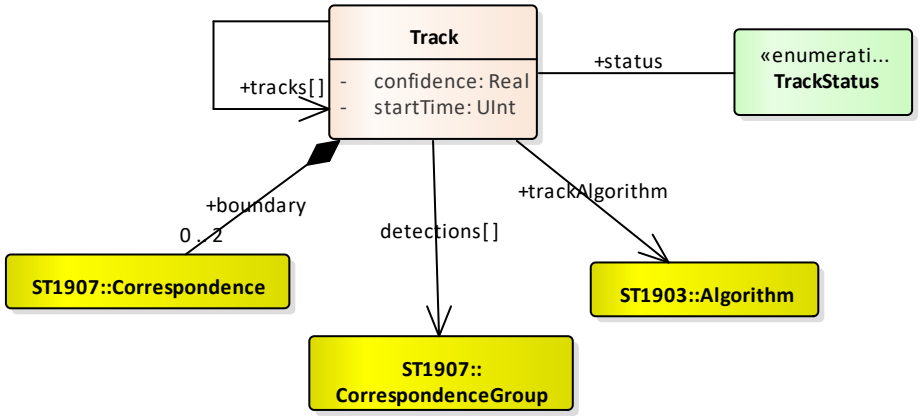

Figure 10: Track Class Model

Table 9 lists the Track class attributes.

Table 9: Track Class Attributes

Id	Name	Type	Min	Max	Res	MLen	Units	Ref
33	startTime	UInt	--	--	N/A	N/A	ns	7.9.1
34	confidence	Real	0.0	100.0	0.1	N/A	%	7.9.2
35	trackAlgorithm	REF<Algorithm>	N/A	N/A	N/A	N/A	None	7.9.3
36	boundary	LIST<Correspondence>	0	2	N/A	N/A	None	7.9.4
37	detections	REF<CorrespondenceGroup>[]	N/A	N/A	N/A	N/A	None	7.9.5
38	tracks	REF<Track>[]	N/A	N/A	N/A	N/A	None	7.9.6
39	status	TrackStatus	N/A	N/A	N/A	N/A	None	7.9.7

7.9.1 Attribute 33 – startTime

The *startTime* attribute is the time when the track starts. When tracking software first assigns a Correspondence Group to a track this time value is a copy of the time of the first Correspondence Group in the track with the base class's timerOffset correction applied. For the life of the Track the startTime does not change, i.e., it is the Track's time of birth (birthtime).

7.9.2 Attribute 34 – confidence

The *confidence* attribute is the measure of track confidence. A value of 0.0 is essentially no confidence and a value of 100.0 is the highest confidence.

7.9.3 Attribute 35 – trackAlgorithm

This attribute is a directed association (or reference) to Class Algorithm. MISB ST 1903 defines the Algorithm class.

The *trackAlgorithm* attribute is a reference to an algorithm in the Algorithm list of the MIMD class. The track algorithm is the name of the algorithm producing the track along with other algorithm information (e.g., version, parameters).

7.9.4 Attribute 36 – boundary

This attribute is a list of Correspondence classes. Section 7.6 defines the Correspondence class.

The *boundary* attribute is a list of correspondence points which bound the track over time. If an object is moving, every update to the track could expand the boundary of the track.

7.9.5 Attribute 37 – detections

This attribute is a directed association (or reference) to Class CorrespondenceGroup. Section 7.4 defines the CorrespondenceGroup class.

The *detections* attribute is a list of detections over time.

7.9.6 Attribute 38 – tracks

This attribute is a directed association (or reference) to Class Track. Section 7.9 defines the Track class.

The *tracks* attribute is an array of Track references that relate to the current Track instance. For example, a tracking system tracks a car for some time then loses the track, sometime later a new track is started for an object and the system determines the object is the same car. The original car track (or tracks) may be associated with the current track via the tracks attribute.

7.9.7 Attribute 39 – status

This attribute is an enumeration. Section 8.8 defines the TrackStatus enumeration.

8 Model Enumerations

8.1 DeviceStatus Enumeration

Table 10: Enumeration Values for DeviceStatus

Id	Name	Description
0	Nominal	The device is in a nominal state
1	Stowed	The device is oriented in a manner that protects it or is in another temporary non-functioning state

8.2 PowerStatus Enumeration

Table 11: Enumeration Values for PowerStatus

Id	Name	Description
0	Off	The device is powered off
1	On	The device is powered on

8.3 DeviceWarning Enumeration

Table 12: Enumeration Values for DeviceWarning

Id	Name	Description
0	Nominal	No Warnings
1	Unspecified_Warning	The device is reporting a warning with unknown meaning
2	Over_Temperature	The device is over its maximum temperature
3	Under_Temperature	The device is under its minimum specified temperature

8.4 DeviceError Enumeration

Table 13: Enumeration Values for DeviceError

Id	Name	Description
0	Nominal	No Errors
1	Unspecified_Error	The device is reporting an error with unspecified meaning
2	Over_Temperature	The device is over its maximum temperature
3	Under_Temperature	The device is under its minimum specified temperature
4	Stowage_Error	The device has a problem while trying to stow or unstow

8.5 GISensorType Enumeration

Table 14: Enumeration Values for GISensorType

Id	Name	Description
0	EO	Electro Optical Sensor
1	LIDAR	LIDAR Sensor
2	RADAR	RADAR Sensor
3	SIGINT	Signal Intelligence Sensor
4	SAR	Synthetic Aperture Radar Sensor

8.6 SafetyState Enumeration

Table 15: Enumeration Values for SafetyState

Id	Name	Description
0	Safe	Laser is set to not be able to fire
1	Armed	Laser is ready to fire
2	Firing	Laser is actively propagating energy
3	Inhibited	Laser is prevented from firing for safety or other reasons (e.g., over temp)

8.7 CorrespondenceGroupType Enumeration

Table 16: Enumeration Values for CorrespondenceGroupType

Id	Name	Description
1	Background	Background Object Group Type
2	MTI	Moving Target Indicator Group Type
3	Footprint	The CorrespondenceGroup defines the image footprint and image center point, may include the horizon line as needed.

8.7.1 Footprint Enumeration Value (Additional Information)

The Footprint type indicates the CorrespondenceGroup instance which defines the image footprint where the first point is the upper left corner, the second point is the upper right, the third corner is the lower right, and the fourth point is the lower left corner. Figure 11 shows two footprint examples, the example on the left shows a full image footprint with the corners labeled as the positions in the boundary list. The example on the right shows an image with a horizon line (in red), in this case the boundary list uses five points to describe the footprint of the image on the earth's surface.

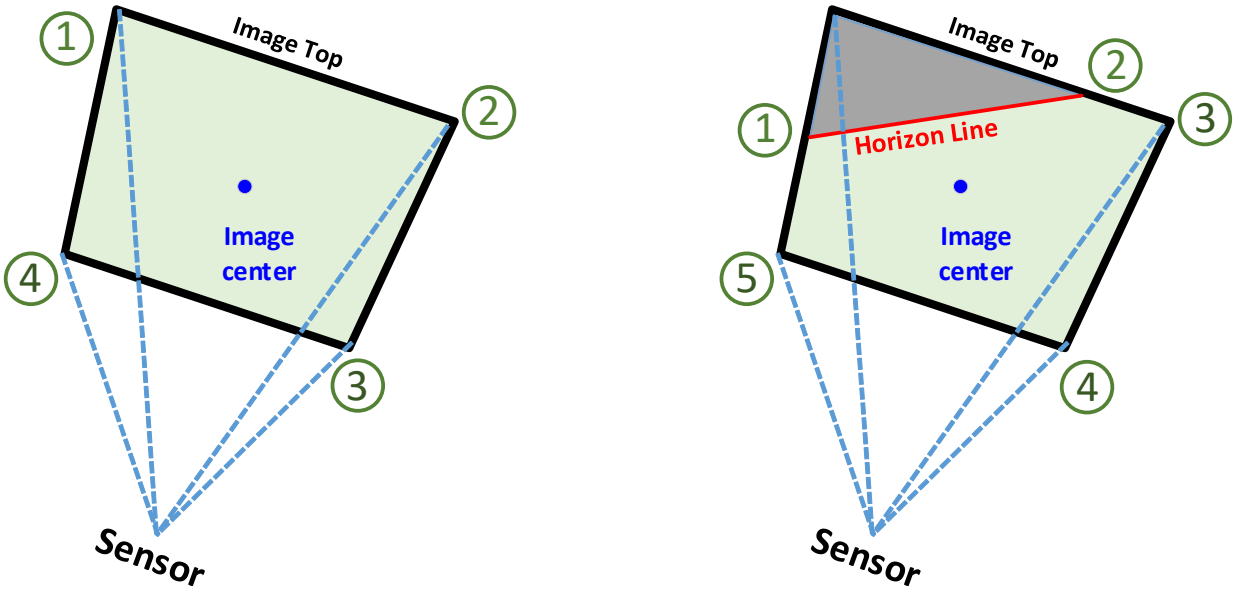

Figure 11: Footprint Examples

When a CorrespondenceGroup instance sets the type to the Footprint value, the centroid attribute defines the image center point. The Figure 11 examples both show the images' center points.

8.8 TrackStatus Enumeration

Table 17: Enumeration Values for TrackStatus

Id	Name	Description
1	Active	Target Track is active
2	InActive	Target track is not active
3	Dropped	Target no longer being tracked
4	Stopped	Target is not moving
5	Coast	Target lost but tracking on an estimated trajectory

8.9 CorrType Enumeration

The CorrType Enumeration provides additional information about the correspondence. With the addition of CorrespondenceGroup class most of the CorrType Enumeration values have been removed; however, the Enumeration is maintained for future use.

Table 18: Enumeration Values for CorrType

Id	Name	Description
0	General_Correspondence	Default value if not including type attribute in the Correspondence instance. If the type attribute is in the ROC_Unknown state, General Correspondence is assumed.

8.10 MeasureMethod Enumeration

Table 19: Enumeration Values for MeasureMethod

Id	Name	Description
0	Unknown	The method is not known. This is the default.
1	Measured	The range distance attribute's value is a measurement using a geo-intelligence sensor such as an LRF
2	Computed	The range distance attribute's value is the result of a computation