MOTION IMAGERY STANDARDS BOARD	MISB ST 0903.4
STANDARD	
Video Moving Target Indicator and Track Metadata	**23 October 2014**

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1 Scope

This Standard defines metadata Local Sets (LSs) used to deliver Video Moving Target[1] Indicator (VMTI) metadata[2] and related Track metadata in accordance with SMPTE ST 336:2007 [1], which defines the "Key-Length-Value" (KLV) encoding method.

This document also provides abstract data models for the Motion Imagery VMTI and Track metadata (see Appendices). These data models, which are defined using the Unified Modeling Language (UML), are provided in anticipation of defining future additional encoding methods, such as, Extensible Markup Language (XML). Definition of an abstract data model provides a consistent, common specification, regardless of the encoding method used. However, the KLV encoding specified herein is currently the normative definition for this Standard.

This document also describes the relationship between this Standard and other relevant Standards, and provides implementation guidance.

The intent is to provide VMTI and Track metadata to downstream clients for the purpose of populating Situational Awareness products and Common Operating Pictures, for generating VMTI and Track overlays on Motion Imagery players, and for providing input to tracking and data fusion systems (e.g., NATO STANAG 4676 ISR Tracking [18] compliant systems). In the interests of data efficiency, these LSs only include elements relevant to VMTI and Tracks not available in any other Universal or Local Sets. For example, it does not include the sensor model parameters detailed in MISB ST 0601 UAS Datalink Local Set [2] (henceforth, "MISB ST 0601").

2 References

This Standard references the following standards and documents:

2.1 Normative References

The following references and the references contained therein are normative.

[1] SMPTE ST 336:2007 Data Encoding Protocol Using Key-Length-Value
[2] MISB ST 0601.8, UAS Datalink Local set, Oct 2014
[3] SMPTE ST 335:2001 Television - Metadata Dictionary Structure
[4] MISB ST 1204.1 Motion Imagery Identification System, Oct 2013
[5] MISB ST 1201.1 Floating Point to Integer Mapping, Feb 2014
[6] MISB ST 0107.2 Bit and Byte Order for Metadata in Motion Imagery Files and Streams, Feb 2014
[7] MISB RP 0701 Common Metadata System: Structure, Aug 2007
[8] W3C Recommendation, Web Ontology Language OWL, Feb 10 2004
[9] ISO 19156:2011 Geographical Information - Observations and Measurements (O&M)

[1] The term "target", rather than "object", is used for a mode of radar operation that discriminates a "target" from its background. Commonly, radar Doppler shift is used to detect moving objects, resulting in "moving target indications", MTI. In this context, "target" has become widely adopted and is used here for consistency.

[2] VMTI metadata is analogous to, but distinct from, NATO STANAG 4607 radar-derived Ground Moving Target Indicator (GMTI) metadata. VMTI metadata contains elements to describe imagery-derived characteristics (e.g. color, shape, features, and unique identity) for which STANAG 4607 GMTI has no counterpart.

[10] ISO/IEC 9834-8:2005 Generation and registration of Universally Unique Identifiers (UUIDs) and their use as ASN.1 Object Identifier components
[11] IETF RFC 3986 Uniform Resource Identifier (URI): Generic Syntax, Jan 2005
[12] MISB ST 0603.2, Common Time Reference for Digital Motion Imagery Using Coordinated Universal Time (UTC), Feb 2014
[13] DMA TM8358.1: Datums, Ellipsoids, Grids, and Grid Reference Systems, 20 Sep 1990
[14] MISB ST 0807.14, KLV Metadata Dictionary, Oct 2014
[15] SMPTE RP 210v13:2012 Metadata Dictionary Registry of Metadata Element Descriptions
[16] ISO/IEC 10646:2014 Information Technology – Universal Coded Character Set (UCS)

2.2 Informative References

[17] MISB TRM 1006, Key-Length-value (KLV) User's Guide
[18] STANAG 4676 NATO Intelligence, Surveillance and Reconnaissance Tracking Standard, EDITION 1 (DRAFT), August 2011
[19] Allied Engineering Documentation Publication AEDP-12 NATO Intelligence, Surveillance and Reconnaissance (ISR) Tracking Standard (NITS) STANAG 4676 Implementation Guide, Edition 1 (DRAFT), October 2011
[20] MISP 2015.1: Motion Imagery Handbook, Oct 2014

3 Modifications and Changes

Date	Change Summary
Jul 2014	1. **Major Change**: Key for Checksum was incorrect; Byte 5 was "04" and should be "01". 2. The document has been significantly reorganized. 3. A number of clarifications have been added. 4. **Major Change**: The method for mapping floating point values to integer values has been changed to comply with MISB ST 1201 Floating Point to Integer Mapping (IMAPB, in particular). This change is not backward compatible. 5. Tag inconsistencies for VObject, VFeature, VTracker, and VChip were corrected. 6. A VChipSeries Variable-Length Pack has been added to the VTarget Pack and the VTrackItem Pack to permit inclusion of more than one image chip for a target. 7. The VChip media type was updated from "MIME image type" to "image media subtype" to be consistent with IANA (Internet Assigned Numbers Authority) media terminology. 8. Clarification: The VChip Local Set Tag 1 Image Type may carry forward over subsequent VChip instances. It need not be specified in every VChip LS. 9. Clarification: The VObject Local Set Tag 1 Ontology may carry forward over subsequent VObject instances. It need not be specified in every VObject LS. 10. Clarification: The VFeature Local Set Tag 1 Schema may carry forward over subsequent VFeature instances. It need not be specified in every VFeature LS. 11. Clarification: Conditions regarding use of the VMTI Local Set Tag 8 Frame Width have been clarified. 12. Acceleration units in the Acceleration Pack were corrected to meters per second squared. 13. Clarification: The terminology used to specify character encoding was made consistent and now specifies compliance with UTF-8.

Date	Change Summary
	14. The WAMI FPA Index has been changed from a Pack with Tags to a Defined-Length Pack and has been renamed simply “FPA Index”. 15. VTrack Local Set Tag 13 Number of Track Items has been renamed Number of Track Points, to be consistent with the VTracker Local Set. 16. The VTracker Local Set Tag 1 Target ID has been renamed Track ID, to be consistent with the VTrack Local Set. 17. Clarification: The conditions under which a Precision Time Stamp should appear in the VMTI Local Set have been clarified. 18. Clarification: The conditions under which a Checksum must appear in the VMTI Local Set have been clarified. 19. The encoded type of VTarget Local Set Tag 8 Color has been changed from “3-byte unsigned integer” to “24-bit RGB color”. 20. To be consistent with the Velocity and Acceleration Packs, the Location Pack has been changed such that the specified location defines the origin of a local tangential East-North-Up (ENU) coordinate system, allowing standard deviations to be expressed in meters with respect to the ENU coordinate axes. A new key has been defined for the Location Pack. 21. To reduce ambiguity, the Location, Velocity, and Acceleration Packs have been changed to use East, North, and Up in place of X, Y, and Z and to be based upon the ENU coordinate system of an associated Location Pack. New Keys have been defined for the Velocity and Acceleration Packs. 22. Corrected several Keys that contained improper values for Byte 6. 23. Corrected several Key value mismatches. 24. Added missing definition tables to Appendix A for VTarget Pack elements Target Centroid Pixel Row and Target Centroid Pixel Column. 25. Clarified the difference between VTrack Local Set elements Track Time Stamp Tag 2 and Track End Time Tag 6. 26. Eliminated the requirement to report VTrackItem Pack elements Target ID Number, Target Time Stamp, and Target Location for a VTrack report when Track Status is “Dropped”. 27. Added a requirement to treat the first vertex of the VMask Local Set Polygon as the last vertex, as well, to close the polygon. 28. Clarification: Added a description of variable length unsigned integer encoding. 29. The limit on the maximum number of vertices in a Boundary Series has been removed. 30. The ordering of the vertices in a Boundary Series has been relaxed. 31. New keys defined for Ontology and Schema.

4 Glossary of Acronyms

BER	Basic Encoding Rules
DMA	Defense Mapping Agency (now National Geospatial-Intelligence Agency)
EO	Electro-Optic
EON	Electro-Optic Narrow
EOW	Electro-Optic Wide
FOV	Field of View
FPA	Focal Plane Array
FPS	Frames per second
GML	Geography Markup Language
HFOV	Horizontal Field of View
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
KLV	Key-Length-Value
LS	Local Set
LVMI	Large Volume Motion Imagery
MISB	Motion Imagery Standards Board
OGC	Open Geospatial Consortium
RTP	Real Time Protocol
SMPTE	Society of Motion Picture and Television Engineers
TLV	Tag, Length, Value
TRM	Technical Reference Material
TS	MPEG-2 Transport Stream
UAS	Unmanned Aerial / Airborne System
UAV	Unmanned Aerial / Airborne Vehicle
UINT	Unsigned Integer
UML	Unified Modeling Language
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
UTC	Coordinate Universal Time
VFOV	Vertical Field of View
VMTI	Video Moving Target Indicator

5 Definitions

frame A two-dimensional array of regularly spaced Pixels in the shape of a rectangle indexed by rows (a.k.a. lines) and columns (a.k.a. samples) along with a Start Time and an End Time for each Pixel (see Motion Imagery Handbook [20]).

frame number A unique number assigned to a Motion Imagery frame typically beginning at one (1) and incrementing by one for each successive frame in order.

6 Introduction

Moving object detections and tracks may be indicators of nefarious activities. As such they represent a source of "geospatial transaction" that can provide a rich source of intelligence for unraveling adversary activities and networks. With increasing appreciation of the importance of tracks and associated indicators of motion, standardized methods to describe and disseminate this type of information enables sharing and reuse in the course of a mission, thereby amplifying ongoing intelligence analysis.

This document defines a metadata standard for tracks and associated indicators of motion for Motion Imagery. It specifies the constructs for reporting the motions of entities, the history of their motions, and the types of the entities being reported. In addition, it provides methods to disseminate the evidential support for inferred movements, tracks, and the characteristics of entities observed in Motion Imagery. As such, the standard is designed to support a stand-alone role in Motion Imagery-based analytics, as well as a cooperative, conjunctive analytics role with other sensor modalities and multi-source methodologies.

MISB ST 0601 [2] defines platform and sensor Metadata elements and their encoding for use within Motion Imagery systems, which is leveraged in the generation of metadata defined in this standard.

This standard defines Local Sets for VMTI and Track Metadata. These Local Sets may be embedded within a MISB ST 0601 LS, or they may stand alone. The latter permits VMTI and Track Metadata to be provided independent of Motion Imagery essence. This is useful in constrained bandwidth environments, where the Motion Imagery may be omitted in favor of the VMTI data.

Finally, the MISB uses the term “Motion Imagery” rather than “Video” as Motion Imagery has stricter criteria, such as providing intelligence information. Please refer to [20] where the differences are discussed. Because this document has become known as the “VMTI or Video Moving Target Indicator standard” this designation is continued.

7 Operational Considerations

The VMTI LS is designed to support a wide gamut of systems ranging from those producing thousands of moving targets to those producing great detail about a small number of targets. The LS is designed to be bandwidth efficient. Information that can readily be calculated, derived, or associated using available information is not included.

The Track LS (VTrack) shares similar design characteristics.

8 Common Data Requirements

This section describes the data constructs and lists requirements that apply for the encoding of data used in this standard.

8.1 KLV and Data Types

MISB ST 0903 is based upon the Key-Length-Value (KLV) construct. Readers unfamiliar with KLV are encouraged to review MISB TRM 1006 Key-Length-Value (KLV) Users Guide [17], which provides a succinct description of KLV principles.

The KLV coding of data items and groups of data items is defined in SMPTE ST 336 [1], which requires that each data element is registered in a Metadata Dictionary. The structure of the Metadata Dictionary, defined in SMPTE ST 335 [3] includes the requirement for a Type entry for each data element. In most cases, these are primitive types, such as, integer or string.

However, SMPTE provides for more common complex types and allows for the definition of additional complex types.[3] Complex types must have an assigned 16-byte Universal Label (UL) and be registered in a Types Dictionary. MISB ST 0903 takes advantage of this capability to define some complex structures that are used in VMTI, as well as other community data models.

NOTE

Although SMPTE convention requires every KLV data element to be registered in a Metadata Dictionary with an assigned 16-byte Universal Label (the Key), MISB ST 0903 (and other MISB standards) sometimes define metadata elements that are specializations of data elements recorded in the Key registry. In effect, the MISB treats such registered data elements as type definitions.

For example, MISB ST 0903 uses the registered Precision Time Stamp element with Key 06.0E.2B.34.01.01.01.03.07.02.01.01.01.05.00.00 in the stead of any particularly named time stamp, such as Start Time Stamp or End Time Stamp, even within the same Local Set or Pack.

The effect of this implementation precludes transforming a collection of nested Local Sets and Packs into a SMPTE Universal Set. However, since the motivation for using KLV to encode data is generally reduction in data volume, this mapping or "flattening" does not occur in practice, because the resulting Universal Set would become bloated by the 16-byte Keys.

8.2 Floating Point Values

Data values for many elements are represented in floating point. Oftentimes, values do not fully utilize the floating point range or precision afforded, and thus, there is opportunity when transmitting the values between systems to reduce the number of bytes that represent the data. MISB ST 1201 [5] specifies an algorithm for converting IEEE 754 floating point values (all precisions, i.e. 16, 32, 64 and 128 bit), including the IEEE special values of infinity and NaN, to an unsigned integer representation.

MISB ST 0903 employs the ST 1201 mapping. The mapping is specified using the notation IMAPB(*min*, *max*, *len*), where *min* is the smallest floating point value in the range, *max* is the largest floating point value in the range, and *len* is the number of bytes to be used for the unsigned integer representation. For example, IMAPB(-200, 3000, 3) specifies that a floating point value in the range from -200 to 3000, inclusive, is mapped to a 3-byte integer value.

8.3 Variable Length Values

Another technique employed by MISB ST 0903 to reduce the number of bytes for data representation is variable length value encoding for unsigned integers. This approach uses the fewest bytes necessary to represent a given value. MISB ST 0903 specifies a nominal maximum number of bytes for a metadata element with an unsigned integer value, large enough to express the maximum value. However, since leading zeroes are not significant, MISB ST 0903 allows smaller values to be expressed using fewer bytes. For example, although the value 255 can be

[3] Common complex types include Universal Sets, Global Sets, Local Sets, Variable-Length Packs, Defined-Length Packs (formerly called Fixed Length Packs), Truncation Packs, and Floating Length Packs. These are defined in MISB RP 0701 [6].

represented by the four-byte value 0x000000FF, it can also be represented using a single byte, namely 0xFF.

The notation used to indicate variable-length encoding is "V*max*", where *max* is the maximum number of bytes to be used. For example, "V4" indicates variable-length encoding using a minimum of one byte to a maximum of four bytes.

Consider VTarget Pack Tag 1 (Target Centroid Pixel Number). This element is defined to be an unsigned integer value with variable length up to 6 bytes, "V6". The Tag-Length-Value (TLV) encoding for a centroid pixel number value of 200 is {[0x01] [0x01] [0xC8]}. The TLV encoding for a centroid pixel number value of 123456 is {[0x01] [0x03] [0x01 E2 40]}.

8.4 Requirements

The following requirements apply to all data constructs used in ST 0903.

Requirement(s)	
ST 0903.4-01	All metadata shall be expressed in accordance with MISB ST 0107 [6].
ST 0903.4-02	All data encoded using the Key-Length-Value (KLV) encoding protocol shall comply with SMPTE ST 336[1].
ST 0903.4-03	Floating point to integer mappings shall comply with MISB ST 1201 [5].
ST 0903.4-04	The number of bytes used to encode a variable-length unsigned integer value shall be less than or equal to the specified maximum length.
ST 0903.4-05	The number of bytes used to encode the value zero for a variable-length unsigned integer value shall be one (1).

9 VMTI Local Set (LS)

Tables that summarize the VMTI LS elements appear in this section. It is recommended to review the information in the tables before the detailed descriptions. A quick look at the Tag Name column will provide an excellent overview of the VMTI LS.

Appendix A contains a more detailed, structured, descriptive table for each element. The Data Element Definition section of the table provides a "computer science" view of the data element; it captures the information needed by a system implementer to use the data element. A KLV encoding section addresses the representation of the data element in KLV and the rules for encoding and decoding the element.

9.1 VMTI LS Structure

The base structure of the VMTI data system is the VMTI LS, which contains the core information applicable to all reported phenomena within a Motion Imagery frame. Appendix B provides an informative model that depicts the VMTI data construct. In addition to the typical KLV and Tag-Length-Value (TLV) constructs complex structures of Packs and Series are also used. The description of these complex types precedes their use in this document.

For bandwidth efficiency, the VMTI LS contains several data elements expressed as offsets from the frame center geographic coordinate provided in MISB ST 0601. Thus, the VMTI LS is generally subordinate to a MISB ST 0601 LS, and Tag 74 in MISB ST 0601 has been assigned to the VMTI LS. However, the VMTI LS also contains corresponding data elements expressed in absolute geographic coordinates, allowing the VMTI LS to be independent (i.e. standalone) of MISB ST 0601. Geographic coordinates in the VTrack LS are absolute, so the VTrack LS is always independent of MISB ST 0601.

The VMTI LS makes use of a subordinate VTargetSeries (a complex KLV construct) that, in itself, contains one or more VTarget Packs which, in turn, may make use of subordinate Local Sets arranged in a hierarchy as shown in Figure 1.

VMTI Local Set (LS) Structure		
KLV/TLV elements		
VTargetSeries		
VTarget Pack$_1$	• • •	VTarget Pack$_N$
VMask LS		VMask LS
VObject LS		VObject LS
VFeature LS		VFeature LS
VTracker LS		VTracker LS
VChip LS		VChip LS
VChipSeries[4]		VChipSeries

Figure 1. VMTI Local Set Structure

VTargetSeries is of type Series.[5] The Series type is a one-dimensional array of data elements, all of the same type, encoded as a SMPTE Variable-Length Pack, as shown in Figure 2. In a Series, the element type is known, the size of each element can be determined prior to parsing and the number of elements is determined as the data is parsed.

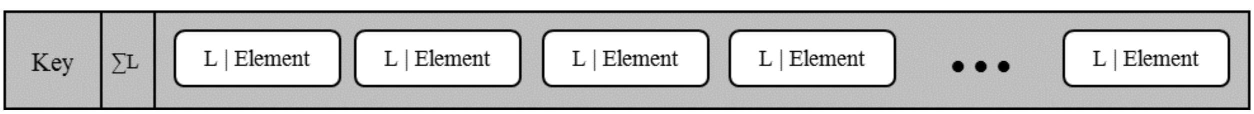

Figure 2. Series Type

	Requirement(s)
ST 0903.4-06	The Series type shall be a one-dimensional array of data elements, all of the same type, encoded as a SMPTE Variable-Length Pack.
ST 0903.4-07	VTargetSeries shall be a Series of VTarget Packs.
ST 0903.4-08	Each VTarget Pack in a VTargetSeries shall contain metadata for a single target.

As shown in Figure 3, the VTargetSeries contains one or more VTarget[6] Packs. A VTarget Pack contains target unique information. The metadata associated with individual targets is delivered

[4] Although permissible, it would be unusual to include both a VChip LS and a VChipSeries in a single VTarget Pack.

[5] No key is required. Each element, a VTarget Pack, consists of only a BER-encoded Length and a Value, which contains metadata elements describing a target.

[6] It is assumed that the LS or Pack name is unique at all levels; therefore, references are to VTarget Pack rather than VMTI. VTarget Pack.

using VTarget Packs (one for each target). The value field of each VTarget pack is preceded by the short or long BER-encoding of its length. The first, mandatory, element in the value field of each VTarget Pack is a BER-OID encoded value to convey the Target ID Number of the target. The following elements form an LS-like structure containing one or more Tag-Length-Value (TLV) triplets that convey information about the target. No particular TLV triplet is mandatory, but at least one must be present.

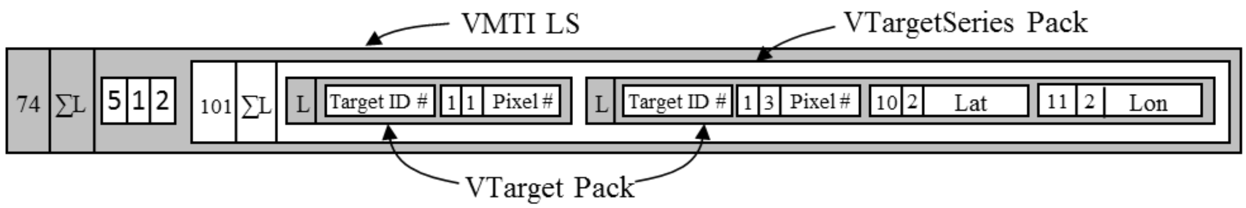

Figure 3. VMTI Local Set VTargetSeries Example

Requirement(s)	
ST 0903.4-09	The first element in the value field of a VTarget Pack shall be a BER-OID-encoded value that represents the Target ID Number of a target.
ST 0903.4-10	At least one Tag-Length-Value (TLV) triplet shall follow the Target ID Number value.
ST 0903.4-11	All elements of a VTarget Pack, other than the first, shall be TLV encoded.
ST 0903.4-12	The Length field of each VTarget pack shall be short or long BER-encoded.

Note that the VTarget Pack is unusual in that the first element of the value field must be the BER-OID encoded Target ID Number, without a Tag or a Length, yet the remaining elements adhere to the more conventional TLV structure, with a Tag and a Length. Since the Target ID Number must always be specified, whereas other elements are optional, this construct has been adopted as a bandwidth saving measure. In the simplest case, a VTarget Pack can consist of just the Target ID Number and the Target Centroid Pixel Number.

The TLV triplets may refer to subordinate nested data structures. These include the VMask, VObject, VFeature, VTracker, and VChip Local Sets and the VChipSeries.

In the VMTI LS packet example shown in Figure 4, the packet begins with a Tag of value 74. This signals the presence of a VMTI LS within a MISB ST 0601 UAS Datalink LS (the ST 0601 LS itself is not shown in the diagram.) The Tag is followed by a Length value, which is the sum of the lengths of all the TLV elements in the VMTI LS; this sum includes the bytes used for the Tag and Length fields of subordinate elements. In this example, the VMTI LS contains (among others) Tag 5 (which specifies the Total Number of Targets Detected in the Motion Imagery frame), and Tag 101 indicating a VTargetSeries Pack. The VTargetSeries Pack contains two VTarget Packs (indicated in green). The Value portion of the first VTarget Pack in turn consists of a BER-OID encoded Target ID Number, a Target Centroid Pixel Number element (Tag 1, Length = 2), a Target Color (Tag 8, Length = 3), and a Target Priority (Tag 4, Length = 1). The Value portion of the second VTarget Pack is similar, except in addition to a Target Centroid

Pixel Number it contains Target Location Latitude Offset and Target Location Longitude Offset elements (Tags 10 and 11). (For purposes of illustration, the Target ID Numbers are assumed each to require just a single byte.)

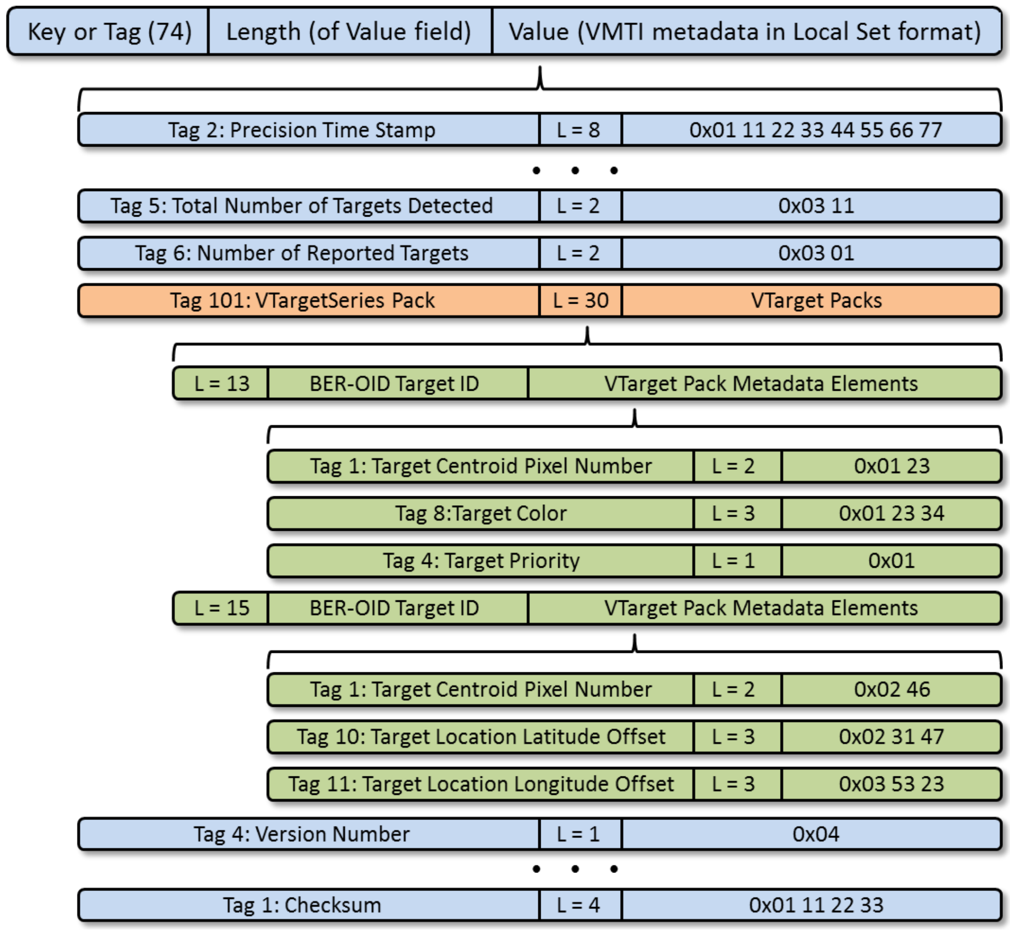

Figure 4. VMTI Local Set Example

9.2 Time Stamping

The VMTI LS Precision Time Stamp (VMTI LS Tag 2) is used to correlate metadata with Motion Imagery frames. MISB ST 0603 [12] defines a Precision Time Stamp referenced to Coordinated Universal Time (UTC), and is intended to represent the time of birth of the metadata within a LS packet. An example of an LS packet containing a Precision Time Stamp is shown in Figure 5.

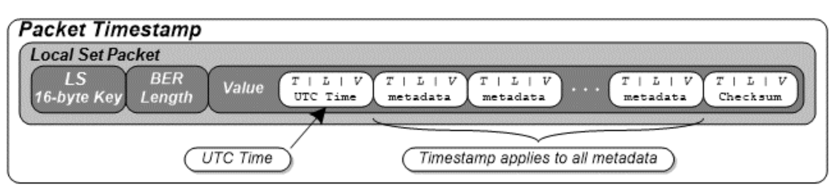

Figure 5. Packet Time Stamp Example

Within a VMTI LS, the Precision Time Stamp can be used to associate the metadata with a particular Motion Imagery frame.

If the VMTI LS is subordinate to a MISB ST 0601 LS under Tag 74, a Precision Time Stamp will already be present in the MISB ST 0601 LS. In this case, the VMTI LS Precision Time Stamp is optional in the VMTI LS, although it is still recommended. If a Precision Time Stamp is included in the VMTI LS, it is to be inserted at the beginning of the value portion of a VMTI LS.

While any combination of metadata items can be included in a VMTI Local Set and most items arranged in any order, the Precision Time Stamp, if present, must come first.

Requirement(s)	
ST 0903.4-13	When a Precision Time Stamp (Tag 2) is included in a VMTI LS, it shall comply with MISB ST 0603 [12].
ST 0903.4-14	When a Precision Time Stamp (Tag 2) is included in a VMTI LS, it shall be the first TLV triplet in the VMTI LS.

Some VMTI systems may not have access to a time reference; this is why the Precision Time Stamp is not mandatory. Data from such systems is still considered useful, however, even if only aligned with the Motion Imagery by time of arrival.

In the absence of a Precision Time Stamp, the VMTI system should use the source (sensor) frame number to populate the Motion Imagery Frame Number metadata element. When recording the frame number it is important to account for timing differences in the sensor/compression signal path. The frame number at the sensor and the frame number after compression may be different.

9.3 Checksum – Error Detection

A 16-bit Checksum (VMTI LS Tag 1) helps prevent erroneous metadata from being processed. The Checksum is a running 16-bit summation through the entire LS packet, starting with the 16-byte Local Set Key and ending with the Length field of the Checksum data item. The checksum, when provided, must always be the last element in the VMTI LS. Figure 6 shows the data range to which the Checksum applies.

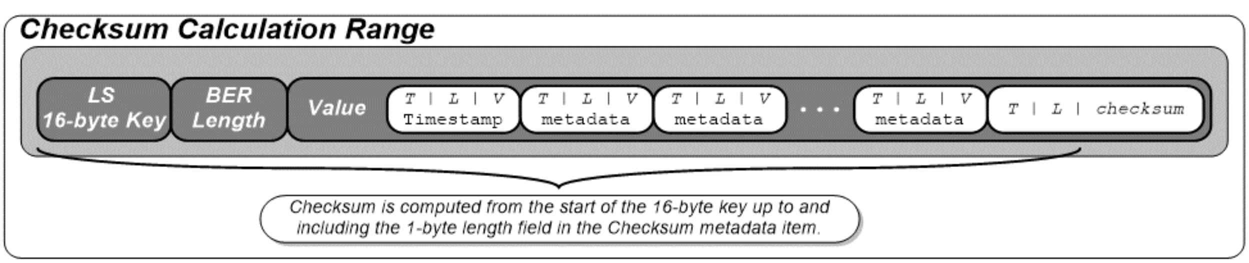

Figure 6. Example Checksum Computation Range for a Standalone VMTI LS

Requirement(s)	
ST 0903.4-15	When the VMTI LS is not embedded within a ST 0601 LS (i.e. standalone), the VMTI LS shall contain a Checksum (Tag 1).
ST 0903.4-16	The VMTI LS Checksum (Tag 1) shall be a 16-bit sum of all bytes in the VMTI LS, starting with the first byte of the 16-byte Local Set Key, up to and including the last byte of the Length field of the Checksum element itself.
ST 0903.4-17	When a Checksum (Tag 1) is included in a VMTI LS it shall be the last TLV triplet in the VMTI LS.

9.4 VMTI LS Elements

Table 1: VMTI LS

VMTI Local Set							
Tag ID	Key Value (hex)	Tag Name*	Data Type	Units	KLV Format	Length in Bytes	Notes
	06.0E.2B.34.02.0B.01.01 0E.01.03.03.06.00.00.00 (CRC 51307)	VMTI KLV Dictionary	N/A	None	N/A	Variable	This is the Universal Key for the VMTI LS
1	06.0E.2B.34.01.01.01.01 0E.01.02.03.01.00.00.00 (CRC 56132)	Checksum	Unsigned Integer	None	Uint16	F2	Checksum used to detect errors within a VMTI LS packet. Lower 16-bits of summation. Performed on entire VMTI LS packet, including 16-byte US key and 1-byte checksum length.
2	06.0E.2B.34.01.01.01.03 07.02.01.01.01.05.00.00 (CRC 64827)	Precision Time Stamp (POSIX Microseconds)	Unsigned Long	Micro-seconds	Uint64	F8	Microseconds elapsed since midnight (00:00:00 UTC), January 1, 1970 (the UNIX Epoch). Reference MISB ST 0603 [12].
3	06.0E.2B.34.01.01.01.01 0E.01.02.02.7C.00.00.00 (CRC 2790)	VMTI System Name / Description	String	String	UTF-8	V32	Text string to allow the inclusion of the name and/or description of the VMTI system.
4	06.0E.2B.34.01.01.01.01 0E.01.02.05.04.00.00.00 (CRC 43652)	VMTI LS Version Number	Unsigned Integer	None	Uint16	V2	Version number of the VMTI LS document used to generate the VMTI metadata. 0 is pre-release, initial release (090x.0), or test data. 1...65535 corresponds to document revisions 1 through 65535.
5	06.0E.2B.34.01.01.01.01 0E.01.02.03.36.00.00.00 (CRC 42624)	Total Number of Targets Detected in the Frame	Unsigned Integer	None	Uint24	V3	The total number of targets detected in the frame. Range 1 to 16,777,215. 0 represents no targets detected – also implied by no value at all and VMTI LS is superfluous and should be discarded. 16,777,215 represents 16,777,215 or more detections.
6	06.0E.2B.34.01.01.01.01 0E.01.02.03.37.00.00.00 (CRC 53300)	Number of Reported Targets	Unsigned Integer	None	Uint24	V3	The number of targets reported following a culling process. For use, for example, where bandwidth limits the number of targets that can be sent. Range 0 to 16,777,215.

VMTI Local Set							
Tag ID	Key Value (hex)	Tag Name*	Data Type	Units	KLV Format	Length in Bytes	Notes
7	06.0E.2B.34.01.01.01.01 0E.01.01.03.1F.00.00.00 (CRC 44121)	Motion Imagery Frame Number	Unsigned Integer	Frames	Uint24	V3	The Motion Imagery Frame Number corresponding to the frame in which the targets were detected. Use of the Precision Time Stamp is preferred but frame number can be used where a Precision Time Stamp is not available. Range 0 to 2^{24} -1 which equates to approximately 155 hours at 30 FPS.
8	06.0E.2B.34.01.01.01.01 0E.01.01.02.07.00.00.00 (CRC 39020)	Frame Width	Unsigned Integer	Pixels	Uint24	V3	Width of the Motion Imagery frame in pixels. Range 1 to 16777215. Value of zero is meaningless and should not be used.
9	06.0E.2B.34.01.01.01.01 0E.01.01.02.08.00.00.00 (CRC 19586)	Frame Height	Unsigned Integer	Pixels	Unit24	V3	Height of the Motion Imagery frame in pixels. Range 1 to 16777215 Value of zero is meaningless and should not be used
10	06.0E.2B.34.01.01.01.01 04.20.01.02.01.01.00.00 (CRC 53038)	VMTI Source Sensor	String	String	UTF-8	V127	String of VMTI source sensor. E.g. 'EO Nose', 'EO Zoom (DLTV)', 'EO Spotter', 'IR Mitsubishi PtSi Model 500', 'IR InSb Amber Model TBT', 'LYNX SAR Imagery', 'TESAR Imagery', etc. Value field is Free Text. Maximum 127 characters. Similar to MISB ST 0601 Tag 11 Used to identify the imagery source for the VMTI process if more than one bore-sighted Motion Imagery source is captured simultaneously.
11	06.0E.2B.34.01.01.01.02 04.20.02.01.01.08.00.00 (CRC 23753)	VMTI Sensor Horizontal Field of View	Float	Degrees	IMAPB (0, 180, 2)	F2	Horizontal field of view of imaging sensor input to VMTI process. Required if VMTI process is run on a different imaging sensor to that described by the parent MISB ST 0601 packet. Can be used with HFOV (Tag 16) from MISB ST 0601 to scale VMTI Column, Row coordinates.
12	06.0E.2B.34. 01.01.01.07 04.20.02.01.01.0A.01.00 (CRC 30292)	VMTI Sensor Vertical Field of View	Float	Degrees	IMAPB (0, 180, 2)	F2	Vertical field of view of imaging sensor input to VMTI process. May be required if VMTI process is run on a different imaging sensor to that included in the MPEG-2 Transport Stream. Can be used with VFOV (Tag 17) from MISB ST 0601 to scale VMTI Column, Row coordinates. Typically only required to cater for aspect ratio variation.
13	06.0E.2B.34.01.01.01.01 0E.01.04.05.03.00.00.00 (CRC 30280)	Motion Imagery ID	Binary	NA	Binary	V	A Motion Imagery Identification System (MIIS) Core Identifier, compliant with MISB ST 1204 [4]. Provides a unique identifier for the Motion Imagery stream in which the targets were detected. Appearance of this data element in the metadata stream is desirable but not mandatory. If the VMTI LS is subordinate to a MISB ST 0601 LS under Tag 74, a MIIS Core Identifier may already be present in the MISB ST 0601 LS. In this case, this data element may be omitted.

VMTI Local Set							
Tag ID	Key Value (hex)	Tag Name*	Data Type	Units	KLV Format	Length in Bytes	Notes
101	06.0E.2B.34.02.04.01.01 0E.01.03.03.1B.00.00.00 (CRC 24953)	VTargetSeries	Array	None	N/A	V	Series of target metadata, each of which is a VTarget Pack. The length field for VTargetSeries is the sum of the lengths of all the contained target metadata. The length field for each VTarget Pack is the size of all elements within that pack including the Target ID #.
*Tag Name may represent an alias of the Normative Name for the UL key							

9.4.1 Requirements Specific to the VMTI LS

9.4.1.1 Tag 5 –Total Number of Targets Detected in the Frame

Requirement(s)	
ST 0903.4-18	If the VMTI LS Total Number of Targets Detected in a Frame (Tag 5) is different from the VMTI LS Number of Reported Targets (Tag 6), the Total Number of Targets Detected in the Frame shall be specified.

9.4.1.2 Tag 6 – Number of Reported Targets

Requirement(s)	
ST 0903.4-19	The VMTI LS Number of Reported Targets (Tag 6) shall always be specified.

9.4.1.3 Tag 8 – Frame Width

Requirement(s)	
ST 0903.4-20	When an associated Motion Imagery stream is different from the Motion Imagery on which the VMTI process was run, VMTI LS Frame Width (Tag 8) shall be specified.
ST 0903.4-21	When there is no associated Motion Imagery stream, VMTI LS Frame Width (Tag 8) shall be specified.
ST 0903.4-22	The frame width shall be taken from VMTI LS Frame Width (Tag 8), if present.
ST 0903.4-23	If the frame width is not present in VMTI LS Frame Width (Tag 8) then the frame width shall be taken from the underlying Motion Imagery.

9.4.1.4 Tag 10 – VMTI Source Sensor

Requirement(s)	
ST 0903.4-24	When the VMTI LS Source Sensor (Tag 10) is specified, it shall appear from time to time in the KLV stream as an element with Periodic Volatility
ST 0903.4-25	When the VMTI LS Source Sensor (Tag 10) is specified, it shall be updated at the first opportunity following a detected change.

9.4.1.5 Tag 11 – VMTI Sensor Horizontal Field of View

Requirement(s)	
ST 0903.4-26	When the Motion Imagery used in the VMTI process is different from the Motion Imagery that is produced for downstream users, the VMTI Sensor Horizontal Field of View (Tag 11) shall be populated.

9.4.1.6 Tag 12 – VMTI Sensor Vertical Field of View

Requirement(s)	
ST 0903.4-27	When the Motion Imagery used in the VMTI process is different from the Motion Imagery that is produced for downstream users, the VMTI Sensor Vertical Field of View (Tag 12) shall be populated.

9.5 VTarget Pack Elements

Table 2: VTarget Pack

VTarget Pack							
Tag ID	Key Value (hex)	Tag Name*	Data Type	Units	KLV Format	Length in Bytes	Notes
	06.0E.2B.34.02.05.01.01. 0E.01.03.03.07.00.00.00 (CRC 60837)	VTarget Pack	N/A	None	N/A	Variable	This is the Universal Key for the VTarget Pack.
N/A	N/A	Target ID Number	Unsigned Integer		Uint24	V3	This element is mandatory and it must come first in the VTarget Pack. It is BER-OID encoded to convey the length but has no Tag or Length field. Range 1 to 2,097,151.
1	06.0E.2B.34.01.01.01.01 0E.01.02.03.38.00.00.00 (CRC 1242)	Target Centroid Pixel Number	Unsigned Integer	Pixels	Uint48	V6	Defines the position of the target within the Motion Imagery frame in pixels. Range 1 to 2^{48}-1. Numbering commences from 1 denoting the Top Left pixel.
2	06.0E.2B.34.01.01.01.01 0E.01.02.03.39.00.00.00 (CRC 29294)	Bounding Box Top Left Pixel Number	Unsigned Integer	Pixels	Uint48	V6	Defines the position of the top left corner of the target bounding box within the Motion Imagery frame in pixels. Range 1 to 2^{48}-1. Numbering commences from 1 denoting the Top Left pixel.
3	06.0E.2B.34.01.01.01.01 0E.01.02.03.3A.00.00.00 (CRC 59826)	Bounding Box Bottom Right Pixel Number	Unsigned Integer	Pixels	Uint48	V6	Defines the position of the bottom right corner of the target bounding box within the Motion Imagery frame in pixels. Range 1 to 2^{48}-1. Numbering commences from 1 denoting the Top Left pixel.
4	06.0E.2B.34.01.01.01.01 0E.01.02.03.3B.00.00.00 (CRC 40710)	Target Priority	Unsigned Integer	None	Uint8	F1	Priority or validity of target based on criteria within the VMTI system. The target(s) with the highest priority may not have the highest confidence level. Potential for use in limited bandwidth scenarios to only send highest priority targets. Range 1 to 255 where 1 is the highest priority. Multiple targets may have the same priority.
5	06.0E.2B.34.01.01.01.01 0E.01.02.03.3C.00.00.00 (CRC 52779)	Target Confidence Level	Unsigned Integer	None	Uint8	F1	Confidence level of target based on criteria within the VMTI system. The target(s) with the highest confidence may not have the highest priority value. Potential for use in limited bandwidth scenarios to only send highest confidence targets. Range 0 to 100, as a percentage, where 100 percent is the highest confidence. Multiple targets may have the same confidence level.
6	06.0E.2B.34.01.01.01.01 0E.01.02.03.3D.00.00.00 (CRC 47263)	New Detection Flag / Target History	Unsigned Integer	Frames	Uint16	V2	The number of previous times the same target has been detected. Range 0 to 65535 frames. Where a value of 0 denotes the target as a new detection. Detections are not required to be in consecutive frames.

VTarget Pack							
Tag ID	Key Value (hex)	Tag Name*	Data Type	Units	KLV Format	Length in Bytes	Notes
7	06.0E.2B.34.01.01.01.01 0E.01.02.03.3E.00.00.00 (CRC 9027)	Percentage of Target Pixels	Unsigned Integer	None	Uint8	F1	The percentage of pixels within the bounding box that are detected to be target pixels rather than background pixels. Range 1 to 100, where 100 signifies that the target completely fills the bounding box.
8	06.0E.2B.34.01.01.01.01 0E.01.02.03.3F.00.00.00 (CRC 22007)	Target Color	Unsigned Integer	None	Uint24	F3	Dominant color of the target. For use when metadata is transmitted in the absence of the underlying Motion Imagery. RGB color value. VFeature LS can be used for more comprehensive color information.
9	06.0E.2B.34.01.01.01.01 0E.01.02.03.40.00.00.00 (CRC 50028)	Target Intensity	Unsigned Integer	None	Uint24	V3	Dominant Intensity of the target. For use when metadata is transmitted in the absence of the underlying Motion Imagery. Range 0 to 2^{24}-1. VFeature LS can be used for more comprehensive temperature information.
10	06.0E.2B.34.01.01.01.01 0E.01.02.03.41.00.00.00 (CRC 46552)	Target Location Latitude Offset	Float	Degrees	IMAPB (-19.2, 19.2, 3)	F3	Latitude offset for target from frame center latitude (MISB ST 0601). Based on WGS84 ellipsoid. Use with Frame Center Latitude.
11	06.0E.2B.34.01.01.01.01 0E.01.02.03.42.00.00.00 (CRC 11780)	Target Location Longitude Offset	Float	Degrees	IMAPB (-19.2, 19.2, 3)	F3	Longitude offset for target from frame center longitude (MISB ST 0601). Based on WGS84 ellipsoid. Use with Frame Center Longitude.
12	06.0E.2B.34.01.01.01.01 0E.01.02.03.43.00.00.00 (CRC 22704)	Target Height	Float	Meters	IMAPB (-900, 19000, 2)	F2	Height of target in meters above WGS84 Ellipsoid.
13	06.0E.2B.34.01.01.01.01 0E.01.02.03.44.00.00.00 (CRC 2461)	Bounding Box Top Left Latitude Offset	Float	Degrees	IMAPB (-19.2, 19.2, 3)	F3	Latitude offset for top left corner of target bounding box. Use with MISB ST 0601 Frame Center Latitude.
14	06.0E.2B.34.01.01.01.01 0E.01.02.03.45.00.00.00 (CRC 32553)	Bounding Box Top Left Longitude Offset	Float	Degrees	IMAPB (-19.2, 19.2, 3)	F3	Longitude offset for top left corner of target bounding box. Use with MISB ST 0601 Frame Center Longitude.
15	06.0E.2B.34.01.01.01.01 0E.01.02.03.46.00.00.00 (CRC 58613)	Bounding Box Bottom Right Latitude Offset	Float	Degrees	IMAPB (-19.2, 19.2, 3)	F3	Latitude offset for bottom right corner of target bounding box. Use with MISB ST 0601 Frame Center Latitude.
16	06.0E.2B.34.01.01.01.01 0E.01.02.03.47.00.00.00 (CRC 37441)	Bounding Box Bottom Right Longitude Offset	Float	Degrees	IMAPB (-19.2, 19.2, 3)	F3	Longitude offset for bottom right corner of target bounding box. Use with MISB ST 0601 Frame Center Longitude.
17	06.0E.2B.34.02.05.01.01 0E.01.03.03.14.00.00.00 (CRC 28126)	Target Location	Structure	None	Location	V	Location of the target (latitude, longitude, & height above the WGS84 Ellipsoid), with associated sigma and rho values.
18	06.0E.2B.34.02.04.01.01 0E.01.03.03.17.00.00.00 (CRC 11851)	Target Boundary	Structure	None	Boundary	V	Boundary around the target, typically defined as a bounding box in two or more locations (latitude, longitude, & height above the WGS84 Ellipsoid).

VTarget Pack							
Tag ID	Key Value (hex)	Tag Name*	Data Type	Units	KLV Format	Length in Bytes	Notes
19	06.0E.2B.34.01.01.01.01 0E.01.02.03.58.00.00.00 (CRC 23816)	Target Centroid Pixel Row	Unsigned Integer	Pixels	Uint32	V4	Specifies the row of the target centroid within the Motion Imagery frame in pixels. Range 1 to 2^{32}-1. Numbering commences from 1, denoting the top row. May be used with Target Centroid Pixel Column (Tag 20) to provide an alternate method to specify Target Pixel Centroid Number (Tag 1), the pixel location of the target centroid. If present, Target Centroid Pixel Column (Tag 20) must also be present.
20	06.0E.2B.34.01.01.01.01 0E.01.02.03.59.00.00.00 (CRC 11196)	Target Centroid Pixel Column	Unsigned Integer	Pixels	Uint32	V4	Specifies the column of the target centroid within the Motion Imagery frame in pixels. Range 1 to 2^{32}-1. Numbering commences from 1, denoting the left column. May be used with Target Centroid Pixel Row (Tag 19) to provide an alternate method to specify Target Pixel Centroid Number (Tag 1), the pixel location of the target centroid. If present, Target Centroid Pixel Row (Tag 19) must also be present.
21	06.0E.2B.34.02.05.01.01 0E.01.03.03.1D.01.00.00 (CRC 43417)	FPA Index	Pack	None	FPA Index	F2	Specifies the column and the row of a sensor Focal Plane Array (FPA) in a two-dimensional array of FPAs. Specifies the FPA in which detection of the target has occurred. Target pixel coordinates are expressed with respect to the FPA within which the target is detected; the FPA is treated as a Motion Imagery "frame" for VMTI data elements that use the frame as a reference.
101	06.0E.2B.34.02.03.01.01 0E.01.03.03.08.00.00.00 (CRC 51391)	VMask LS	Structure	None	N/A	V	Local set tag to include a mask for delineating the perimeter of the target. It may be used to extract the target and populate the VChip LS. Use the VMask Local Set Tags. The length field is the size of all VMask items to be packaged within this tag.
102	06.0E.2B.34.02.03.01.01 0E.01.03.03.09.00.00.00 (CRC 48651)	VObject LS	Structure	None	N/A	V	Local set tag to specify the class or type of a target. Uses an ontology to describe the set of allowed class or type values.
103	06.0E.2B.34.02.03.01.01 0E.01.03.03.0A.00.00.00 (CRC 9687)	VFeature LS	Structure	None	N/A	V	Local set tag to include features about the target. More than one VFeature LS can be included within the VTarget Pack. Use the VFeature Local Set Tags. The length field is the size of all VFeature items to be packaged within this tag.
104	06.0E.2B.34.02.03.01.01 0E.01.03.03.0B.00.00.00 (CRC 21347)	VTracker LS	Structure	None	N/A	V	Local set tag to include track information about the target. Use the VTracker Local Set Tags. The length field is the size of all VTracker items to be packaged within this tag.

VTarget Pack							
Tag ID	Key Value (hex)	Tag Name*	Data Type	Units	KLV Format	Length in Bytes	Notes
105	06.0E.2B.34.02.03.01.01 0E.01.03.03.13.00.00.00 (CRC 52487)	VChip LS	Structure	None	N/A	V	Local set tag to include underlying pixel values for the target. The VChip LS contains a target chip extracted from the Motion Imagery. Use the VChip Local Set Tags. The length field is the size of all VChip items to be packaged within this tag.
106	06.0E.2B.34.02.04.01.01 0E.01.03.03.14.00.00.00 (CRC 46487)	VChipSeries	Series	None	N/A	V	VChipSeries is a Series of one or more VChip LSs. Multiple VChips could be useful for including an image chip from the source sensor and another image chip of the target from another sensor, say one of higher resolution or of a different modality (e.g. IR).
*Tag Name may represent an alias of the Normative Name for the UL key							

9.5.1 Requirements Specific to the VTarget Pack

9.5.1.1 Target ID Number

Requirement(s)	
ST 0903.4-28	To the extent possible a VTarget Pack Target ID Number shall uniquely identify a given target.

9.5.1.2 Tag 1 – Target Centroid Pixel Number

Requirement(s)	
ST 0903.4-29	At least one representation of VTarget Pack Target Centroid Pixel Number (Tag 1) shall be present. The Target Centroid Pixel Number can be specified using either the data element Target Centroid Pixel Number (Tag 1) or the pair of data elements Target Centroid Pixel Row (Tag 19) and Target Centroid Pixel Column (Tag 20).

9.5.1.3 Tag 10 – Target Location Latitude Offset

Requirement(s)	
ST 0903.4-30	VTarget Pack Target Location Latitude Offset (Tag 10) shall only be present when the VMTI LS is embedded within a MISB ST 0601 LS [2].

9.5.1.4 Tag 11 – Target Location Longitude Offset

Requirement(s)	
ST 0903.4-31	VTarget Pack Target Location Longitude Offset (Tag 11) shall only be present when the VMTI LS is embedded within a MISB ST 0601 LS [2].

9.5.1.5 Tag 13 – Bounding Box Top Left Latitude Offset

Requirement(s)	
ST 0903.4-32	VTarget Pack Bounding Box Top Left Latitude Offset (Tag 13) shall only be present when the VMTI LS is embedded within a MISB ST 0601 LS [2].

9.5.1.6 Tag 14 – Bounding Box Top Left Longitude Offset

Requirement(s)	
ST 0903.4-33	VTarget Pack Bounding Box Top Left Longitude Offset (Tag 14) shall only be present when the VMTI LS is embedded within a MISB ST 0601 LS [2].

9.5.1.7 Tag 15 – Bounding Box Bottom Right Latitude Offset

Requirement(s)	
ST 0903.4-34	VTarget Pack Bounding Box Bottom Right Latitude Offset (Tag 15) shall only be present when the VMTI LS is embedded within a MISB ST 0601 LS [2].

9.5.1.8 Tag 16 – Bounding Box Bottom Right Longitude Offset

Requirement(s)	
ST 0903.4-35	VTarget Pack Bounding Box Bottom Right Longitude Offset (Tag 16) shall only be present when the VMTI LS is embedded within a MISB ST 0601 LS [2].

9.5.1.9 Tag 17 – Target Location

Requirement(s)	
ST 0903.4-36	When the VMTI LS is not embedded within a MISB ST 0601 LS [2], VTarget Pack Target Location (Tag 17) shall be used instead of VTarget Pack Target Location Latitude Offset (Tag 10) and VTarget Pack Target Location Longitude Offset (Tag 11).

9.5.1.10 Tag 19 – Target Centroid Pixel Row

Requirement(s)	
ST 0903.4-37	VTarget Pack Target Centroid Pixel Row (Tag 19) shall be present, if VTarget Pack Target Centroid Pixel Column (Tag 20) is present.

9.5.1.11 Tag 20 – Target Centroid Pixel Column

Requirement(s)	
ST 0903.4-38	If VTarget Pack Target Centroid Pixel Row (Tag 19) is present, then VTarget Pack Target Centroid Pixel Column (Tag 20) shall be present,

9.6 VMask Local Set (LS)

Table 3: VMask LS

VMask Local Set							
Tag ID	Key Value (hex)	Tag Name*	Data Type	Units	KLV Format	Length in Bytes	Notes
	06.0E.2B.34.02.03.01.01 0E.01.03.03.08.00.00.00 (CRC 51391)	VMask LS	N/A	None	N/A	Variable	This is the Universal Key for the VMask Local Set.
1	06.0E.2B.34.02.04.01.01 0E.01.03.03.18.00.00.00 (CRC 64165)	Polygon	Array of unsigned integers	NA	Series of Unsigned Integers	V	This is a Series of at least three pixel numbers that specify the vertices of a polygon representing the outline of the target. Numbering commences from 1, denoting the Top Left pixel. Values are encoded using the Length-Value construct of a Variable-Length Pack.
2	06.0E.2B.34.02.04.01.01 0E.01.03.03.19.00.00.00 (CRC 35857)	Bit Mask	Array of unsigned integers	NA	Series of Unsigned Integers	V	This element describes the area of the frame occupied by a target, using a run-length encoded bit mask, with 1 to indicate that a pixel subtends a part of the target and 0 to indicate otherwise. A Series of pixel-number-plus-run-length pairs, each describing the starting pixel number and the number of pixels in a run. Numbering commences from 1, denoting the Top Left pixel. Pixel numbers are encoded using the Length-Value construct of a Variable-Length Pack. The length of each run is encoded using BER Length encoding.
*Tag Name may represent an alias of the Normative Name for the UL key							

9.6.1 Requirements Specific to the VMask LS

9.6.1.1 VMTI LS Tag 101 – VMask LS

Requirement(s)	
ST 0903.4-39	Coordinates used for VMask LS Polygon (Tag 1) and VMask LS Bit Mask (Tag 2) shall be specified using pixel numbers calculated with the equation *Column* + ((*Row*-1) x frame width)), where numbering commences at 1 from the left for *Column* and from the top for *Row*, and where frame width is the number of columns in the image.

9.6.1.2 Tag 1 – Polygon

Requirement(s)	
ST 0903.4-40	The points specified in VMask LS Polygon (Tag 1) shall be listed in clockwise order.
ST 0903.4-41	Each pixel number specified in VMask LS Polygon (Tag 1) shall be encoded using the Length-Value construct of a Variable-Length Pack.
ST 0903.4-42	The polygon specified in VMask LS Polygon (Tag 1) shall be closed by connecting the last point in the series to the first point in the series.

9.6.1.3 Tag 2 – Bit Mask

Requirement(s)	
ST 0903.4-43	Each run of pixels in VMask LS Bit Mask (Tag 2) that subtends a part of the target shall be encoded by specifying the number of the pixel at the start of the run and the number of pixels in the run.
ST 0903.4-44	The run length in VMask LS Bit Mask (Tag 2) shall be encoded using BER Length encoding.

9.7 VObject Local Set (LS)

Table 4: VObject LS

VObject Local Set							
Tag ID	Key Value (hex)	Tag Name*	Data Type	Units	KLV Format	Length in Bytes	Notes
	06.0E.2B.34.02.03.01.01 0E.01.03.03.09.00.00.00 (CRC 48651)	VObject LS	N/A	None	N/A	Variable	This is the Universal Key for the VObject Local Set.
1	06.0E.2B.34.01.01.01.01 0E.01.01.03.33.01.00.00 (CRC 58133)	Ontology	String	NA	UTF-8	V	This element is a Uniform Resource Identifier (URI) which refers to a VObject ontology. The ontology shall be expressed using the Web Ontology Language OWL [8].
2	06.0E.2B.34.01.01.01.01 0E.01.01.03.33.00.00.00 (CRC 54309)	Ontology_Class	String	NA	UTF-8	V	The name of the target class or type, as defined in the VObject Ontology
*Tag Name may represent an alias of the Normative Name for the UL key							

9.7.1 Requirements Specific to the VObject LS

9.7.1.1 Tag 1 – Ontology

Requirement(s)	
ST 0903.4-45	The ontology referred to by the URI of the VObject LS Ontology (Tag 1) shall be expressed using the Web Ontology Language (OWL) [8].
ST 0903.4-46	The VObject LS Ontology (Tag 1) element shall appear in the KLV stream prior to any appearance of a VObject Class (Tag 2) element.
ST 0903.4-47	The VObject Ontology (Tag 1) element shall appear from time to time in the KLV stream as an element with Periodic Volatility.

9.7.1.2 Tag 2 – Ontology_Class

Requirement(s)	
ST 0903.4-48	The VObject LS Ontology_Class (Tag 2) shall have a value taken from the ontology specified by VObject LS Ontology (Tag 1) that precedes it in the KLV stream.

9.8 VFeature Local Set (LS)

Table 5: VFeature LS

VFeature Local Set							
Tag ID	Key Value (hex)	Tag Name*	Data Type	Units	KLV Format	Length in Bytes	Notes
	06.0E.2B.34.02.03.01.01 0E.01.03.03.0A.00.00.00 (CRC 9687)	VFeature LS	N/A	None	N/A	Variable	This is the Universal Key for the VFeature Local Set.
1	06.0E.2B.34.01.01.01.01 0E.01.01.03.34.01.00.00 (CRC 45624)	Schema	String	NA	UTF-8	V	Uniform Resource Identifier (URI) which refers to an OGC Geography Markup Language (GML) Observations and Measurements (O&M) application schema.
2	06.0E.2B.34.01.01.01.01 0E.01.01.03.34.00.00.00 (CRC 34056)	Schema_Feature	String	NA	UTF-8	V	OGC GML document structured according to the schema specified by Tag 1. Intended to capture properties (values) observed for a feature of interest.
*Tag Name may represents an alias of the Normative Name for the UL key							

9.8.1 Requirements Specific to the VFeature LS

9.8.1.1 VMTI LS Tag 103 – VFeature LS

Requirement(s)	
ST 0903.4-49	The VFeature LS shall conform to ISO ST 19156 Geographic Information - Observations and Measurements (O&M) [9] and related schemas.

9.8.1.2 Tag 1 – Schema

Requirement(s)	
ST 0903.4-50	The VFeature LS Schema (Tag 1) element shall be present in the KLV stream prior to any appearance of a VFeature LS Feature (Tag 2) element.
ST 0903.4-51	The VFeature Schema (Tag 1) element shall appear from time to time in the KLV stream as an element with Periodic Volatility.

9.8.1.3 Tag 2 – Schema_Feature

Requirement(s)	
ST 0903.4-52	The VFeature LS Schema_Feature (Tag 2) shall conform to the schema specified by VFeature LS Schema (Tag 1).

9.9 VTracker Local Set (LS)

Table 6: VTracker LS

VTracker Local Set							
Tag ID	Key Value (hex)	Tag Name*	Data Type	Units	KLV Format	Length in Bytes	Notes
	06.0E.2B.34.02.03.01.01 0E.01.03.03.0B.00.00.00 (CRC 21347)	VTracker LS	N/A	None	N/A	Variable	This is the Universal Key for the VTracker Local Set.
1	06.0E.2B.34.01.01.01.01 0E.01.01.03.35.00.00.00 (CRC 62396)	Track ID	Unsigned Integer	NA	Uint128	F16	A unique identifier (UUID) for the track.
2	06.0E.2B.34.01.01.01.01 0E.01.01.03.36.00.00.00 (CRC 26720)	Detection Status	Unsigned Integer	NA	Uint8	F1	An enumeration indicating the current state of VMTI detections for a given entity (Inactive, Active, Dropped, Stopped).
3	06.0E.2B.34.01.01.01.03 07.02.01.01.01.05.00.00 (CRC 64827)	Start Time Stamp	Unsigned Long	Micro-seconds	Uint64	V8	Date and time for the first observation of the entity.
4	06.0E.2B.34.01.01.01.03 07.02.01.01.01.05.00.00 (CRC 64827)	End Time Stamp	Unsigned Long	Micro-seconds	Uint64	V8	Date and time of the most recent observation of the entity.
5	06.0E.2B.34.02.04.01.01 0E.01.03.03.17.00.00.00 (CRC 11851)	Bounding Box	Structure	NA	Boundary	V	Set of Boundary vertices that specify a minimum bounding area or volume, which encloses the full extent of VMTI detections for the entity.
6	06.0E.2B.34.01.01.01.01 0E.01.02.03.49.00.00.00 (CRC 12315)	Algorithm	String	NA	UTF-8	V	Name or description of the algorithm or method used to create or maintain object movement reports or intervening predictions of such movement. The intent of this element is to identify uniquely the VMTI algorithm or method used.
7	06.0E.2B.34.01.01.01.01 0E.01.01.03.37.00.00.00 (CRC 7892)	Confidence	Unsigned Integer	NA	Uint8	F1	An estimation of the certainty or correctness of VMTI movement detections. Larger values indicate greater confidence. Zero indicates no confidence.
8	06.0E.2B.34.01.01.01.01 0E.01.01.03.38.00.00.00 (CRC 51770)	Number of Track Points	Unsigned Integer	NA	Uint16	V2	Number of coordinates of type Location that describe the locus of VMTI detections.
9	06.0E.2B.34.02.04.01.01 0E.01.03.03.1A.00.00.00 (CRC 6093)	Locus	Series	NA	Location	V	Points of type Location that represent the locations of VMTI detections.
10	06.0E.2B.34.02.05.01.01 0E.01.03.03.15.00.00.00 (CRC 7018)	Velocity	Structure	NA	Velocity	V	Velocity of the entity at the time of last observation.
11	06.0E.2B.34.02.05.01.01 0E.01.03.03.16.00.00.00 (CRC 32950)	Acceleration	Structure	NA	Acceleration	V	Acceleration of the entity at the time of last observation.
*Tag Name may represent an alias of the Normative Name for the UL key							

9.9.1 Requirements Specific to the VTracker LS

9.9.1.1 Tag 1 – Tracker ID

Requirement(s)	
ST 0903.4-53	The VTracker LS Target ID (Tag 1) shall be a 16-byte Universal Unique Identification (UUID) as standardized by ISO/IEC 9834-8 [10].

9.9.1.2 Tag 5 – Bounding Box

Requirement(s)	
ST 0903.4-54	VTracker LS Bounding Box (Tag 5) vertices shall be ordered so that looking toward Earth center they spiral in a clockwise direction from lowest elevation to highest.

9.9.1.3 Tag 8 – Number of Track Points

Requirement(s)	
ST 0903.4-55	If an instance of the VTracker LS is present in the KLV stream, then the number of track points specified by VTracker LS Number of Track Points (Tag 8) shall be at least one (1).

9.9.1.4 Tag 9 – Locus

Requirement(s)	
ST 0903.4-56	VTracker LS Locus (Tag 9) points shall be ordered chronologically from start to end of the VMTI detections.

9.10 VChip Local Set (LS)

Table 7: VChip LS

VChip Local Set							
Tag ID	Key Value (hex)	Tag Name*	Data Type	Units	KLV Format	Length in Bytes	Notes
	06.0E.2B.34.02.03.01.01 0E.01.03.03.13.00.00.00 (CRC 52487)	VChip LS	N/A	None	N/A	Variable	This is the Universal Key for the VChip Local Set.
1	06.0E.2B.34.01.01.01.01 0E.01.01.03.30.00.00.00 (CRC 20473)	Image Type	String	NA	UTF-8	V	Internet Assigned Numbers Authority (IANA) image media subtype specifying the VChip image type (limited to “jpeg”, and “png”).
2	06.0E.2B.34.01.01.01.01 0E.01.01.03.31.00.00.00 (CRC 14669)	Image URI	String	NA	UTF-8	V	Uniform Resource Identifier (or Uniform Resource Locator) that refers to an image stored on a server.
3	06.0E.2B.34.01.01.01.01 0E.01.01.03.32.00.00.00 (CRC 41617)	Embedded Image	Binary	NA	Binary	V	An image “chip” of the image type specified by Tag 1.
*Tag Name represents a local alias of the Normative Name for the UL key							

9.10.1 Requirements Specific to the VChip LS

9.10.1.1 Tag 1 – Image Type

Requirement(s)	
ST 0903.4-57	The VChip LS Image Type (Tag 1) element shall appear in the KLV stream prior to a VChip LS Image URI (Tag 2) or a VChip LS Embedded Image (Tag 3) element.
ST 0903.4-58	The VChip LS Image Type (Tag 1) element shall appear in the KLV stream with Periodic Volatility.
ST 0903.4-59	The type of the image referred to by VChip LS Image URI (Tag 2) shall be that specified by the preceding VChip LS Image Type (Tag 1).
ST 0903.4-60	The type of a VChip LS Embedded Image (Tag 3) shall be that specified by the preceding VChip LS Image Type (Tag 1).

9.11 FPA Index Defined-Length Pack

Table 8: FPA Index Defined-Length Pack

FPA Index Pack							
Tag ID	Key Value (hex)	Name*	Data Type	Units	KLV Format	Length in Bytes	Notes
	06.0E.2B.34.02.05.01.01 0E.01.03.03.1D.01.00.00 (CRC 43417)	FPA Index	N/A	None	N/A	F2	This is the Universal Key for the FPA Index Pack.
N/A	06.0E.2B.34.01.01.01.01 0E.01.02.03.5A.00.00.00 (CRC 45152)	FPA Row	Unsigned Integer	NA	Uint8	F1	Specifies the row of a sensor Focal Plane Array (FPA) in a two-dimensional array of FPAs, numbering from 1, top to bottom, starting at the upper left of the array. Specifies the FPA in which detection of the target has occurred. Target pixel coordinates are expressed with respect to the FPA within which the target is detected; the FPA is treated as a Motion Imagery “frame” for VMTI data elements that use the frame as a reference.
N/A	06.0E.2B.34.01.01.01.01 0E.01.02.03.5B.00.00.00 (CRC 50900)	FPA Column	Unsigned Integer	NA	Uint8	F1	Specifies the column of a sensor Focal Plane Array (FPA) in a two-dimensional array of FPAs, numbering from 1, left to right, starting at the upper left of the array. Specifies the FPA in which detection of the target has occurred. Target pixel coordinates are expressed with respect to the FPA within which the target is detected; the FPA is treated as a Motion Imagery “frame” for VMTI data elements that use the frame as a reference.
*Name may represent an alias of the Normative Name for the UL key							

9.12 Complex KLV Types

Within the VTarget Pack and VTracker LS several complex KLV types are used: Location Structure, Velocity Structure, Acceleration Structure and Boundary Structure. This section defines these data types.

The following requirements apply to the complex KLV data types discussed in this section.

Requirement(s)	
ST 0903.4-61	Defined-Length Truncation Packs shall be defined in accordance with MISB RP 0701[7].
ST 0903.4-62	Truncation of Location, Velocity, and Acceleration Defined-Length Truncation Packs shall be allowed only at a group boundary.
ST 0903.4-63	Within a Location, Velocity, or Acceleration Defined-Length Truncation Pack, no filler values shall be used for (unknown) higher priority elements.

9.12.1 Location Structure

The Location Structure captures geo-positioning data about a specific location on or in close proximity to the surface of the Earth. The Location elements are structured as a Defined-Length

Truncation Pack. The elements fall into three groups (see Figure 7.) The first, and highest priority group, includes elements for Latitude, Longitude, and Height. These elements of the Location Pack define the origin of a local tangential East-North-Up (ENU) coordinate system. The Standard Deviations group and the Correlation Coefficients group express uncertainty with respect to the ENU coordinate axes. The second, and medium priority group, provides standard deviations for the location in meters (with respect to the ENU coordinate axes). Standard deviation provides a measure of the variability of a coordinate value, an estimate of potential error. The third, and lowest priority group, provides correlation coefficients for the location (with respect to the ENU coordinate axes). The correlation coefficients provide a measure of systematic behavior, whether variation in the values of pairs of variables is "coupled" or random.[7]

Standard deviations and correlation coefficients can be useful means to express confidence in the geo-coordinates. For example, if standard deviations are small and correlation coefficients are near unity, then "confidence" in the accuracy of the coordinate values is high. On the other hand, if standard deviations are large and correlation coefficients are near zero, potentially large, random errors can be expected.

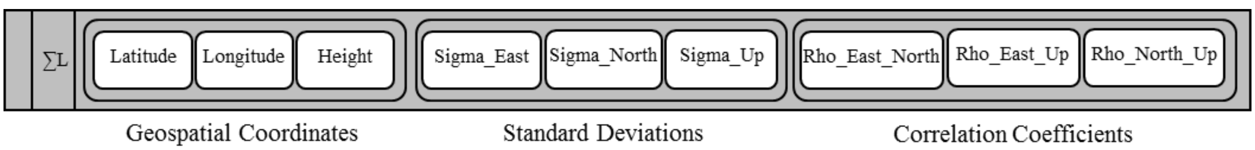

Figure 7. Location Structure

Requirement(s)	
ST 0903.4-64	The Location Structure shall be encoded as a Defined-Length Truncation Pack.
ST 0903.4-65	The Location Pack shall consist of up to three sets of information that include a Geospatial Coordinate triplet, a Standard Deviation triplet, and a Correlation Coefficient triplet, in that order.
ST 0903.4-66	The Geospatial Coordinate triplet of the Location Pack shall always be present.
ST 0903.4-67	The Geospatial Coordinate triplet of the Location Pack shall consist of elements for Latitude, Longitude, and Height, in that order.
ST 0903.4-68	The Latitude, Longitude, and Height elements of the Geospatial Coordinate triplet of the Location Pack all shall use the WGS84 Ellipsoid as reference.
ST 0903.4-69	The Height element in the Geospatial Coordinate triplet of the Location Pack shall be expressed as Height Above the Ellipsoid (HAE) in meters with respect to the WGS84 ellipsoid.
ST 0903.4-70	When the Correlation Coefficient triplet of a Location data type is present, the Standard Deviation triplet shall also be present.

[7] Correlation is used because it is dimensionless and can be specified with a fixed range of values from -1.0 to +1.0, inclusive. Covariance, while it is a similar measure of "relatedness," is in units obtained by multiplying the units of two variables, and thus has values less well constrained.

ST 0903.4-71	The Standard Deviation triplet of the Location Pack shall consist of elements for the standard deviations of the values in the Geospatial Coordinate Component triplet with respect to the East-North-Up local coordinate system, specifically East, North, and Up, in that order.
ST 0903.4-72	The Correlation Coefficient triplet of the Location Pack shall consist of elements for the pairwise correlation coefficients of the values in the Geospatial Coordinate Component triplet with respect to the East-North-Up local coordinate system, specifically East-to-North, East-to-Up, and North-to-Up, in that order.

9.12.1.1 Location Truncation Pack

Table 9: Location Truncation Pack

Location Truncation Pack							
Tag ID	Key Value (hex)	Name*	Data Type	Units	KLV Format	Length in Bytes	Notes
	06.0E.2B.34.02.05.01.01 0E.01.03.03.14.01.00.00 (CRC 23278)	Location Truncation Pack	N/A	None	N/A	Variable	This is the Universal Key for the Location Truncation Pack type
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.28.00.00.00 (CRC 53661)	Latitude	Float	Degrees	IMAPB (-90, 90, 4)	F4	Latitude in degrees of a point with respect to the WGS84 datum. For expressing standard deviations, correlation coefficients, velocity, and acceleration, the point represents the origin of a local tangential East-North-Up (ENU) coordinate system.
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.29.00.00.00 (CRC 42793)	Longitude	Float	Degrees	IMAPB (-180, 180, 4)	F4	Longitude in degrees of a point with respect to the WGS84 datum. For expressing standard deviations, correlation coefficients, velocity, and acceleration, the point represents the origin of a local tangential East-North-Up (ENU) coordinate system.
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2A.00.00.00 (CRC 15605)	Height	Float	Meters	IMAPB (-900, 19000, 2)	F2	Height of a point in meters above the WGS84 Ellipsoid (HAE). For expressing standard deviations, correlation coefficients, velocity, and acceleration, the point represents the origin of a local tangential East-North-Up (ENU) coordinate system.

Location Truncation Pack							
Tag ID	Key Value (hex)	Name*	Data Type	Units	KLV Format	Length in Bytes	Notes
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2D.00.00.00 (CRC 28120)	Sigma_ East	Float	Meters	IMAPB (0, 650, 2)	F2	Standard deviation of the location of the point with respect to the ENU coordinate system East axis.
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2D.01.00.00 (CRC 23272)	Sigma_ North	Float	Meters	IMAPB (0, 650, 2)	F2	Standard deviation of the location of the point with respect to the ENU coordinate system North axis.
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2D.02.00.00 (CRC 952)	Sigma_ Up	Float	Meters	IMAPB (0, 650, 2)	F2	Standard deviation of the location of the point with respect to the ENU coordinate system Up axis.
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2E.00.00.00 (CRC 62980)	Rho_East_North	Float	N/A	IMAPB (-1, 1, 2)	F2	Correlation coefficient between the East and North components.
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2E.01.00.00 (CRC 49460)	Rho_East_Up	Float	N/A	IMAPB (-1, 1, 2)	F2	Correlation coefficient between East and Up components of error.
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2E.02.00.00 (CRC 39012)	Rho_North_Up	Float	N/A	IMAPB (-1, 1, 2)	F2	Correlation coefficient between North and Up components of error.
*Name may represent an alias of the Normative Name for the UL key							

9.12.2 Velocity Structure

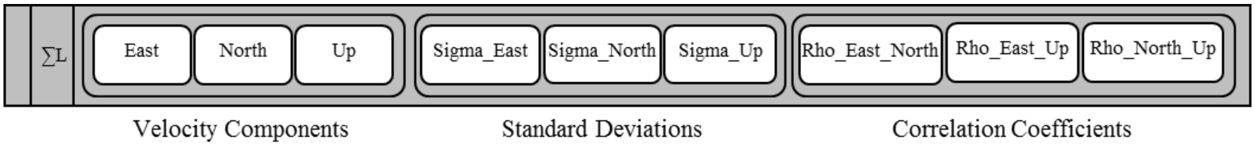

Figure 8. Velocity Structure

The Velocity Structure (Figure 8) captures data about the velocity of a moving object. The Velocity Structure is structured as a Defined-Length Truncation Pack. The elements of this pack fall into three groups, as shown in Figure 8. The first, and highest priority group, provides the measurements of velocity along the coordinate axes of the East-North-Up coordinate system specified by the Location Truncation Pack for the location of the moving object. he second, and medium priority group, provides standard deviations for the first group measurements. The third and lowest priority group provides three correlation coefficients for elements in the first group.

Requirement(s)	
ST 0903.4-73	The Velocity Structure shall be encoded as a Defined-Length Truncation Pack.
ST 0903.4-74	The Velocity Pack shall consist of a Velocity Component triplet, a Standard Deviation triplet, and a Correlation Coefficient triplet, in that order.
ST 0903.4-75	The Velocity Component triplet of the Velocity Pack shall be present.
ST 0903.4-76	The Velocity Component triplet of the Velocity Pack shall consist of elements for East, North, and Up, in that order.
ST 0903.4-77	The East, North, and Up elements of the Velocity Component triplet of the Velocity Pack shall be expressed using the East-North-Up coordinate system specified by a Location Truncation Pack for the location of the moving object.
ST 0903.4-78	The East, North, and Up elements in the Velocity Component triplet of the Velocity Pack shall be expressed in meters per second.
ST 0903.4-79	When the Velocity Pack Correlation Coefficient triplet is present, the Velocity Pack Standard Deviation triplet shall also be present.
ST 0903.4-80	The Standard Deviation triplet of the Velocity Pack shall consist of elements for the standard deviations of the East, North, and Up values in the Velocity Component triplet, in that order.
ST 0903.4-81	The Correlation Coefficient triplet of the Velocity Pack shall consist of elements for the pairwise correlation coefficients of the values in the Velocity Component triplet, specifically East-to-North, East-to-Up, and North-to-Up, in that order.
ST 0903.4-82	The Velocity Pack shall be present only if there is an associated Location Pack.

9.12.2.1 Velocity Truncation Pack

Table 10: Velocity Truncation Pack

Velocity Truncation Pack							
Tag ID	Key Value (hex)	Name*	Data Type	Units	KLV Format	Length in Bytes	Notes
	06.0E.2B.34.02.05.01.01 0E.01.03.03.15.01.00.00 (CRC 11354)	Velocity Truncation Pack	N/A	None	N/A	Variable	This is the Universal Key for the Velocity Truncation Pack type
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2B.00.00.00 (CRC 19009)	East_Component	Float	Meters/Second	IMAPB (-900, 900, 2)	F2	Velocity along the East axis of the East-North-Up coordinate system.
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2B.01.00.00 (CRC 32113)	North_Component	Float	Meters/Second	IMAPB (-900, 900, 2)	F2	Velocity along the North axis of the East-North-Up coordinate system
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2B.02.00.00 (CRC 9249)	Up_Component	Float	Meters/Second	IMAPB (-900, 900, 2)	F2	Velocity along the Up axis of the East-North-Up coordinate system
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2D.03.00.00 (CRC 13448)	Sigma_East	Float	Meters/Second	IMAPB (0, 650, 2)	F2	Standard deviation along East axis.
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2D.04.00.00 (CRC 45336)	Sigma_North	Float	Meters/Second	IMAPB (0, 650, 2)	F2	Standard deviation along North axis.
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2D.05.00.00 (CRC 34344)	Sigma_Up	Float	Meters/Second	IMAPB (0, 650, 2)	F2	Standard deviation along Up axis
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2E.03.00.00 (CRC 44884)	Rho_East_North	Float	N/A	IMAPB (-1, 1, 2)	F2	Correlation coefficient between East and North.
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2E.04.00.00 (CRC 10948)	Rho_East_Up	Float	N/A	IMAPB (-1, 1, 2)	F2	Correlation coefficient between East and Up.
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2E.05.00.00 (CRC 7668)	Rho_North_Up	Float	N/A	IMAPB (-1, 1, 2)	F2	Correlation coefficient between North and Up.
*Name may represents an alias of the Normative Name for the UL key							

9.12.3 Acceleration Structure

The Acceleration Structure captures data about the acceleration of a moving object. The Acceleration Structure is structured as a Defined-Length Truncation Pack. The elements of this pack fall into three groups, as shown in Figure 9. The first, and highest priority group, provide measurements of acceleration along the coordinate axes of the East-North-Up coordinate system specified by the Location Truncation Pack for the location of the moving object. The second, and medium priority group, provides the standard deviations for the first group measurements. The third and lowest priority group provides the three correlation coefficients for the elements in the first group.

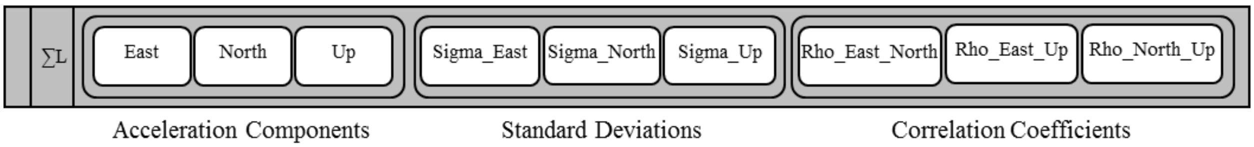

Figure 9. Acceleration Structure

Requirement(s)	
ST 0903.4-83	The Acceleration Structure shall be encoded as a Defined-Length Truncation Pack.
ST 0903.4-84	The Acceleration Pack shall consist of up to three sets of information that include an Acceleration Component triplet, a Standard Deviation triplet, and a Correlation Coefficient triplet, in that order.
ST 0903.4-85	The Acceleration Component triplet of the Acceleration Pack shall always be present.
ST 0903.4-86	The Acceleration Component triplet of the Acceleration Pack shall consist of elements for East, North, and Up, in that order.
ST 0903.4-87	The East, North, and Up elements in the Acceleration Component triplet of the Acceleration Pack shall be expressed in meters per second squared
ST 0903.4-88	The East, North, and Up elements of the Acceleration Component triplet of the Acceleration Pack shall be expressed using the East-North-Up coordinate system specified by a Location Truncation Pack for the location of the moving object.
ST 0903.4-89	When the Acceleration Pack Correlation Coefficient triplet is present, the Acceleration Pack Standard Deviation triplet shall also be present.
ST 0903.4-90	The Standard Deviation triplet of the Acceleration type shall consist of elements for the standard deviations of the East, North, and Up values in the Acceleration Component triplet, in that order.
ST 0903.4-91	The Correlation Coefficient triplet of the Acceleration type shall consist of elements for the pairwise correlation coefficients of the values in the Acceleration Component triplet, specifically East-to-North, East-to-Up, and North-to-Up, in that order.
ST 0903.4-92	The Acceleration Pack shall be present only if there is an associated Location Pack.

9.12.3.1 Acceleration Truncation Pack

Table 11: Acceleration Truncation Pack

Acceleration Truncation Pack							
Tag ID	Key Value (hex)	Name*	Data Type	Units	KLV Format	Length in Bytes	Notes
	06.0E.2B.34.02.05.01.01 0E.01.03.03.16.01.00.00 (CRC 46982)	Acceleration Truncation Pack	N/A	None	N/A	Variable	This is the Universal Key for the Acceleration Truncation Pack type
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2C.00.00.00 (CRC 7020)	East_Component	Float	Meters/Second^2	IMAPB (-900, 900, 2)	F2	Acceleration along the East axis of the East-North-Up coordinate system.
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2C.01.00.00 (CRC 11356)	North_Component	Float	Meters/Second^2	IMAPB (-900, 900, 2)	F2	Acceleration along the North axis of the East-North-Up coordinate system.
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2C.02.00.00 (CRC 29964)	Up_Component	Float	Meters/Second^2	IMAPB (-900, 900, 2)	F2	Acceleration along the Up axis of the East-North-Up coordinate system.
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2D.06.00.00 (CRC 57208)	Sigma_East	Float	Meters/Second^2	IMAPB (0, 650, 2)	F2	Standard deviation along East axis.
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2D.07.00.00 (CRC 59464)	Sigma_North	Float	Meters/Second^2	IMAPB (0, 650, 2)	F2	Standard deviation along North axis.
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2D.08.00.00 (CRC 50297)	Sigma_Up	Float	Meters/Second^2	IMAPB (0, 650, 2)	F2	Standard deviation along Up axis.
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2E.06.00.00 (CRC 17572)	Rho_East_North	Float	N/A	IMAPB (-1, 1, 2)	F2	Correlation coefficient between East and North.
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2E.07.00.00 (CRC 29588)	Rho_East_Up	Float	N/A	IMAPB (-1, 1, 2)	F2	Correlation coefficient between East and Up.
N/A	06.0E.2B.34.01.01.01.01 0E.01.01.03.2E.08.00.00 (CRC 24485)	Rho_North_Up	Float	N/A	IMAPB (-1, 1, 2)	F2	Correlation coefficient between North and Up.
*Name may represent an alias of the Normative Name for the UL key							

9.12.4 Boundary Structure

A Boundary Structure is a Series of vertices that define an area or volume enclosing a region of interest. The Boundary Structure is a SMPTE 336M-2007 Variable-Length Pack, which includes the BER-encoded Length for each element.

Each vertex is an element of type Location. There is no limit on the number of vertices in a Boundary. The vertices should be ordered so that looking toward Earth center, they spiral in a clockwise direction away from the Earth[8]. An example of a shape and expected ordering of vertices is depicted in Figure 10. Vertices 1-4 are coplanar, as are vertices 5-8. The vertices would be encoded in the following order: [1, 2, 3, 4, 5, 6, 7, and 8].

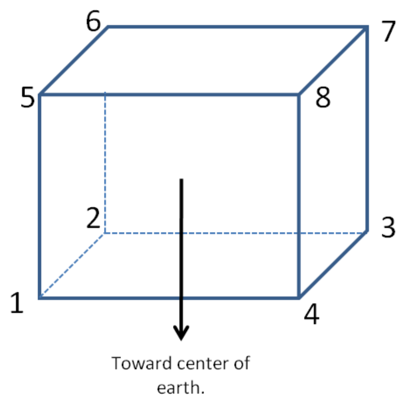

Figure 10. Example of a Simple Cubic Boundary

At least two vertices must be specified. When only two vertices are provided, they should be interpreted as opposite corners of a simple, planar bounding box, aligned with the Latitude-Longitude grid.

Requirement(s)	
ST 0903.4-93	A Boundary data type shall contain at least two vertices.
ST 0903.4-94	If Boundary data type contains just two vertices, then the vertices shall be interpreted as opposite corners of a simple, planar bounding box, aligned with the Latitude-Longitude grid.

[8] The distances of the vertices from the Earth might not increase in a strictly monotonic fashion. One can imagine a sequence of vertices that exhibit "rollercoaster" behavior (without loops and crossovers).

9.12.4.1 Boundary Series

Table 12: Boundary Series

Boundary Series							
Tag ID	Key Value (hex)	Key Name	Data Type	Units	KLV Format	Length in Bytes	Notes
	06.0E.2B.34.02.04.01.01 0E.01.03.03.17.00.00.00 (CRC 11851)	Boundary Series	N/A	None	N/A	Variable	This is the Universal Key for the Bounding Box Series
N/A	06.0E.2B.34.02.05.01.01 0E.01.03.03.14.00.00.00 (CRC 28126)	Location Pack	An Array of Location Elements	NA	A Series of Location Elements	V	A Series of Location data elements, one for each vertex of a bounding area or volume. Generally used for (planar) bounding boxes. However, it can support the specification of multifaceted (triangulated) volumes, as well, and it is used in this manner to describe the bounding volume of a track in VTracker.

10 VTrack Local Set (LS) – Track Metadata

This section defines the track metadata local set, which is named VTrack LS. With few exceptions, the data elements of the VTrack LS are the same as those defined for the VMTI LS. Whereas the VMTI LS describes detections of object movement associated with a single frame, the VTrack LS describes a set of detections that may span many frames and are presumed to be associated with a single, identified object. The VTrack LS adopts a “track-centric” view of the detection data, whereas the VMTI LS has a “frame-centric” view. The data elements used to describe a detection are the same, regardless of which view is taken, but they are organized differently. Section 12 portrays the UML[9] data model of the VMTI LS, and Section 13 the data model of the VTrack LS. Examination and comparison of the two models should make the differences in organization readily apparent.

The VMTI LS contains an element VTargetSeries, which is comprised of a set of VTarget detections for a given frame. Similarly, the VTrack LS contains an element VTrackItemSeries, which is comprised of a set of VTrackItem detections associated with a track.

The VTrack LS and its constituent VTrackItem Packs provide a mechanism for reporting complete tracks, from the first detection of object movement to the latest. However, VTrack LS can also be used to report track updates, including new detections that extend a previously reported track, or updates to previously reported track information.

Tables summarizing the VTrack LS and the VTrackItem Pack are defined in this section, with descriptions of each element unique to the VTrack LS (those not found in the VMTI LS).

Note that the VMTI LS contains an element, VTracker[10], which could be used as an alternative to VTrack LS to specify track metadata. VTracker contains spatial and temporal information for a given detection within a frame, including preceding detections of the same (presumed) object. Use of VTracker is discouraged (although not forbidden). Use of VTrack LS is recommended, because it maps more directly to NATO STANAG 4676, the NATO ISR Tracking Standard.[11]

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[9] Unified Modeling Language (UML) is a specification developed by Object Management Group, a not-for-profit computer industry consortium, defining a graphical language for visualizing, specifying, constructing, and documenting the artifacts of distributed object systems.

[10] Note the distinction between VTrack<u>er</u> and VTrack (no “er”).

[11] STANAG 4676 Edition 1 currently lacks the extensive set of motion imagery feature information provided by VTrack to support object disambiguation and identification. Also, STANAG 4676 Edition 1 recognizes only XML as a data encoding method, which (because of its “verbosity”) limits its use in bandwidth-limited communications environments. Use of a more efficient data encoding method (such as, “binary XML”) might mitigate this deficiency. As STANAG 4676 matures to address these deficiencies, it may become the preferred representation for motion imagery derived tracks.

10.1 VTrack LS Elements

The VTrack LS, shown in Table 13, consists primarily of metadata elements that appear in the VMTI LS (and its VTracker Pack), plus one additional data element, VTrackItemSeries.

VTrackItemSeries contains a set of VTrackItem Packs. Each VTrackItem Pack describes a time-ordered sequence of points (e.g. VMTI detections) along the track of a moving object. Such track points are often connected using straight line segments to describe (an approximation of) the path taken by the moving object. However, this Standard does not restrict interpretation of the points solely to this manifestation.

Table 13: VTrack LS

VTrack LS							
Tag ID	Key Value (hex)	Tag Name*	Data Type	Units	KLV Format	Length in Bytes	Notes
	06.0E.2B.34.02.03.01.01. 0E.01.03.03.1E.00.00.00 (CRC 62593)	VTrack KLV Dictionary	N/A	None	N/A	Variable	This is the Universal Key for the VTrack LS
1	06.0E.2B.34.01.01.01.01 0E.01.02.03.01.00.00.00 (CRC 56132)	Checksum					See Table 1: VMTI LS.
2	06.0E.2B.34.01.01.01.03 07.02.01.01.01.05.00.00 (CRC 64827)	Track Time Stamp					See Table 1: VMTI LS. This Precision Time Stamp indicates the time of the track report. By contrast, Track End Time (VTrack LS Tag 6) indicates the time of the most recent observation of the entity.
3	06.0E.2B.34.01.01.01.01 0E.01.01.03.35.00.00.00 (CRC 62396)	Track ID					See Table 6: VTracker LS
4	06.0E.2B.34.01.01.01.01 0E.01.01.03.36.00.00.00 (CRC 26720)	Track Status					See Table 6: VTracker LS.
5	06.0E.2B.34.01.01.01.03 07.02.01.01.01.05.00.00 (CRC 64827)	Track Start Time					See Table 6: VTracker LS.
6	06.0E.2B.34.01.01.01.03 07.02.01.01.01.05.00.00 (CRC 64827)	Track End Time					See Table 6: VTracker LS.
7	06.0E.2B.34.02.04.01.01 0E.01.03.03.17.00.00.00 (CRC 11851)	Track Bounding Box					See Table 6: VTracker LS.
8	06.0E.2B.34.01.01.01.01 0E.01.02.03.49.00.00.00 (CRC 12315)	Tracker Algorithm					See Table 6: VTracker LS.
9	06.0E.2B.34.01.01.01.01 0E.01.01.03.37.00.00.00 (CRC 7892)	Track Confidence					See Table 6: VTracker LS.

VTrack LS							
Tag ID	Key Value (hex)	Tag Name*	Data Type	Units	KLV Format	Length in Bytes	Notes
10	06.0E.2B.34.01.01.01.01 0E.01.02.02.7C.00.00.00 (CRC 2790)	VMTI System Name / Description					See Table 1: VMTI LS.
11	06.0E.2B.34.01.01.01.01 0E.01.02.05.04.00.00.00 (CRC 43652)	VMTI LS Version Number					See Table 1: VMTI LS.
12	06.0E.2B.34.01.01.01.01 04.20.01.02.01.01.00.00 (CRC 53038)	VMTI Source Sensor					See Table 1: VMTI LS.
13	06.0E.2B.34.01.01.01.01 0E.01.01.03.38.00.00.00 (CRC 51770)	Number of Track Points					The number of VTrackItem Packs contained in the VTrackItemSeries (Tag 101).
101	06.0E.2B.34.02.04.01.01 0E.01.03.03.1F.01.00.00 (CRC 40120)	VTrackItemSeries	Series	NA	NA	V	Series of track item metadata elements, each of which is a VTrackItem Pack.
*Tag Name may represent an alias of the Normative Name for the UL key							

10.2 VTrackItem Pack

The VTrackItem Pack, shown in Table 14 contains data elements from the VMTI LS and the VMTI VTarget Pack to describe not only the geographic location of a track point, but also a rich characterization of the moving object, including velocity, acceleration, appearance (features), and type. Furthermore, VTrackItem supports identification and reference (“linking”) to the Motion Imagery essence in which the moving object appeared and from which detections of its movement were made.

The reference to – that is, the link to – the Motion Imagery essence is a Uniform Resource Identifier (URI), which uniquely identifies a Motion Imagery stream or file. The Motion Imagery essence URI may be a Uniform Resource Name (URN) that is a Core Identifier compliant with MISB ST 1204 Motion Imagery Identification System [4]. Alternatively, the Motion Imagery essence URI may be a Uniform Resource Locator (URL) that not only uniquely identifies the Motion Imagery essence but also provides a means for locating the essence by describing its access mechanism (e.g. its network “location”). IETF RFC 3986 [11] defines URI syntax and a process for resolving URI references.

The VTrackItem Pack contains two distinct metadata elements to reference the Motion Imagery essence: (1) Tag 19 Motion Imagery ID that is a URN compliant with MISB ST 1204 [4] and (2) Tag 24 Motion Imagery URL that is a URL compliant with RFC 3986. If desired, both elements may appear.

Table 14: VTrackItem Pack

VTrackItem Pack							
Tag ID	Key Value (hex)	Tag Name*	Data Type	Units	KLV Format	Length in Bytes	Notes
	06.0E.2B.34.02.05.01.01 0E.01.03.03.20.01.00.00 (CRC 48374)	VTrackItem Pack	N/A	None	N/A	Variable	This is the Universal Key for the VTrackItem Pack.
N/A	N/A	Target ID Number					See Table 2: VTarget Pack.
1	06.0E.2B.34.01.01.01.03 07.02.01.01.01.05.00.00 (CRC 64827)	Target Time Stamp					See Table 1: VMTI LS.
2	06.0E.2B.34.01.01.01.01 0E.01.02.03.38.00.00.00 (CRC 1242)	Target Centroid Pixel Number					See Table 2: VTarget Pack.
3	06.0E.2B.34.01.01.01.01 0E.01.02.03.58.00.00.00 (CRC 23816)	Target Centroid Pixel Row					See Table 2: VTarget Pack.
4	06.0E.2B.34.01.01.01.01 0E.01.02.03.59.00.00.00 (CRC 11196)	Target Centroid Pixel Column					See Table 2: VTarget Pack.
5	06.0E.2B.34.01.01.01.01 0E.01.02.03.39.00.00.00 (CRC 29294)	Bounding Box Top Left Pixel Number					See Table 2: VTarget Pack.
6	06.0E.2B.34.01.01.01.01 0E.01.02.03.3A.00.00.00 (CRC 59826)	Bounding Box Bottom Right Pixel Number					See Table 2: VTarget Pack.
7	06.0E.2B.34.01.01.01.01 0E.01.02.03.3B.00.00.00 (CRC 40710)	Target Priority					See Table 2: VTarget Pack.
8	06.0E.2B.34.01.01.01.01 0E.01.02.03.3C.00.00.00 (CRC 52779)	Target Confidence Level					See Table 2: VTarget Pack.
9	06.0E.2B.34.01.01.01.01 0E.01.02.03.3D.00.00.00 (CRC 47263)	New Detection Flag / Target History					See Table 2: VTarget Pack.
10	06.0E.2B.34.01.01.01.01 0E.01.02.03.3E.00.00.00 (CRC 9027)	Percentage of Target Pixels					See Table 2: VTarget Pack.
11	06.0E.2B.34.01.01.01.01 0E.01.02.03.3F.00.00.00 (CRC 22007)	Target Color					See Table 2: VTarget Pack.
12	06.0E.2B.34.01.01.01.01 0E.01.02.03.40.00.00.00 (CRC 50028)	Target Intensity					See Table 2: VTarget Pack.
13	06.0E.2B.34.02.05.01.01 0E.01.03.03.14.00.00.00 (CRC 28126)	Target Location					See Table 2: VTarget Pack.
14	06.0E.2B.34.02.04.01.01 0E.01.03.03.17.00.00.00 (CRC 11851)	Target Boundary					See Table 2: VTarget Pack.

VTrackItem Pack							
Tag ID	Key Value (hex)	Tag Name*	Data Type	Units	KLV Format	Length in Bytes	Notes
15	06.0E.2B.34.02.05.01.01 0E.01.03.03.15.00.00.00 (CRC 7018)	Velocity					See Table 6: VTracker LS.
16	06.0E.2B.34.02.05.01.01 0E.01.03.03.16.00.00.00 (CRC 32950)	Acceleration					See Table 6: VTracker LS.
17	06.0E.2B.34.02.05.01.01 0E.01.03.03.1D.01.00.00 (CRC 43417)	FPA Index					See Table 2: VTarget Pack.
18	06.0E.2B.34.01.01.01.01 0E.01.01.03.1F.00.00.00 (CRC 44121)	Motion Imagery Frame Number					See Table 1: VMTI LS.
19	06.0E.2B.34.01.01.01.01 0E.01.04.05.03.00.00.00 (CRC 30280)	Motion Imagery ID	Binary	NA	Binary	V	A Motion Imagery Identification System (MIIS) Core Identifier, compliant with ST 1204[4].
20	06.0E.2B.34.01.01.01.01 0E.01.01.02.07.00.00.00 (CRC 39020)	Frame Width					See Table 1: VMTI LS.
21	06.0E.2B.34.01.01.01.01 0E.01.01.02.08.00.00.00 (CRC 19586)	Frame Height					See Table 1: VMTI LS.
22	06.0E.2B.34.01.01.01.02 04.20.02.01.01.08.00.00 (CRC 23753)	Sensor Horizontal Field of View					See Table 1: VMTI LS.
23	06.0E.2B.34. 01.01.01.07 04.20.02.01.01.0A.01.00 (CRC 30292)	Sensor Vertical Field of View					See Table 1: VMTI LS.
24	06.0E.2B.34.01.01.01.01 0E.01.01.03.31.00.00.00 (CRC 14669)	Motion Imagery URL	String	NA	UTF-8	V	A Uniform Resource Locator (URL) for the Motion Imagery essence, compliant with Internet Standard RFC 3986 [11].
101	06.0E.2B.34.02.03.01.01 0E.01.03.03.08.00.00.00 (CRC 51391)	VMask LS					See Table 3: VMask LS.
102	06.0E.2B.34.02.03.01.01 0E.01.03.03.09.00.00.00 (CRC 48651)	VObject					See Table 4: VObject LS.
103	06.0E.2B.34.02.03.01.01 0E.01.03.03.0A.00.00.00 (CRC 9687)	VFeature LS					See Table 5: VFeature LS.
105	06.0E.2B.34.02.03.01.01 0E.01.03.03.13.00.00.00 (CRC 52487)	VChip LS					See Table 7: VChip LS

VTrackItem Pack							
Tag ID	Key Value (hex)	Tag Name*	Data Type	Units	KLV Format	Length in Bytes	Notes
106	06.0E.2B.34.02.04.01.01 0E.01.03.03.14.00.00.00 (CRC 46487)	VChipSeries					See Table 2: VTarget Pack
*Tag Name may represent an alias of the Normative Name for the UL key							

Requirement(s)	
ST 0903.4-95	VTrackItem Pack Motion Imagery ID (Tag 19) shall be a Motion Imagery Identification System Core Identifier that complies with MISB ST 1204 [4].
ST 0903.4-96	VTrackItem Pack Motion Imagery URL (Tag 24) shall be a Uniform Resource Locator (URL) that complies with IETF RFC 3986 [11].

10.3 Required VTrack and VTrackItem Data Elements

Both the VTrack LS and the VTrackItem Pack contain data elements that might not be required every time VTrack and its constituent VTrackItems are reported, either because the tracking system is incapable of producing such data or because the data changes infrequently.

Especially when sending metadata in a bandwidth-constrained environment, it is prudent and justified to devote most of the available bandwidth to information that changes rapidly, sending less frequently changing information less often. For example, the location of the moving object should be provided at every opportunity, whereas an image chip (VChip) of the object might be provided just "once in a while".

With one exception, data elements that must be provided every time a track is reported or updated are listed in Table 15.

Table 15: Required Metadata Elements[12]

Required Metadata Elements			
VTrack	**VTrackItem**	**Tag ID**	**Name**
X		01	Checksum
X		02	Track Time Stamp (Precision Time Stamp)
X		03	Track ID
	X	N/A	Target ID Number
	X	01	Target Time Stamp
	X	13	Target Location

[12] These required metadata elements are consistent with those required by STANAG 4676.

The exception occurs for a VTrack report when Track Status is "Dropped". In this case, there might be no location information to report, in which case the VTrackItem metadata elements may be omitted.

Requirement(s)	
ST 0903.4-97	The VTrack LS and VTrackItem Pack metadata elements listed in MISB ST 0903.4 Table 15 shall be provided every time a track is reported or updated, unless the VTrack LS Track Status (Tag 4) indicates a status of "Dropped", in which case the VTrackItem metadata elements may be omitted.

11 Appendix A: Detailed Key Data – Normative

The following sections provide additional information on the metadata elements in ST 0903. Note that additional requirements follow usage of some elements.

11.1 Tag 1: Checksum

Data Element Definition			
Element Name	Checksum	Type	Units
		Unsigned Integer	None
Valid Values	All integer values from 0 to 0xFFFF (65,535) Recomputed for each VMTI LS instance		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.02.03.01.00.00.00 (CRC 56132)		VMTI LS Tag
			1
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	2 Bytes	Binary
Notes			
- Checksum used to detect errors within a Local Set packet. - Lower 16-bits of summation. Refer to MISB ST 0601 for 16-bit checksum algorithm. - Performed on entire LS packet, including 16-byte US key and 1-byte checksum length.			
Conversion			
NA			
Example Value		Example Encoded LS Value	
0x00 00		[K] [L] [V] = [0x01] [0x02] [0x00 00]	

11.2 Tag 2: Precision Time Stamp

<table>
<tr><th colspan="4">Data Element Definition</th></tr>
<tr><td rowspan="2">Element Name</td><td rowspan="2">UNIX Time Stamp</td><td>Type</td><td>Units</td></tr>
<tr><td>Unsigned Integer</td><td>Microseconds</td></tr>
<tr><td rowspan="2">Valid Values</td><td colspan="2" rowspan="2">All integer values from 0 to (2 ^ 64) – 1
Unique for each VMTI LS instance</td><td>Precision</td></tr>
<tr><td>1 microsecond</td></tr>
<tr><th colspan="4">KLV Encoding</th></tr>
<tr><td rowspan="2">Universal Label</td><td colspan="2" rowspan="2">06.0E.2B.34.01.01.01.03.07.02.01.01.01.05.00.00 (CRC 64827)</td><td>VMTI LS Tag</td></tr>
<tr><td>2</td></tr>
<tr><td>Volatility</td><td>Encoded Type</td><td>Length</td><td>Format</td></tr>
<tr><td>Dynamic</td><td>Unsigned Integer</td><td>8 Bytes</td><td>Binary</td></tr>
<tr><td colspan="4">Notes</td></tr>
<tr><td colspan="4">- Microseconds elapsed since midnight Coordinated Universal Time (UTC) of January 1, 1970.
- See MISB ST 0603 [12].
- If the VMTI LS is subordinate to a MISB ST 0601 LS under Tag 74, a time stamp will already be present in the MISB ST 0601 LS. In this case, the VMTI LS Precision Time Stamp may be omitted. However, it is still recommended, albeit not required, that a Precision Time Stamp be included at the beginning of the value portion of a VMTI LS.
- The most significant reason the VMTI LS Precision Time Stamp is only recommended and not mandatory is that some VMTI systems will not have access to a time source. Data from such systems is still considered useful even if only aligned with the Motion Imagery by time of arrival.</td></tr>
<tr><td colspan="4">Conversion</td></tr>
<tr><td colspan="4">NA</td></tr>
<tr><td colspan="2">Example Value</td><td colspan="2">Example Encoded LS Value</td></tr>
<tr><td colspan="2">April 19 2001, 04:25:21.000000 GMT</td><td colspan="2">[K] [L] [V] = [0x02] [0x08] [0x00 03 82 44 30 F6 CE 40]</td></tr>
</table>

11.3 Tag 3: VMTI System Name / Description

Data Element Definition			
Element Name	VMTI System Name / Description	Type	Units
		String	NA
Valid Values	A string of any UTF-8 Characters up to 32 characters long		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.02.02.7C.00.00.00 (CRC 2790)		VMTI LS Tag
			3
Volatility	Encoded Type	Length	Format
Static	String	Variable up to 32 Bytes	UTF-8
Notes			
- Name or description of the VMTI system that produced the VMTI targets. It should be as descriptive as possible. - Value field is free text. - Null termination is not required			
Conversion			
NA			
Example Value	Example Encoded LS Value		
DSTO_ADSS_VMTI	[K] [L] [V] = [0x03] [0x0E] [0x44 53 54 4F 5F 41 44 53 53 5F 56 4D 54 49]		

11.4 Tag 4: VMTI LS Version Number

Data Element Definition			
Element Name	VMTI LS Version Number	Type	Units
		Unsigned Integer	NA
Valid Values	All integer values from 0 to 0xFFFF (65535)		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.02.05.04.00.00.00 (CRC 43652)		VMTI LS Tag
			4
Volatility	Encoded Type	Length	Format
Static	Unsigned Integer	Variable up to 2 Bytes	Binary
Notes			
- Version number of the VMTI LS document used to generate the VMTI metadata. Notifies downstream clients of the version of the VMTI LS used to encode the VMTI metadata. - Values of 1 through 65535 correspond to document revisions 1 through 65535. - Version 4 (ST0903.4) would be encoded as shown in the example below.			
Conversion			
NA			
Example Value	Example Encoded LS Value		
4	[K] [L] [V] = [0x04] [0x01] [0x04]		

11.5 Tag 5: Total Number of Targets Detected in the Frame

Data Element Definition			
Element Name	Total Number of Targets Detected in the Frame	Type	Units
		Unsigned Integer	NA
Valid Values	All integer values from 0 to 0xFFFFFF (16,777,215)		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.02.03.36.00.00.00 (CRC 42624)		VMTI LS Tag
			5
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	Variable up to 3 Bytes	Binary
Notes			
- Total number of moving targets detected in the frame. Particularly relevant when the number of targets reported (VMTI LS Tag 6) is less than the total number detected in the frame. - A value of 0 represents no targets detected			
Conversion			
NA			
Example Value	Example Encoded LS Value		
28 (0x1C)	[K] [L] [V] = [0x05] [0x01] [0x1C]		

11.6 Tag 6: Number of Reported Targets

Data Element Definition			
Element Name	Total Number of Reported Targets	Type	Units
		Unsigned Integer	NA
Valid Values	All integer values from 0 to 0xFFFFFF (16,777,215)		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.02.03.37.00.00.00 (CRC 53300)		VMTI LS Tag
			6
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	Variable up to 3 Bytes	Binary
Notes			
- Number of moving targets reported from the frame. May be necessary (for bandwidth efficiency) to report only a subset of detected targets. - Number of Reported Targets = Total Number of Targets (Tag 5) – Number of Culled Targets - The culling process is usually linked to priority value or confidence level.			
Conversion			
NA			
Example Value	Example Encoded LS Value		
14 (0x0E)	[K] [L] [V] = [0x06] [0x01] [0x0E]		

11.7 Tag 7: Motion Imagery Frame Number

Data Element Definition			
Element Name	Motion Imagery Frame Number	Type	Units
		Unsigned Integer	NA
Valid Values	All integer values from 0 to 0xFFFFFF (16,777,215)		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.01.03.1F.00.00.00 (CRC 44121)		VMTI LS Tag
			7
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	Variable up to 3 Bytes	Binary
Notes			
- The Motion Imagery frame number corresponding to the frame in which the targets were detected. - Use of the Precision Time Stamp (Tag 2) is preferred, but frame number can be used when a time stamp is not available. - Range 0 to 2^{24} -1 which equates to approximately 155 hours at 30fps.			
Conversion			
NA			
Example Value	Example Encoded LS Value		
78,000 (0x0130B0)	[K] [L] [V] = [0x07] [0x03] [0x01 30 B0]		

11.8 Tag 8: Frame Width

Data Element Definition			
Element Name	Frame Width	Type	Units
		Unsigned Integer	Pixels
Valid Values	All integer values from 1 to 0xFFFFFF (16,777,215)		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.01.02.07.00.00.00 (CRC 39020)		VMTI LS Tag
			8
Volatility	Encoded Type	Length	Format
Periodic	Unsigned Integer	Variable up to 3 Bytes	Binary
Notes			
- Width of the Motion Imagery frame in pixels. - Pixels are assumed to appear in row-major order. Frame Width corresponds to the number of pixels in a row of the image. - Value of zero is meaningless and should not be used			
Conversion			
NA			
Example Value	Example Encoded LS Value		
1920 (0x0780)	[K] [L] [V] = [0x08] [0x02] [0x07 80]		

An efficient method to express the location of a target within a Motion Imagery frame is with Target Centroid Pixel Number (VTarget Pack Tag 1). Computing Target Centroid Pixel Number from pixel row and column coordinates requires knowledge of the Motion Imagery frame width. Fortunately, the Motion Imagery from which VMTI information is derived will always include appropriate frame size information.

Converting Target Centroid Pixel Number back to row/column coordinates, however, presents an issue. Consider the case when VMTI information is derived from Motion Imagery different than that disseminated; for example, two cameras in one turret (say, narrow and wide angle), one used in the VMTI process and the other producing Motion Imagery within a transport stream for downstream users. A second case is when VMTI information is transported independent of Motion Imagery. In both cases, the frame width must be specified using the Frame Width metadata element.

11.9 Tag 9: Frame Height

Data Element Definition			
Element Name	Frame Height	Type	Units
		Unsigned Integer	Pixels
Valid Values	All integer values from 1 to 0xFFFFFF (16,777,215)		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.01.02.08.00.00.00 (CRC 19586)		VMTI LS Tag
			9
Volatility	Encoded Type	Length	Format
Periodic	Unsigned Integer	Variable up to 3 Bytes	Binary
Notes			
- Height of the Motion Imagery frame in pixels. Frame Height is never a required field. - Pixels are assumed to appear in row-major order. Frame Height corresponds to the number of rows of pixels in the image. - Value of zero is meaningless and should not be used			
Conversion			
NA			
Example Value	Example Encoded LS Value		
1080 (0x0438)	[K] [L] [V] = [0x09] [0x02] [0x04 38]		

11.10 Tag 10: VMTI Source Sensor

Data Element Definition			
Element Name	VMTI Source Sensor	Type	Units
		String	NA
Valid Values	A string of any UTF-8 Characters up to 127 characters long		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.04.20.01.02.01.01.00.00 (CRC 53038)		VMTI LS Tag
			10
Volatility	Encoded Type	Length	Format
Periodic	String	Variable up to 127 Bytes	UTF-8
Notes			
- Free text identifier of the image source sensor e.g. 'EO Nose', 'EO Zoom (DLTV)', 'EO Spotter', 'IR Mitsubishi PtSi Model 500', 'IR InSb Amber Model TBT', 'LYNX SAR Imagery', 'TESAR Imagery', etc. - Can be used to identify the VMTI process if more than one is run simultaneously. - Can be used to identify the imagery source on which the VMTI process was run for systems that have multiple bore-sighted sensors. - Null termination of the string is not required - Must be updated at the first opportunity following a change.			
Conversion			
NA			
Example Value	Example Encoded LS Value		
“EO Nose”	[K] [L] [V] = [0x0A][0x07][0x45 4F 20 4E 6F 73 65]		

11.11 Tag 11: VMTI Sensor Horizontal Field of View

Data Element Definition			
Element Name	VMTI Sensor Horizontal Field of View	Type	Units
		Float	Degrees
Valid Values	The set of real numbers from 0 to 180 inclusive		Precision
			Refer to MISB ST 1201
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.02.04.20.02.01.01.08.00.00 (CRC 23753)		VMTI LS Tag
			11
Volatility	Encoded Type	Length	Format
Periodic	Unsigned Integer	2 Bytes	Binary
Notes			
- Horizontal field of view of imaging sensor input to VMTI process. Required only if VMTI process is run on a different imaging sensor than that described by the parent MISB ST 0601 packet. - Can be used with HFOV (Tag 16) from MISB ST 0601 to scale VMTI column, Row coordinates.			
Conversion			
IMAPB(0, 180, 2)			
Example Value	Example Encoded LS Value		
12.5 Degrees	[K] [L] [V] = [0x0B][0x02][0x06 40]		

VMTI Sensor Horizontal Field of View Tag 11 (HFOV) should only be populated when the Motion Imagery input to the VMTI process is *different* from that streamed (i.e. with an MPEG-2 TS or RTP container) with the MISB ST 0601 data. Under these circumstances and when the two sensors share a common boresight, the ratio (k_x) of the HFOV value in the VMTI LS to the value recorded in the MISB ST 0601 stream can be used to scale the VMTI *Column* coordinate for the display of the streamed Motion Imagery. The scaling is given by:

$$x_2 = k_x\left(x_1 - \left(\frac{Frame\_Width}{2}\right)\right) + \frac{Frame\_Width}{2}$$

Where: x_1 is the original *Column* coordinate of the target extracted from the target pixel number.
x_2 is the scaled *Column* coordinate of the target in the Motion Imagery.
k_x is the scaling factor calculated according to the following equation:

$$k_x = \frac{\tan\left(\frac{1}{2}\theta_{H1}\right)}{\tan\left(\frac{1}{2}\theta_{H2}\right)}$$

Where: θ_{H1} is the HFOV of the original (VMTI) sensor (degrees).
θ_{H2} is the HFOV of the sensor to which the targets are being scaled (degrees).

It is expected that in most cases k_x will be sufficient to perform scaling in the *Column* direction (*Row* scaling uses frame height rather than frame width – see Tag 12). The VFOV element in VMTI LS Tag 12 is provided for those cases where the aspect ratio of the two sensors is different (for example 4:3 and 16:9).

These equations are valid if the frame width of the two sensors is the same. If not, the equation becomes more complex.

When the streamed Motion Imagery is from a narrow field of view sensor, and the VMTI process is run on Motion Imagery from a bore-sighted wide field of view sensor, it can be expected that moving targets will be outside the frame boundaries of the streamed Motion Imagery. Under these circumstances, the display device could add a blank border around the active area and present the moving targets to the operator – albeit without the underlying Motion Imagery content. Alternatively, the display device could present highlights around the perimeter of the frame to indicate movers that are outside the frame along with their radial direction from the bore-sight.

11.12 Tag 12: VMTI Sensor Vertical Field of View

Data Element Definition			
Element Name	VMTI Sensor Vertical Field of View	Type: Float	Units: Degrees
Valid Values	The set of real numbers from 0 to 180 inclusive		Precision: Refer to MISB ST 1201
KLV Encoding			
Universal Label	06.0E.2B.34. 01.01.01.07.04.20.02.01.01.0A.01.00 (CRC 30292)		VMTI LS Tag: 12
Volatility	Encoded Type	Length	Format
Periodic	Unsigned Integer	2 Bytes	Binary
Notes			
- Vertical field of view of imaging sensor input to VMTI process. Required only if VMTI process is run on a different imaging sensor from that described by the parent MISB ST 0601 packet. - Can be used with VFOV (Tag 17) from MISB ST 0601 to scale VMTI *Column*, *Row* coordinates - Typically required only to account for aspect ratio variation.			
Conversion			
IMAPB(0, 180, 2)			
Example Value	Example Encoded LS Value		
10.0 Degrees	[K] [L] [V] = [0x0C][0x02][0x05 00]		

VMTI Sensor Vertical Field of View Tag 12 should only be populated when the Motion Imagery input to the VMTI process is *different* from that streamed (i.e. with an MPEG-2 TS or RTP container) with the MISB ST 0601 data. Under these circumstances, and when the two sensors share a common boresight, the ratio (k_y) of the VFOV value in the VMTI LS to the value recorded in the MISB ST 0601 stream can be used to scale the VMTI *Row* coordinate for the display of the streamed Motion Imagery. The scaling is given by:

$$y_2 = k_y\left(y_1 - \left(\frac{Frame\_Height}{2}\right)\right) + \frac{Frame\_Height}{2}$$

Where: y_1 is the original *Row* coordinate of the target extracted from the target pixel number.
y_2 is the scaled *Row* coordinate of the target in the Motion Imagery.
k_y is the scaling factor calculated according to the following equation:

$$k_y = \frac{\tan\left(\frac{1}{2}\theta_{V1}\right)}{\tan\left(\frac{1}{2}\theta_{V2}\right)}$$

Where: θ_{V1} is the VFOV of the original (VMTI) sensor (degrees).
θ_{V2} is the VFOV of the sensor to which the targets are being scaled (degrees).

It is expected that in most cases k_x (see Tag 11) will be sufficient to perform scaling in the *Row* direction. The VFOV element in VMTI LS Tag 12 is provided for those cases where the aspect ratio of the two sensors is different (for example 4:3 and 16:9). These equations are valid if the frame height of the two sensors is the same. If not, the equation becomes more complex.

11.13 Tag 13: Motion Imagery ID

Data Element Definition			
Element Name	Motion Imagery ID	Type	Units
		Binary	NA
Valid Values	A Motion Imagery Identification System (MIIS) Core Identifier, compliant with MISB ST 1204 [4].		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.04.05.03.00.00.00 (CRC 30280)		VMTI LS Tag
			13
Volatility	Encoded Type	Length	Format
Periodic	Unsigned Integer	Variable	Binary
Notes			
- Provides a unique identifier for the Motion Imagery stream in which the targets were detected. - Appearance of this data element in the metadata stream is desirable but not mandatory. - If the VMTI LS is subordinate to a MISB ST 0601 LS under Tag 74, a MIIS Core Identifier may already be present in the MISB ST 0601 LS. In this case, this data element may be omitted.			
Conversion			
NA			
Example Value	Example Encoded LS Value		
See MISB ST 1204 [4].			

11.14 Tag 101: VTargetSeries

Data Element Definition			
Element Name	VTargetSeries	Type	Units
		Array	VTarget Pack
Valid Values	All valid VTarget Pack structures		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.02.04.01.01.0E.01.03.03.1B.00.00.00 (CRC 24953)		VMTI LS Tag
			101
Volatility	Encoded Type	Length	Format
Dynamic	Series	Variable	VTarget Pack

Notes

- Series of VTarget Packs.
- The length field for VTargetSeries is the sum of the lengths of all the contained target metadata.
- The length field for each VTarget Pack is the size of all elements within that pack, including the TargetID.
- The mandatory Target ID Number (first element of each VTarget Pack) allows discrimination between instances.
- Multiple instances of VTarget Pack can reside in one VTargetSeries.

Conversion

NA

Example Value	Example Encoded LS Value
Three VTarget Packs with Target IDs of 1, 2 and 3	[K] [L] [V] = [0x65] [0xL0] [0xL1 0x01 … 0xL2 0x02 … 0xL3 0x03 …]

11.15 VTarget Pack

<table>
<tr><th colspan="4">Data Element Definition</th></tr>
<tr><td rowspan="2">Element Name</td><td rowspan="2">VTarget Pack</td><td>Type</td><td>Units</td></tr>
<tr><td>Structure</td><td>NA</td></tr>
<tr><td rowspan="2">Valid Values</td><td colspan="2" rowspan="2">This is a data structure composed of a Target ID Number and a sequence of Tag-Length-Value triplets</td><td>Precision</td></tr>
<tr><td>NA</td></tr>
<tr><th colspan="4">KLV Encoding</th></tr>
<tr><td rowspan="2">Universal Label</td><td colspan="2" rowspan="2">06.0E.2B.34.02.05.01.01.0E.01.03.03.07.00.00.00 (CRC 60837)</td><td>LS Tag</td></tr>
<tr><td>NA</td></tr>
<tr><td>Volatility</td><td>Encoded Type</td><td>Length</td><td>Format</td></tr>
<tr><td>Dynamic</td><td>Pack</td><td>Variable</td><td>Binary</td></tr>
<tr><td colspan="4">Notes</td></tr>
<tr><td colspan="4">- A VTarget Pack has a structure that is identical to a Local Set with the exception that the mandatory Target ID Number element has neither Tag nor length.
- VTarget Pack contains metadata elements that describe one single target.</td></tr>
<tr><td colspan="4">Conversion</td></tr>
<tr><td colspan="4">NA</td></tr>
<tr><td>Example Value</td><td colspan="3">Example Encoded LS Value</td></tr>
<tr><td>Target ID = 27 (0x1B)
Centroid Pixel = 409,600 (0x06 40 00)</td><td colspan="3">[ID {T_i L_i V_i}] = [0x1B {0x01 0x03 [0x06 40 00]}]</td></tr>
</table>

11.15.1 Target ID Number

<table>
<tr><th colspan="4">Data Element Definition</th></tr>
<tr><td rowspan="2">Element Name</td><td rowspan="2">Target ID Number</td><td>Type</td><td>Units</td></tr>
<tr><td>Unsigned Integer</td><td>NA</td></tr>
<tr><td rowspan="2">Valid Values</td><td colspan="2" rowspan="2">All integer values from 1 to 2,097,151</td><td>Precision</td></tr>
<tr><td>NA</td></tr>
<tr><th colspan="4">KLV Encoding</th></tr>
<tr><td rowspan="2">Universal Label</td><td colspan="2" rowspan="2">NA</td><td>Pack Tag</td></tr>
<tr><td>NA</td></tr>
<tr><td>Volatility</td><td>Encoded Type</td><td>Length</td><td>Format</td></tr>
<tr><td>Dynamic</td><td>Unsigned Integer</td><td>Variable up to 3 Bytes</td><td>BER-OID</td></tr>
<tr><td colspan="4">Notes</td></tr>
<tr><td colspan="4">- This element is mandatory and it must come first in the VTarget Pack.
- It is BER-OID encoded to convey the length but has no Tag field.
- A value of zero is not to be used.
- BER-OID encoding allocates the upper bit of each Byte to indicate “last Byte” (0) or not (1). 3 Bytes provide up to 21 bits for the ID value, for a maximum value of 2,097,151.
- Uniquely identifies a target across multiple frames until the identification number is reset by the New Detection Flag (Tag 6 within the VTarget Pack).
- Sophisticated VMTI systems may use the same Target ID Number to identify a common target detected by different sensors, and therefore allow correlation between targets detected simultaneously by different sensor systems.</td></tr>
<tr><td colspan="4">Conversion</td></tr>
<tr><td colspan="4">NA</td></tr>
<tr><td colspan="2">Example Value</td><td colspan="2">Example Encoded LS Value</td></tr>
<tr><td colspan="2">1234 = [0x04 D2] = [0000 0100][1101 0010]$_2$</td><td colspan="2">[V] = [1 000 1001][0 101 0010]$_2$ = [0x89 52]</td></tr>
</table>

11.15.2 Tag 1: Target Centroid Pixel Number

Data Element Definition			
Element Name	Target Centroid Pixel Number	Type	Units
		Unsigned Integer	Pixels
Valid Values	All integer values from 1 to 0xFFFFFFFFFFFF (281,474,976,710,655)		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.02.03.38.00.00.00 (CRC 1242)		VTarget Pack Tag
			1
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	Variable up to 6 Bytes	Binary
Notes			
- Defines the position of the centroid of the target within the Motion Imagery frame in pixels. - Numbering commences with 1, at the top left pixel, and proceeds from left to right, top to bottom.			
Conversion			
NA			
Example Value	Example Encoded LS Value		
409,600 (0x06 40 00)	[K] [L] [V] = [0x01][0x03][0x06 40 00]		

The **Target Centroid Pixel Number Tag 1** specifies the position of the target centroid[13] within a frame. The calculation of the pixel number uses the equation: *Column* + ((*Row*-1) x Frame Width)). The top left pixel of a frame equates to (*Column*, *Row*) = (1, 1) and pixel number 1. The Frame Width is taken from VMTI LDS Tag 8, if present. If it is not present, then the Frame Width is taken from the underlying Motion Imagery. In the absence of underlying Motion Imagery, VMTI LDS Tag 8 must be present.

[13] The coordinates of the centroid (geometric center) (x_c, y_c) of a non-intersecting closed polygon with n vertices can be calculated using:

$$x_c = \frac{1}{6A}\sum_{i=0}^{n-1}(x_i + x_{i+1})(x_i y_{i+1} - x_{i+1} y_i), \quad y_c = \frac{1}{6A}\sum_{i=0}^{n-1}(y_i + y_{i+1})(x_i y_{i+1} - x_{i+1} y_i)$$

Where, $$A = \frac{1}{2}\sum_{i=0}^{n-1}(x_i y_{i+1} - x_{i+1} y_i)$$

As a practical matter, calculation of the exact centroid is probably not necessary, although it is not precluded. The centroid of a simple bounding box might be adequate.

11.15.3 Tag 2: Target Bounding Box Top Left Pixel Number

Data Element Definition			
Element Name	Target Bounding Box Top Left Pixel Number	Type	Units
		Unsigned Integer	Pixels
Valid Values	All integer values from 1 to 0xFFFFFFFFFFFF (281,474,976,710,655)		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.02.03.39.00.00.00 (CRC 29294)		VTarget Pack Tag
			2
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	Variable up to 6 Bytes	Binary
Notes			
- Defines the position of the top left corner of the target bounding box within the Motion Imagery frame in pixels. - Numbering commences with 1, at the top left pixel, and proceeds from left to right, top to bottom			
Conversion			
NA			
Example Value	Example Encoded LS Value		
409,600 (0x06 40 00)	[K] [L] [V] = [0x02][0x03][0x06 40 00]		

Target Bounding Box Top Left Pixel Number Tag 2 specifies the position of the top left corner of the target bounding box within a frame as a pixel number. The calculation of the pixel number uses the equation: *Column* + ((*Row*-1) x Frame Width)). The top left pixel of the frame equates to (*Column*, *Row*) = (1, 1) and pixel number 1. The Frame Width is taken from VMTI LDS Tag 8, if present. If it is not present, then the Frame Width is taken from the underlying Motion Imagery. In the absence of underlying Motion Imagery, VMTI LDS Tag 8 must be present.

It is important for bit efficiency to rely on variable length payloads for this value.

11.15.4 Tag 3: Target Bounding Box Bottom Right Pixel Number

Data Element Definition			
Element Name	Target Bounding Box Bottom Right Pixel Number	Type	Units
		Unsigned Integer	Pixels
Valid Values	All integer values from 1 to 0xFFFFFFFFFFFF (281,474,976,710,655)		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.02.03.3A.00.00.00 (CRC 59826)		VTarget Pack Tag
			3
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	Variable up to 6 Bytes	Binary
Notes			
- Defines the position of the bottom right corner of the target bounding box within the Motion Imagery frame in pixels. - Numbering commences with 1, at the top left pixel, and proceeds from left to right, top to bottom.			
Conversion			
NA			
Example Value	Example Encoded LS Value		
409,600 (0x06 40 00)	[K] [L] [V] = [0x03][0x03][0x06 40 00]		

Target Bounding Box Bottom Right Pixel Number Tag 3 specifies the position of the bottom right corner of the target bounding box within the frame as a pixel number. The calculation of the pixel number uses the equation: *Column* + ((*Row*-1) x Frame Width)). The top left pixel of the frame equates to (*Column*, *Row*) = (1, 1) and pixel number 1. The Frame Width is taken from VMTI LDS Tag 8, if present. If it is not present, then the Frame Width is taken from the underlying Motion Imagery. In the absence of underlying Motion Imagery, VMTI LDS Tag 8 must be present.

It is important for bit efficiency to rely on variable length payloads for this value.

11.15.5 Tag 4: Target Priority

Data Element Definition			
Element Name	Target Priority	Type	Units
		Unsigned Integer	NA
Valid Values	All integer values from 1 to 0xFF (255)		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01 .0E.01.02.03.3B.00.00.00 (CRC 40710)		VTarget Pack Tag
			4
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	1 Byte	Binary
Notes			
- Priority or validity of target based on criteria within the VMTI system. The target(s) with the highest priority may not have the highest confidence level. - Potential for use in limited bandwidth scenarios to only send highest priority targets. - Multiple targets may have the same priority. - Range is 1 to 255, where 1 is the highest priority.			
Conversion			
NA			
Example Value	Example Encoded LS Value		
27 (0x1B)	[K] [L] [V] = [0x04][0x01][0x1B]		

Target Priority Tag 4 provides systems downstream from VMTI processors a means to intelligently cull targets for a given frame. For example, VMTI processors may generate thousands of hits. These may be used meaningfully in trackers (where bandwidth may not be an issue). However, other clients may have more restrictive bandwidth limitations, or not wish to overload systems with thousands of hits. For example, from a human perspective, it may be undesirable to clutter a situational awareness display with thousands of VMTI targets.

11.15.6 Tag 5: Target Confidence Level

<table>
<tr><th colspan="5">Data Element Definition</th></tr>
<tr><td rowspan="2">Element Name</td><td rowspan="2" colspan="2">Target Confidence Level</td><td>Type</td><td>Units</td></tr>
<tr><td>Unsigned Integer</td><td>NA</td></tr>
<tr><td rowspan="2">Valid Values</td><td rowspan="2" colspan="3">The set of integer values from 0 to 100 inclusive</td><td>Precision</td></tr>
<tr><td>NA</td></tr>
<tr><th colspan="5">KLV Encoding</th></tr>
<tr><td rowspan="2">Universal Label</td><td rowspan="2" colspan="3">06.0E.2B.34.01.01.01.01.0E.01.02.03.3C.00.00.00 (CRC 52779)</td><td>VTarget Pack Tag</td></tr>
<tr><td>5</td></tr>
<tr><td>Volatility</td><td colspan="2">Encoded Type</td><td>Length</td><td>Format</td></tr>
<tr><td>Dynamic</td><td colspan="2">Unsigned Integer</td><td>1 Byte</td><td>Binary</td></tr>
<tr><td colspan="5">Notes</td></tr>
<tr><td colspan="5">- Confidence level, expressed as a percentage, based on criteria within the VMTI system. Target(s) with the highest confidence may not have the highest priority value.
- Potential for use in limited bandwidth scenarios to only send highest confidence targets.
- Multiple targets may have the same confidence level.
- Range 0 to 100, where 100 percent is the highest confidence.
- Although a confidence level of 0 percent is permitted, it indicates no confidence that a detection is a potential target.
- A target may be detected with a high confidence, but be a low priority target.</td></tr>
<tr><td colspan="5">Conversion</td></tr>
<tr><td colspan="5">NA</td></tr>
<tr><td colspan="2">Example Value</td><td colspan="3">Example Encoded LS Value</td></tr>
<tr><td colspan="2">80 (0x50)</td><td colspan="3">[K] [L] [V] = [0x05][0x01][0x50]</td></tr>
</table>

11.15.7 Tag 6: New Detection Flag / Target History

<table>
<tr><th colspan="5">Data Element Definition</th></tr>
<tr><td rowspan="2">Element Name</td><td rowspan="2" colspan="2">New Detection Flag / Target History</td><td>Type</td><td>Units</td></tr>
<tr><td>Unsigned Integer</td><td>NA</td></tr>
<tr><td rowspan="2">Valid Values</td><td rowspan="2" colspan="3">All integer values from 0 to 0xFFFF (65535)</td><td>Precision</td></tr>
<tr><td>NA</td></tr>
<tr><th colspan="5">KLV Encoding</th></tr>
<tr><td rowspan="2">Universal Label</td><td rowspan="2" colspan="3">06.0E.2B.34.01.01.01.01.0E.01.02.03.3D.00.00.00 (CRC 47263)</td><td>VTrack Pack Tag</td></tr>
<tr><td>6</td></tr>
<tr><td>Volatility</td><td colspan="2">Encoded Type</td><td>Length</td><td>Format</td></tr>
<tr><td>Dynamic</td><td colspan="2">Unsigned Integer</td><td>Variable up to 2 Bytes</td><td>Binary</td></tr>
<tr><td colspan="5">Notes</td></tr>
<tr><td colspan="5">- Primarily indicates detection of a new target or reuse of a previous VTarget Pack Target ID Number.
- Also provides the ability to indicate target persistence, and may provide useful context when a target reappears after not being detected for a significant time.
- The number of previous times the same target has been detected.
- Range 0 to 65535 frames, where a value of 0 denotes the target as a new detection.
- Detections are not required to be in consecutive frames.</td></tr>
<tr><td colspan="5">Conversion</td></tr>
<tr><td colspan="5">NA</td></tr>
<tr><td colspan="2">Example Value</td><td colspan="3">Example Encoded LS Value</td></tr>
<tr><td colspan="2">2765 (0x0A CD)</td><td colspan="3">[K] [L] [V] = [0x06][0x02][0x0A CD]</td></tr>
</table>

11.15.8 Tag 7: Percentage of Target Pixels

Data Element Definition			
Element Name	Percentage of Target Pixels	Type	Units
		Unsigned Integer	Percent
Valid Values	The set of integer numbers from 1 to 100 inclusive		Precision
			1 %
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.02.03.3E.00.00.00 (CRC 9027)		VTrack Pack Tag
			7
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	1 Byte	Binary
Notes			
- The percentage of pixels within the bounding box that are detected to be target pixels rather than background pixels. - Range 1 to 100, where 100 signifies that the target completely fills the bounding box. - Use of the VMask, VChip, VObject, or VFeature Local Sets is recommended where more detail about a target is required. - A value of 0 is invalid. (If a detection has occurred, the bounding box should be sized such that a non-zero percentage of pixels overlaps the target.) - Values above 100 are invalid.			
Conversion			
NA			
Example Value	Example Encoded LS Value		
50% (0x32)	[K] [L] [V] = [0x07][0x01][0x32]		

11.15.9 Tag 8: Target Color

Data Element Definition			
Element Name	Target Color	Type	Units
		24-bit RGB Color	NA
Valid Values	All integer values from 0 to 0xFF (255) for each of three one-byte fields		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.02.03.3F.00.00.00 (CRC 22007)		VTarget Pack Tag
			8
Volatility	Encoded Type	Length	Format
Dynamic	24-bit RGB Color	3 Bytes	Binary
Notes			

- Dominant color of the target, expressed using RGB color values.
- General mapping of any multispectral dataset to an RGB value.
- Primary use when metadata is transmitted in the absence of the underlying Motion Imagery.
- VFeature LS can be used for more comprehensive color information.
- Represents the RGB color value with:
  - First byte = Red
  - Second byte = Green
  - Third byte = Blue			

Conversion			
Let: Red = 0x55, Green = 0x88, Blue = 0x33 Then: Target Color = [0x55 00 00] | [0x88 00] | [0x33] = [0x55 88 33]			
Example Value	Example Encoded LS Value		
[0x55 88 33]	[K] [L] [V] = [0x08][0x03][0x55 88 33]		

11.15.10 Tag 9: Target Intensity

Data Element Definition			
Element Name	Target Intensity	Type	Units
		Unsigned Integer	NA
Valid Values	All integer values from 0 to 0xFFFFFF (16,777,215)		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.02.03.40.00.00.00 (CRC 50028)		VTrack Pack Tag
			9
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	Variable up to 3 Bytes	Binary
Notes			
- Dominant intensity of the target with dynamic range up to 24 bits. - For use when metadata is transmitted in the absence of the underlying Motion Imagery. - Primarily designed for Infrared systems that may detect targets with greater than 8-bits per pixel dynamic range, and transmit the signal at a lower dynamic range. - VFeature LS can be used for more comprehensive spectral information. - Value 0 is black.			
Conversion			
NA			
Example Value	Example Encoded LS Value		
13140 [0x33 54]	[K] [L] [V] = [0x09][0x02][0x33 54]		

11.15.11 Tag 10: Target Location Latitude Offset

Data Element Definition			
Element Name	Target Location Latitude Offset	Type	Units
		Float	Degrees
Valid Values	The set of real numbers from -19.2 to 19.2 inclusive		Precision
			Refer to MISB ST 1201
KLV Encoding			
Universal Label	06.0E.2B.34. 01.01.01.01.0E.01.02.03.41.00.00.00 (CRC 46552)		VTrack Pack Tag
			10
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	3 Bytes	Binary
Notes			
- Latitude offset for target from Frame Center Latitude (MISB ST 0601), based on WGS84 ellipsoid. - Use with MISB ST 0601 Frame Center Latitude.			
Conversion			
IMAPB(-19.2, 19.2, 3)			
Example Value	Example Encoded LS Value		
10.00 Degrees	[K] [L] [V] = [0x0A][0x03][0x3A 66 67]		

Target Location Latitude Offset Tag 10 has a real earth coordinate represented by a latitude-longitude pair. Target locations that lie above the horizon do not correspond to a point on the earth. Also, target locations may lie outside of the mapped range. Both cases should either not be reported, or be reported as an "error".

Target Location Latitude Offset has meaning only if the VMTI LS is embedded within a MISB ST 0601 LS. The Target Location Latitude Offset is added to the Frame Center Latitude metadata item from the parent MISB ST 0601 packet to determine the Latitude of the target. Both KLV data items must be converted to decimal prior to addition to determine the actual measured or calculated Motion Imagery target location.

11.15.12 Tag 11: Target Location Longitude Offset

<table>
<tr><th colspan="4">Data Element Definition</th></tr>
<tr><td rowspan="2">Element Name</td><td rowspan="2">Target Location Longitude Offset</td><td>Type</td><td>Units</td></tr>
<tr><td>Float</td><td>Degrees</td></tr>
<tr><td rowspan="2">Valid Values</td><td colspan="2" rowspan="2">The set of real numbers from -19.2 to 19.2 inclusive</td><td>Precision</td></tr>
<tr><td>Refer to MISB ST 1201</td></tr>
<tr><th colspan="4">KLV Encoding</th></tr>
<tr><td rowspan="2">Universal Label</td><td colspan="2" rowspan="2">06.0E.2B.34. 01.01.01.01.0E.01.02.03.42.00.00.00 (CRC 11780)</td><td>VTrack Pack Tag</td></tr>
<tr><td>11</td></tr>
<tr><td>Volatility</td><td>Encoded Type</td><td>Length</td><td>Format</td></tr>
<tr><td>Dynamic</td><td>Unsigned Integer</td><td>3 Bytes</td><td>Binary</td></tr>
<tr><td colspan="4">Notes</td></tr>
<tr><td colspan="4">- Longitude offset for target from Frame Center Longitude (MISB ST 0601), based on WGS84 ellipsoid.
- Use with Frame Center Longitude.</td></tr>
<tr><td colspan="4">Conversion</td></tr>
<tr><td colspan="4">IMAPB(-19.2, 19.2, 3)</td></tr>
<tr><td>Example Value</td><td colspan="3">Example Encoded LS Value</td></tr>
<tr><td>10.00 Degrees</td><td colspan="3">[K] [L] [V] = [0x0B][0x03][0x3A 66 67]</td></tr>
</table>

Target Location Longitude Offset Tag 11 has a real earth coordinate represented by a latitude-longitude pair. Target locations that lie above the horizon do not correspond to a point on the earth. Also, target locations may lie outside of the mapped range. Both cases should either not be reported, or be reported as an "error".

Target Location Longitude Offset has meaning only if the VMTI LS is embedded within a MISB ST 0601 LS. The Target Location Longitude Offset is added to the Frame Center Longitude metadata item from the parent MISB ST 0601 packet to determine the Longitude of the target. Both KLV data items must be converted to decimal prior to addition to determine the actual measured or calculated Motion Imagery target location.

11.15.13 Tag 12: Target Height

Data Element Definition			
Element Name	Target Height	Type	Units
		Float	Meters
Valid Values	The set of real numbers from -900 to 19,000 inclusive		Precision
			Refer to MISB ST 1201
KLV Encoding			
Universal Label	06.0E.2B.34. 01.01.01.01.0E.01.02.03.43.00.00.00 (CRC 22704)		VTarget Pack Tag
			12
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	2 Bytes	Binary
Notes			
- Height of the target, expressed as height in meters above the WGS84 ellipsoid (HAE).			
Conversion			
IMAPB(-900, 19000, 2)			
Example Value	Example Encoded LS Value		
10,000 Meters	[K] [L] [V] = [0x0C][0x02][0x2A 94]		

11.15.14 Tag 13: Bounding Box Top Left Latitude Offset

Data Element Definition			
Element Name	Bounding Box Top Left Latitude Offset	Type	Units
		Float	Degrees
Valid Values	The set of real numbers from -19.2 to 19.2 inclusive		Precision
			Refer to MISB ST 1201
KLV Encoding			
Universal Label	06.0E.2B.34. 01.01.01.01.0E.01.02.03.44.00.00.00 (CRC 2461)		VTarget Pack Tag
			13
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	3 Bytes	Binary
Notes			
- Latitude offset for top left corner of target bounding box from Frame Center Latitude (MISB ST 0601), based on WGS84 ellipsoid. - Use with Frame Center Latitude. - Added to the Frame Center Latitude from the parent MISB ST 0601 packet to determine the Latitude of the top left corner of the target bounding box. Both KLV data items must be converted to decimal prior to addition to determine the actual measured or calculated Motion Imagery bounding box corner location. - Bounding box corners that lie above the horizon do not correspond to points on the earth. Bounding box corners may lie outside of the mapped range. Both cases should either not be reported, or be reported as an “error”.			
Conversion			
IMAPB(-19.2, 19.2, 3)			
Example Value	Example Encoded LS Value		
10.00 Degrees	[K] [L] [V] = [0x0D][0x03] [0x3A 66 67]		

11.15.15 Tag 14: Bounding Box Top Left Longitude Offset

Data Element Definition			
Element Name	Bounding Box Top Left Longitude Offset	Type	Units
		Float	Degrees
Valid Values	The set of real numbers from -19.2 to 19.2 inclusive		Precision
			Refer to MISB ST 1201
KLV Encoding			
Universal Label	06.0E.2B.34. 01.01.01.01.0E.01.02.03.45.00.00.00 (CRC 32553)		VTarget Pack Tag
			14
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	3 Bytes	Binary
Notes			
- Longitude offset for top left corner of target bounding box from Frame Center Latitude (MISB ST 0601), based on WGS84 ellipsoid. Use with Frame Center Longitude. - Added to the Frame Center Longitude from the parent MISB ST 0601 packet to determine the Longitude of the top left corner of the target bounding box. Both KLV data items must be converted to decimal prior to addition to determine the actual measured or calculated Motion Imagery bounding box corner location. - Bounding box corners that lie above the horizon do not correspond to points on the earth. Bounding box corners may lie outside of the mapped range. Both cases should either not be reported, or be reported as an "error".			
Conversion			
IMAPB(-19.2, 19.2, 3)			
Example Value	Example Encoded LS Value		
10.00 Degrees	[K] [L] [V] = [0x0E][0x03] [0x3A 66 67]		

11.15.16 Tag 15: Bounding Box Bottom Right Latitude Offset

Data Element Definition			
Element Name	Bounding Box Bottom Right Latitude Offset	Type	Units
		Float	Degrees
Valid Values	The set of real numbers from -19.2 to 19.2 inclusive		Precision
			Refer to MISB ST 1201
KLV Encoding			
Universal Label	06.0E.2B.34. 01.01.01.01.0E.01.02.03.46.00.00.00 (CRC 58613)		VTarget Pack Tag
			15
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	Bytes	Binary
Notes			
- Latitude offset for bottom right corner of target bounding box from Frame Center Latitude (MISB ST 0601), based on WGS84 ellipsoid. Use with Frame Center Latitude. - Added to the Frame Center Latitude from the parent MISB ST 0601 packet to determine the Latitude of the bottom right corner of the target bounding box. Both KLV data items must be converted to decimal prior to addition to determine the actual measured or calculated Motion Imagery bounding box corner location. - Bounding box corners that lie above the horizon do not correspond to points on the earth. Bounding box corners may lie outside of the mapped range. Both cases should either not be reported, or be reported as an "error".			
Conversion			
IMAPB(-19.2, 19.2, 3)			
Example Value	Example Encoded LS Value		
10.00 Degrees	[K] [L] [V] = [0x0F][0x03] [0x3A 66 67]		

11.15.17 Tag 16: Bounding Box Bottom Right Longitude Offset

<table>
<tr><th colspan="4">Data Element Definition</th></tr>
<tr><td rowspan="2">Element Name</td><td rowspan="2">Bounding Box Bottom Right Longitude Offset</td><td>Type</td><td>Units</td></tr>
<tr><td>Float</td><td>Degrees</td></tr>
<tr><td rowspan="2">Valid Values</td><td colspan="2" rowspan="2">The set of real numbers from -19.2 to 19.2 inclusive</td><td>Precision</td></tr>
<tr><td>Refer to MISB ST 1201</td></tr>
<tr><th colspan="4">KLV Encoding</th></tr>
<tr><td rowspan="2">Universal Label</td><td colspan="2" rowspan="2">06.0E.2B.34. 01.01.01.01.0E.01.02.03.47.00.00.00 (CRC 37441)</td><td>VTarget Pack Tag</td></tr>
<tr><td>16</td></tr>
<tr><td>Volatility</td><td>Encoded Type</td><td>Length</td><td>Format</td></tr>
<tr><td>Dynamic</td><td>Unsigned Integer</td><td>3 Bytes</td><td>Binary</td></tr>
<tr><td colspan="4">Notes</td></tr>
<tr><td colspan="4">- Longitude offset for bottom right corner of target bounding box from Frame Center Latitude (MISB ST 0601), based on WGS84 ellipsoid.
- Use with Frame Center Longitude.
- Added to the Frame Center Longitude from the parent MISB ST 0601 packet to determine the Longitude of the bottom right corner of the target bounding box. Both KLV data items must be converted to decimal prior to addition to determine the actual measured or calculated Motion Imagery bounding box corner location.
- Bounding box corners that lie above the horizon do not correspond to points on the earth. Bounding box corners may lie outside of the mapped range. Both cases should either not be reported, or be reported as an “error”.</td></tr>
<tr><td colspan="4">Conversion</td></tr>
<tr><td colspan="4">IMAPB(-19.2, 19.2, 3)</td></tr>
<tr><td>Example Value</td><td colspan="3">Example Encoded LS Value</td></tr>
<tr><td>10.00 Degrees</td><td colspan="3">[K] [L] [V] = [0x10][0x03] [0x3A 66 67]</td></tr>
</table>

11.15.18 Tag 17: Target Location

Data Element Definition			
Element Name	Target Location	Type	Units
		Location Structure	NA
Valid Values	See Location Type definition		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.02.05.01.01.0E.01.03.03.14.00.00.00 (CRC 28126)		VTarget Pack Tag
			17
Volatility	Encoded Type	Length	Format
Dynamic	Location	Variable	Binary

Notes

- Provides detailed geopositioning information for a target, optionally including the standard deviation and correlation coefficients. This element is of type Location and can be treated as a Defined-Length Truncation Pack.
- To specify the geographic coordinates for a target when the VMTI LS is not embedded within a MISB ST 0601 LS [2], Target Location VTarget Pack Tag 17 must be used in lieu of Target Location Latitude Offset VTarget Pack Tag 10 and Target Location Longitude Offset VTarget Pack Tag 11, since MISB ST 0601 Target Latitude and Target Longitude (Frame Center Coordinates) will not be specified.
- However, even if the VMTI LS is embedded within a MISB ST 0601 LS, Target Location may still be used.
- See the Location Type definition for a full description of this element.

Conversion

NA

Example Value	Example Encoded LS Value
NA	NA

11.15.19 Tag 18: Target Boundary

Data Element Definition			
Element Name	Target Boundary	Type	Units
		Boundary Structure	NA
Valid Values	See Boundary Type definition		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.02.04.01.01.0E.01.03.03.17.00.00.00 (CRC 11851)		VTarget Pack Tag
			18
Volatility	Encoded Type	Length	Format
Dynamic	Boundary	Variable	Binary
Notes			
- Provides detailed geo-positioning information for the boundary around an area or volume of interest. This boundary is defined by an arbitrary number of vertices. Each vertex is an element of type Location. Typical boundaries are the bounding boxes defined by two or four vertices. - Location type captures geopositioning data about a specific location on or in close proximity to the surface of the Earth. The elements of these packs fall into three groups, namely, geospatial location (Latitude, Longitude, and Height), standard deviations for these values, and correlation coefficients among them. Location elements are structured as Defined-Length Truncation Packs, allowing unknown or less important elements to be omitted from the end of the Pack. - Use of Target Boundary is preferred over Target Bounding Box (Tags 13 through 16) if accuracy and correlation information is available. Such information is valuable for fusion with other moving object indicators, such as, radar-based GMTI, to support track identification and tracking. - See the Boundary Type definition for a full description of this element.			
Conversion			
NA			
Example Value		Example Encoded LS Value	
NA		NA	

11.15.20 Tag 19: Target Centroid Pixel Row

<table>
<tr><th colspan="4">Data Element Definition</th></tr>
<tr><td rowspan="2">Element Name</td><td rowspan="2">Target Centroid Pixel Row</td><td>Type</td><td>Units</td></tr>
<tr><td>Unsigned Integer</td><td>Pixels</td></tr>
<tr><td rowspan="2">Valid Values</td><td colspan="2" rowspan="2">Integer values in the range 1 to 2^{32}-1</td><td>Precision</td></tr>
<tr><td>NA</td></tr>
<tr><th colspan="4">KLV Encoding</th></tr>
<tr><td rowspan="2">Universal Label</td><td colspan="2" rowspan="2">06.0E.2B.34.01.01.01.01.0E.01.02.03.58.00.00.00 (CRC 23816)</td><td>VTarget Pack Tag</td></tr>
<tr><td>19</td></tr>
<tr><td>Volatility</td><td>Encoded Type</td><td>Length</td><td>Format</td></tr>
<tr><td>Dynamic</td><td>Unsigned Integer</td><td>Variable</td><td>Binary</td></tr>
<tr><td colspan="4">Notes</td></tr>
<tr><td colspan="4">- Specifies the row of the target centroid within the Motion Imagery frame in pixels.
- Numbering commences from 1, denoting the top row.
- May be used with Target Centroid Pixel Column (Tag 20) to provide an alternate method to specify Target Pixel Centroid Number (Tag 1), the pixel location of the target centroid.
- If present, Target Centroid Pixel Column (Tag 20) must also be present.</td></tr>
<tr><td colspan="4">Conversion</td></tr>
<tr><td colspan="4">NA</td></tr>
<tr><td colspan="2">Example Value</td><td colspan="2">Example Encoded LS Value</td></tr>
<tr><td colspan="2">872 (0x03 68)</td><td colspan="2">[K] [L] [V] = [0x13][0x02][0x03 68]</td></tr>
</table>

11.15.21 Tag 20: Target Centroid Pixel Column

Data Element Definition			
Element Name	Target Centroid Pixel Column	Type	Units
		Unsigned Integer	Pixels
Valid Values	Integer values in the range 1 to 2^{32}-1		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.02.03.59.00.00.00 (CRC 11196)		VTarget Pack Tag
			20
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	Variable	Binary
Notes			
- Specifies the column of the target centroid within the Motion Imagery frame in pixels. - Numbering commences from 1, denoting the left column. - May be used with Target Centroid Pixel Row (Tag 19) to provide an alternate method to specify Target Pixel Centroid Number (Tag 1), the pixel location of the target centroid. - If present, Target Centroid Pixel Row (Tag 19) must also be present.			
Conversion			
NA			
Example Value	Example Encoded LS Value		
1137 (0x04 71)	[K] [L] [V] = [0x14][0x02][0x04 71]		

11.15.22 Tag 21: FPA Index

Data Element Definition			
Element Name	FPA Index	Type	Units
		Defined-Length Pack	NA
Valid Values	A pair of one-byte unsigned integers, each with a value ranging from 1 to 255, inclusive.		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.02.05.01.01.0E.01.03.03.1D.01.00.00 (CRC 43417)		VTarget Pack Tag
			21
Volatility	Encoded Type	Length	Format
Dynamic	Binary	2 Bytes	Binary
Notes			
- None			
Conversion			
NA			
Example Value	Example Encoded LS Value		
(row, column) = (2, 3)	[T] [V] = [0x15][0x02 03]		

The **FPA Index Tag 21** specifies the row and the column, in that order, of a sensor Focal Plane Array (FPA) in a two-dimensional array of FPAs. The purpose of the FPA Index is to support sensors constructed using multiple FPAs, such as those used to capture Large Volume Motion Imagery (LVMI).

The FPA Index specifies the FPA in which detection of the target has occurred.

Rows are numbered from 1, top to bottom, starting from the top of the array. Columns are numbered from 1, left to right, starting from the left of the array (see Figure 11).

	1	2	3	4	5
1					
2			X		
3					
4					

Figure 11. Array of FPAs: "X" is located in Row 2, Column 3

Target pixel coordinates are expressed with respect to the FPA within which the target is detected; the FPA is treated as a Motion Imagery "frame" for VMTI data elements that use the frame as a reference.

11.15.23 Tag 101: VMask LS

Data Element Definition			
Element Name	VMask LS	Type	Units
		VMask Structure	NA
Valid Values	NA		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.02.03.01.01.0E.01.03.03.08.00.00.00 (CRC 51391)		VTarget Pack Tag
			101
Volatility	Encoded Type	Length	Format
Dynamic	VMask LS	Variable	Binary
Notes			
- Allows inclusion of metadata elements that define the outline of the detected target within a Motion Imagery frame. This information can be used to redraw the outline in downstream clients or to “chip” the target from Motion Imagery. - The VMask shape can be specified by either (1) a Series of three or more points that represent the vertices of a polygon within a Motion Imagery frame, or (2) a bit mask that identifies the pixels of the Motion Imagery frame subsumed by the target. There is no restriction that forbids specification of the target outline using both a polygon and a bit mask simultaneously.			
Conversion			
NA			
Example Value		Example Encoded LS Value	
NA		NA	

11.15.23.1 Tag 1: Polygon

<table>
<tr><th colspan="4">Data Element Definition</th></tr>
<tr><td rowspan="2">Element Name</td><td rowspan="2">Polygon</td><td>Type</td><td>Units</td></tr>
<tr><td>Array</td><td>NA</td></tr>
<tr><td rowspan="2">Valid Values</td><td colspan="2" rowspan="2">All integer values from 1 to 0xFFFFFFFFFFFF (281,474,976,710,655)</td><td>Precision</td></tr>
<tr><td>NA</td></tr>
<tr><th colspan="4">KLV Encoding</th></tr>
<tr><td rowspan="2">Universal Label</td><td colspan="2" rowspan="2">06.0E.2B.34.02.04.01.01.0E.01.03.03.18.00.00.00 (CRC 64165)</td><td>VMask LS Tag</td></tr>
<tr><td>1</td></tr>
<tr><td>Volatility</td><td>Encoded Type</td><td>Length</td><td>Format</td></tr>
<tr><td>Dynamic</td><td>Series of Unsigned Integers</td><td>Variable</td><td>Binary</td></tr>
<tr><td colspan="4">Notes</td></tr>
<tr><td colspan="4">- A Series of three or more points that represent the vertices of a polygon within a Motion Imagery frame.
    - Points are to be listed in clockwise order. The polygon shall be closed by connecting the last point in the series to the first point in the series. Each point is a pixel number with numbering commencing with 1, at the top left pixel, proceeding from left to right, top to bottom, then encoded using the Length-Value construct of a Variable-Length Pack
- The calculation of the pixel number uses the equation: pixel number = Column + ((Row-1) x frame width)). The top left pixel of the frame equates to (Column, Row) = (1, 1) and a pixel number of 1. For example, if frame width = 1920, then at pixel location (1, 1) pixel number =1; at pixel location (2, 1) pixel number = 2; at pixel location (1, 2) pixel number = 1921.</td></tr>
<tr><td colspan="4">Conversion</td></tr>
<tr><td colspan="4">NA</td></tr>
<tr><td colspan="2">Example Value</td><td colspan="2">Example Encoded LS Value</td></tr>
<tr><td colspan="2">14762, 14783, 15115</td><td colspan="2">[T][L] { [L][V] [L][V] [L][V] } =
[0x01][0x09] [0x02][0x39 AA] [0x02][0x39 BF] [0x02][0x3B 0B]</td></tr>
</table>

11.15.23.2 Tag 2: Bit Mask

Data Element Definition			
Element Name	Bit Mask	Type	Units
		Array	NA
Valid Values	All integer values from 1 to 0xFFFFFFFFFFFF (281,474,976,710,655) for pixel number. All positive integers up to the maximum pixel number for run length.		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.02.04.01.01.0E.01.03.03.19.00.00.00 (CRC 35857)		VMask LS Tag
			2
Volatility	Encoded Type	Length	Format
Dynamic	Series of Unsigned Integers	Variable	Binary
Notes			
- A run-length encoding of a bit mask describing the pixels that subtend the target within the Motion Imagery frame. - A Series of pixel-number-plus-run-length pairs, each describing the starting pixel number and the number of pixels in a run. - Pixel numbering commences with 1, at the top left pixel, proceeding from left to right, top to bottom. - Pixel numbers are encoded using the Length-Value construct of a Variable-Length Pack. - The length of each run is encoded using BER Length encoding. - The criterion used to decide whether or not a particular pixel "covers" a portion of the target is somewhat arbitrary and is left to the implementer. The implementer is free to decide whether overlap with all, a majority, or just a fraction of the pixel constitutes "covering" the target.			
Conversion			
NA			
Example Value		Example Encoded LS Value	
(pixel, run) = { (74, 2), (89, 4), (106, 2) }		[T][L][V} = [T][L] { [L] { [L][V][BER] } …} = [0x02][0F] { [0x04] { [0x02][0x01 4A][0x02] } [0x04] { [0x02][0x01 59][0x04] } [0x04] { [0x02][0x01 6A][0x02] } }	

The calculation of the pixel number uses the equation: *Column* + ((*Row*-1) x frame width)). The top left pixel of the frame equates to (*Column*, *Row*) = (1, 1) with a pixel number of 1. The pixel number is to be encoded using the Length-Value construct of a Variable-Length Pack.

For example, in the 16 x 9 table below (Figure 12), the pairs of pixel numbers and run lengths (pixel, run) are:

(74, 2) = [0x01 4A] [0x02]
(89, 4) = [0x01 59] [0x04]
(106, 2) = [0x01 6A] [0x02]

For this example, each run length is encoded in a single byte (as shown), using the short form of BER Length encoding. The long form of BER Length encoding would, of course, be used for run lengths exceeding 127 pixels. It is expected that run lengths will usually (but not necessarily) be "small", leveraging the bit efficiency of the short form.

1	2	3	4	.	.	.									
17															
33															
49															
65									1	1					
81								1	1	1	1				
97									1	1					
113															
129															144

Figure 12. Sample Bit Mask

11.15.24 Tag 102: VObject LS

Data Element Definition			
Element Name	VObject LS	Type	Units
		VObject Structure	NA
Valid Values	NA		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.02.03.01.01.0E.01.03.03.09.00.00.00 (CRC 48651)		VTarget Pack Tag
			102
Volatility	Encoded Type	Length	Format
Dynamic	VObject LS	Variable	Binary
Notes			
- Allow the inclusion of data that describes the class or type of a target (aircraft, watercraft, car, truck, train, dismount, etc.), to an arbitrary level of detail. For example, it might be useful to expand the notion of a "dismount" to include combatant, noncombatant, male, female, etc. - MISB ST 0903 mandates the use of the Web Ontology Language (OWL) [8], developed by the World Wide Web Consortium (W3C), to define the VObject ontology. - The VObject LS contains two elements, Tag 1 Ontology and Tag 2 Class, both of which must appear.			
Conversion			
NA			
Example Value		Example Encoded LS Value	
NA		NA	

11.15.24.1 Tag 1: Ontology

Data Element Definition			
Element Name	Ontology	Type	Units
		String	NA
Valid Values	A URI constructed from UTF-8 characters, which refers to a valid OWL ontology		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.01.03.33.01.00.00 (CRC 58133)		VObject LS Tag
			1
Volatility	Encoded Type	Length	Format
Dynamic	String	Variable	UTF-8

Notes

- The **Ontology Tag 1** element is a Uniform Resource Identifier (URI), which refers to a VObject ontology. The ontology is expressed using the Web Ontology Language OWL.
- The Jet Propulsion Laboratory Semantic Web for Earth and Environmental Terminology (SWEET) (https://sweet.jpl.nasa.gov/) provides a collection of ontologies, written in the OWL ontology language that can serve as examples and starting points for the development of additional domain-specific extended ontologies.
- Must be specified in the KLV stream before any Class Tag 2 element appears for a target. However, for bandwidth efficiency, Ontology need not be specified in every VObject LS (although it may). Once Ontology has been specified, VObject Class elements in subsequent VTarget Packs may reference the specified ontology for their values. See Section 14.1 for guidelines on the frequency with which Ontology must appear in the KLV stream. Ontology is considered to have Periodic Volatility.

Conversion

NA

Example Value	Example Encoded LS Value
NA	NA

11.15.24.2 Tag 2: Ontology_Class

Data Element Definition			
Element Name	Ontology_Class	Type	Units
		String	NA
Valid Values	A string of UTF-8 characters that comprise the name of the class, as defined in the VObject Ontology.		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.01.03.33.00.00.00 (CRC 54309)		VObject LS Tag
			2
Volatility	Encoded Type	Length	Format
Dynamic	String	Variable	UTF-8

Notes

- A value representing a target class or type, as defined in the VObject Ontology.
- For bandwidth efficiency, it is desirable that the Ontology specify a mapping between compact values (perhaps BER-OID encoded) for use in Ontology_Class and more descriptive names for use by systems that present the information to human observers.

Conversion

NA

Example Value	Example Encoded LS Value
Dismount/Non-combatant/Female/Child	[T][L][V] = [0x02] [0x23] [Dismount/Non-combatant/Female/Child]

11.15.25 Tag 103: VFeature LS

Data Element Definition			
Element Name	VFeature LS	Type	Units
		VFeature Structure	NA
Valid Values	NA		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.02.03.01.01.0E.01.03.03.0A.00.00.00 (CRC 9687)		VTarget Pack Tag
			103
Volatility	Encoded Type	Length	Format
Dynamic	VFeature LS	Variable	Binary
Notes			
- None			
Conversion			
NA			
Example Value	Example Encoded LS Value		
NA	NA		

VFeature LS Tag 103 allows inclusion of data that describes the target or features of the target (shape, size, dents, number of wheels, thermal signature, etc.). Descriptive information can range from simple text for a label, to complex data sets containing spectral or radiometric data.

The definition of a set of elements to describe target features can be a complex undertaking. Rather than create a unique specification, the VFeature LS is based on ISO Standard 19156 Geographic Information - Observations and Measurements (O&M) [9] and related schemas. The O&M standard defines a conceptual schema for observations and for features involved in sampling during observation. These artifacts support the exchange of information that describes the acts of observation and their results.

The O&M standard defines an observation as an act of measuring or otherwise determining the value of a property of a feature of interest. Such an act may involve the use of a method, sensor, instrument, human observation, algorithm, computation, process, etc. to estimate the value of the property. An observation is associated with a discrete instant or interval of time.

A value can be expressed using a variety of scales including nominal, ordinal, ratio, interval, spatial, and temporal. Primitive data types can be combined to form aggregate data types with aggregate values, including vectors, tensors and images. A value may be exact, or it may be an estimate, with a finite error. Observation results may have many data types, including primitive types like category or measure, but also more complex types such as time, location and geometry.

11.15.25.1 Tag 1: Schema

<table>
<tr><th colspan="4">Data Element Definition</th></tr>
<tr><td rowspan="2">Element Name</td><td rowspan="2">Schema</td><td>Type</td><td>Units</td></tr>
<tr><td>String</td><td>NA</td></tr>
<tr><td rowspan="2">Valid Values</td><td colspan="2" rowspan="2">A URI constructed from UTF-8 characters which refers to the Observation schema (http://schemas.opengis.net/om/1.0.0/) or a related schema.</td><td>Precision</td></tr>
<tr><td>NA</td></tr>
<tr><th colspan="4">KLV Encoding</th></tr>
<tr><td rowspan="2">Universal Label</td><td colspan="2" rowspan="2">06.0E.2B.34.01.01.01.01.0E.01.01.03.34.01.00.00 (CRC 45624)</td><td>VFeature LS Tag</td></tr>
<tr><td>1</td></tr>
<tr><td>Volatility</td><td>Encoded Type</td><td>Length</td><td>Format</td></tr>
<tr><td>Dynamic</td><td>String</td><td>Variable</td><td>UTF-8</td></tr>
<tr><td colspan="4">Notes</td></tr>
<tr><td colspan="4">- None</td></tr>
<tr><td colspan="4">Conversion</td></tr>
<tr><td colspan="4">NA</td></tr>
<tr><td colspan="2">Example Value</td><td colspan="2">Example Encoded LS Value</td></tr>
<tr><td colspan="2">NA</td><td colspan="2">NA</td></tr>
</table>

The VFeature LS **Schema Tag 1** element is a Uniform Resource Identifier (URI) which points to a relevant Observation schema (http://schemas.opengis.net/om/1.0.0/) or a related schema.

The O&M standard defines an Observation as "an action with a result which has a value describing some phenomenon". The Observation is defined as a Feature within the context of the General Feature Model [ISO 19101, ISO 19109]. An Observation may involve use of a sensor or observer, analytical procedure, simulation, or other mathematical process. An Observation yields an estimate of the value of a property of the feature of interest, and can account for error that may be present in the estimate. Observation values may have many data types, from primitive to complex, including category, measure, and geometry. Combinations of data types can be used to encode properties having multiple components. The notion of "coverage" can be used for properties that vary over the feature of interest. O&M Sampling addresses the sampling of sub-elements of a feature that are used to represent the whole.

Schema is a required element of VFeature. However, for bandwidth efficiency, Schema need not be specified in every VFeature LS (although it may). Once Schema has been specified, Feature elements in subsequent VTarget Packs may be interpreted with respect to the specified schema. See Section 14.1for guidelines on the frequency with which Schema must appear in the KLV stream. Schema is considered to have Periodic Volatility.

11.15.25.2 Tag 2: Schema_Feature

<table>
<tr><th colspan="4">Data Element Definition</th></tr>
<tr><td rowspan="2">Element Name</td><td rowspan="2">Schema_Feature</td><td>Type</td><td>Units</td></tr>
<tr><td>String</td><td>NA</td></tr>
<tr><td rowspan="2">Valid Values</td><td colspan="2" rowspan="2">Any OGC GML document that validates against the schema specified in Tag 1: Schema</td><td>Precision</td></tr>
<tr><td>NA</td></tr>
<tr><th colspan="4">KLV Encoding</th></tr>
<tr><td rowspan="2">Universal Label</td><td colspan="2" rowspan="2">06.0E.2B.34.01.01.01.01.0E.01.01.03.34.00.00.00 (CRC 34056)</td><td>VFeature LS Tag</td></tr>
<tr><td>2</td></tr>
<tr><td>Volatility</td><td>Encoded Type</td><td>Length</td><td>Format</td></tr>
<tr><td>Dynamic</td><td>String</td><td>Variable</td><td>UTF-8</td></tr>
<tr><td colspan="4">Notes</td></tr>
<tr><td colspan="4">- A Geographic Markup Language (GML) document structured according to the schema specified by VFeature LS Tag 1 Schema. It may contain one or more values observed for a feature of interest.</td></tr>
<tr><td colspan="4">Conversion</td></tr>
<tr><td colspan="4">NA</td></tr>
<tr><td colspan="3">Example Value</td><td>Example Encoded LS Value</td></tr>
<tr><td colspan="3">(Temperature, Pressure) =

<gml:DataBlock>
<gml:rangeParameters>
<gml:CompositeValue>
<gml:valueComponents>
<Temperature uom="urn:x-si:v1999:uom:degreesC">template</Temperature>
<Pressure uom="urn:x-si:v1999:uom:kPa">template</Pressure>
</gml:valueComponents>
</gml:CompositeValue>
</gml:rangeParameters>
<gml:tupleList>3,101.2</gml:tupleList>
</gml:DataBlock></td><td>[T][L][V] = [0x02] [0x82 01 43] [<gml:DataBlock><gml:rangeParameters><gml:CompositeValue> . . . </gml:DataBlock>]

Note: “0x82 01 43” above is the long-form BER encoding of the length of the string (323 characters).</td></tr>
</table>

11.15.26 Tag 104: VTracker LS

Data Element Definition			
Element Name	VTracker LS	Type	Units
		VTracker Structure	NA
Valid Values	NA		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.02.03.01.01.0E.01.03.03.0B.00.00.00 (CRC 21347)		VTarget Pack Tag
			104
Volatility	Encoded Type	Length	Format
Dynamic	VTracker LS	Variable	Binary
Notes			
- Contains spatial and temporal information ancillary to VChip, VObject, and VFeature to assist in tracking the target. Such information will allow Motion Imagery tracking algorithms to produce better tracks from the VMTI target information. - Note that use of the VTrack (no “er”) LS is generally preferred over the VTracker LS for representation of target tracks.			
Conversion			
NA			
Example Value	Example Encoded LS Value		
NA	NA		

11.15.26.1 Tag 1: Track ID

Data Element Definition			
Element Name	Track ID	Type	Units
		Unsigned Integer	NA
Valid Values	A 128-bit (16-byte) Universal Unique Identification (UUID) as standardized by the Open Software Foundation in ISO/IEC 9834-8 [10].		Precision
			1
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.01.03.35.00.00.00 (CRC 62396)		VTracker LS Tag
			1
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	16 Bytes	Binary
Notes			
- A value that uniquely identifies a track, using a 128-bit (16-byte) Universal Unique Identification (UUID) as standardized by the Open Software Foundation in ISO/IEC 9834-8 [10].			
Conversion			
NA			
Example Value	Example Encoded LS Value		
F81D4FAE7DEC11D0A76500A0C91E6BF6	[K] [L] [V] = [0x10][0x04][0xF8 1D 4F AE 7D EC 11 D0 A7 65 00 A0 C9 1E 6B F6]		

11.15.26.2 Tag 2: Detection Status

Data Element Definition			
Element Name	Detection Status	Type	Units
		Unsigned Integer	NA
Valid Values	Detection Status is an enumerated data element with values assigned from Table 16: Track Status Values below.		Precision
			1
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.01.03.36.00.00.00 (CRC 26720)		VTracker LS Tag
			2
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	1 Byte	Binary
Notes			
- None			
Conversion			
NA			
Example Value		Example Encoded LS Value	
1 [0x01]		[K] [L] [V] = [0x02][0x01][0x01]	

VTracker LS **Detection Status Tag 2** (Table 16 indicates the state of VMTI detections for a given entity.[14])

Table 16: Track Status Values

Value	Status	Description
0	Inactive	The VMTI detections for the entity have ended. The entity may have merged with one or more other entities, to have split into two or more new entities, or to have ceased to exist because no VMTI detection can be correlated with it.
1	Active	Detections for the entity have been established or updated on the basis of an associated VMTI report or a prediction. An entity can resume this state by transition from Stopped or Dropped to “moving”, when a VMTI detection (or a prediction) with a new position has become associated with it.
2	Dropped	The entity could not be correlated with any VMTI detection for an interval of time that exceeds a particular threshold. An entity can remain in a Dropped, or “lost”, condition for an indeterminate period of time, if there is some likelihood that it might be resumed (Active) again. Eventually, it may become Inactive.
3	Stopped	The entity has either become stationary or was always in a fixed location.

[14] Ideally (eventually), the content of Table 16: Track Status Valuesand those of *NATO STANAG 4676 Tracking Standard for ISR Systems* should be defined consistently.

11.15.26.3 Tag 3: Start Time Stamp

Data Element Definition			
Element Name	Start Time Stamp	Type	Units
		Unsigned Long Integer	Microseconds
Valid Values	All integer values from 0 to (2 ^ 64) – 1		Precision
			1 microsecond
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.03.07.02.01.01.01.05.00.00 (CRC 64827)		VTracker LS Tag
			3
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	Variable up to 8 Bytes	Binary
Notes			
- Captures the date and time of the first observation of the entity in Microseconds elapsed since midnight (00:00:00), January 1, 1970. - See MISB ST 0603 [12].			
Conversion			
NA			
Example Value	Example Encoded LS Value		
April 19 2001, 04:25:21 GMT	[K] [L] [V] = [0x03] [0x08] [0x00 03 82 44 30 F6 CE 40]		

11.15.26.4 Tag 4: End Time Stamp

Data Element Definition			
Element Name	End Time Stamp	Type	Units
		Unsigned Long Integer	Microseconds
Valid Values	All integer values from 0 to (2 ^ 64) – 1		Precision
			1 microsecond
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.03.07.02.01.01.01.05.00.00 (CRC 64827)		VTracker LS Tag
			4
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	Variable up to 8 Bytes	Binary
Notes			
- Captures the date and time of the most recent observation of the entity. - Microseconds elapsed since midnight (00:00:00), January 1, 1970. - See MISB ST 0603 [12].			
Conversion			
NA			
Example Value	Example Encoded LS Value		
April 19 2001, 04:25:21 GMT	[K] [L] [V] = [0x04] [0x08] [0x00 03 82 44 30 F6 CE 40]		

11.15.26.5 Tag 5: Bounding Box

Data Element Definition			
Element Name	Bounding Box	Type	Units
		Boundary Structure	NA
Valid Values	See VMTI Boundary Type Description		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.02.04.01.01.0E.01.03.03.17.00.00.00 (CRC 11851)		VTracker LS Tag
			5
Volatility	Encoded Type	Length	Format
Dynamic	Boundary	Variable	Binary
Notes			
- Comprises a set of Boundary vertices that specify a bounding area or volume, which encloses the full extent of VMTI detections for the entity. For a simple, planar bounding box, the area will generally lie on the surface of the Earth (although not necessarily, depending upon the Height values provided), in essence defining the "footprint" of the track. By specifying additional vertices, complex, multifaceted volumes can be described.			
Conversion			
NA			
Example Value		Example Encoded LS Value	
NA		NA	

11.15.26.6 Tag 6: Algorithm

Data Element Definition			
Element Name	Algorithm	Type	Units
		String	NA
Valid Values	The set of all UTF-8 characters		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.02.03.49.00.00.00 (CRC 12315)		VTracker LS Tag
			6
Volatility	Encoded Type	Length	Format
Dynamic	String	Variable	UTF-8
Notes			
- Name or description of the algorithm or method used to create or maintain object movement reports or intervening predictions of such movement. The intent of this element is to identify uniquely the VMTI algorithm or method used.			
Conversion			
NA			
Example Value		Example Encoded LS Value	
"test" [74 65 73 74]		[K] [L] [V] = [0x06][0x04][74 65 73 74]	

11.15.26.7 Tag 7: Confidence

Data Element Definition			
Element Name	Confidence	Type: Unsigned Short	Units: NA
Valid Values	The set of all integers from 0 to 100 inclusive		Precision: 1
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.01.03.37.00.00.00 (CRC 7892)		VTracker LS Tag: 7
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	1 Byte	Binary
Notes			
- Confidence level, expressed as a percentage. - Value 0 percent indicates no confidence; value 100 percent indicates absolute certainty. - An estimation of the certainty or correctness that the track described by the sequence of VMTI movement detections corresponds to the same object. Larger values indicate greater confidence. Zero indicates no confidence. A high degree of confidence might be indicated for detections derived from a large number of unambiguous target reports, such as, for a single vehicle on a road in a desert environment. A lower degree of confidence might be appropriate when target reports could be associated with several overlapping or nearby tracks in a partially obscured environment, such as, for dismounts (people) in an urban setting.			
Conversion			
NA			
Example Value	Example Encoded LS Value		
50 [0x32]	[K] [L] [V] = [0x07][0x01][0x32]		

11.15.26.8 Tag 8: Number of Track Points

Data Element Definition			
Element Name	Number of Track Points	Type: Unsigned Short	Units: NA
Valid Values	The set of all integers from 1 to 65,536 inclusive		Precision: 1
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.01.03.38.00.00.00 (CRC 51770)		VTracker LS Tag: 8
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	Variable up to 2 Bytes	Binary
Notes			
- The number of coordinates of type Location that describe the locus of VMTI detections for the target. Strictly speaking, Number of Track Points need not be specified, since the value can be derived from Length information associated with VTracker Tag 9 Locus. If specified, the number of track points must be at least 1, else no locus would exist.			
Conversion			
NA			
Example Value	Example Encoded LS Value		
27 [0x1B]	[K] [L] [V] = [0x08][0x01][0x1B]		

11.15.26.9 Tag 9: Locus

Data Element Definition			
Element Name	Locus	Type	Units
		Array	NA
Valid Values	See Series Description		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.02.04.01.01.0E.01.03.03.1A.00.00.00 (CRC 6093)		VTracker LS Tag
			9
Volatility	Encoded Type	Length	Format
Dynamic	Series of Location data elements	Variable	Binary
Notes			
- A Series of points that represent the locations of entity VMTI detections. Each point is an element of type Location. The points must be ordered chronologically from start to end of the VMTI detections.			
Conversion			
NA			
Example Value		Example Encoded LS Value	
NA		NA	

11.15.26.10 Tag 10: Velocity

Data Element Definition			
Element Name	Velocity	Type	Units
		Velocity Structure	NA
Valid Values	See Velocity Type Description		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.02.05.01.01.0E.01.03.03.15.00.00.00 (CRC 7018)		VTracker LS Tag
			10
Volatility	Encoded Type	Length	Format
Dynamic	Velocity	Variable	Binary
Notes			
- The velocity of the entity at the time of last detection.			
Conversion			
NA			
Example Value		Example Encoded LS Value	
NA		NA	

11.15.26.11 Tag 11: Acceleration

Data Element Definition			
Element Name	Acceleration	Type	Units
		Acceleration Structure	NA
Valid Values	See Acceleration Type Description		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.02.05.01.01.0E.01.03.03.16.00.00.00 (CRC 32950)		VTracker LS Tag
			11
Volatility	Encoded Type	Length	Format
Dynamic	Acceleration	Variable	Binary
Notes			
- The acceleration of the entity at the time of last detection.			
Conversion			
NA			
Example Value		Example Encoded LS Value	
NA		NA	

11.15.27 Tag 105: VChip LS

<table>
<tr><th colspan="4">Data Element Definition</th></tr>
<tr><td rowspan="2">Element Name</td><td rowspan="2">VChip LS</td><td>Type</td><td>Units</td></tr>
<tr><td>VChip Structure</td><td>NA</td></tr>
<tr><td rowspan="2">Valid Values</td><td colspan="2" rowspan="2">NA</td><td>Precision</td></tr>
<tr><td>NA</td></tr>
<tr><th colspan="4">KLV Encoding</th></tr>
<tr><td rowspan="2">Universal Label</td><td colspan="2" rowspan="2">06.0E.2B.34.02.03.01.01.0E.01.03.03.13.00.00.00 (CRC 52487)</td><td>VTarget Pack Tag</td></tr>
<tr><td>105</td></tr>
<tr><td>Volatility</td><td>Encoded Type</td><td>Length</td><td>Format</td></tr>
<tr><td>Dynamic</td><td>VChip LS</td><td>Variable</td><td>Binary</td></tr>
<tr><td colspan="4">Notes</td></tr>
<tr><td colspan="4">- Allows the inclusion of an image “chip” of the target. It is expected that this LS will find use in bandwidth constrained environments, where the operator does not have access to the underlying Motion Imagery stream. In general, the image chip will simply be “embedded” with the VMTI metadata. However, this specification permits reference to an image using a Uniform Resource Identifier/Locator (URI / URL) to support linking to a previously stored image, obviating the need to include the image data itself in the stream., likely to be used downstream of the collector.</td></tr>
<tr><td colspan="4">Conversion</td></tr>
<tr><td colspan="4">NA</td></tr>
<tr><td colspan="2">Example Value</td><td colspan="2">Example Encoded LS Value</td></tr>
<tr><td colspan="2">NA</td><td colspan="2">NA</td></tr>
</table>

11.15.27.1 Tag 1: Image Type

Data Element Definition			
Element Name	Image Type	Type	Units
		String	NA
Valid Values	A string of UTF-8 characters that correspond to an IANA media image subtype		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.01.03.30.00.00.00 (CRC 20473)		VChip LS Tag
			1
Volatility	Encoded Type	Length	Format
Dynamic	String	Variable	UTF-8

Notes

- Only a subset of IANA media image subtypes is permitted: jpeg and png.
- The jpeg and png image types are chosen because they are common formats for compressing a still image. The most significant advantage of jpeg is that it is ubiquitous. A disadvantage is that it is lossy, although the degree of compression (and, hence, quality) is adjustable. The primary advantage of png is that it is lossless. Moreover, it provides RGB bit depths up to 48 bits per pixel (16 bits per color component) and, therefore provides a format that can preserve "raw" pixel values.
- Image Type Tag 1 is a required element of VChip. It must be specified. However, for bandwidth efficiency, Image Type need not be specified in every VChip LS (although it may). Once Image Type has been specified, the Image URI and Embedded Image elements in subsequent VChip LSs must be consistent with the specified image type. See MISB ST 0903.4 Section 14.1 for guidelines on the frequency with which Image Type must appear in the KLV stream. Image Type is considered to have Periodic Volatility.

Conversion

NA

Example Value	Example Encoded LS Value
jpeg	[K] [L] [V] = [0x01][0x04][0x6A 70 65 67]

11.15.27.2 Tag 2: Image URI

Data Element Definition			
Element Name	Image_URI	Type	Units
		String	NA
Valid Values	A string of UTF-8 characters that comply with the rules for building a valid URI		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.01.03.31.00.00.00 (CRC 14669)		VChip LS Tag
			2
Volatility	Encoded Type	Length	Format
Dynamic	String	Variable	UTF-8

Notes

- A Uniform Resource Identifier (usually, a Uniform Resource Locator) that refers to an image of the type specified by VChip LS Image Type Tag 1, stored on a network or a file system.
- In some situations, probably downstream from the collection source, such a reference could be used in lieu of embedding the image chip in the stream.

Conversion

NA

Example Value	Example Encoded LS Value
NA	NA

11.15.27.3 Tag 3: Embedded Image

Data Element Definition			
Element Name	Embedded Image	Type	Units
		Bnary	NA
Valid Values	Any image implemented in compliance with the IANA media image subtype specified in Tag 1.		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.01.03.32.00.00.00 (CRC 41617)		VChip LS Tag
			3
Volatility	Encoded Type	Length	Format
Dynamic	Binary	Variable	Binary
Notes			
- An image "chip" of the type specified by VChip Image Type Tag 1, embedded in the VMTI stream.			
Conversion			
NA			
Example Value		Example Encoded LS Value	
NA		NA	

11.15.28 Tag 106: VChipSeries

Data Element Definition			
Element Name	VChipSeries	Type	Units
		Series	NA
Valid Values	NA		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.02.04.01.01.0E.01.03.03.14.00.00.00 (CRC 46487)		VTarget Pack Tag
			106
Volatility	Encoded Type	Length	Format
Dynamic	Series	Variable	Binary
Notes			
- A Series of one or more image chips associated with a specific target. Each image chip is formatted in accordance with the VChip LS, except the VChip LS Tag 105 is omitted. The Tag is omitted, because all elements in the Series are of the same type. Just the Length and Value for VChip need be specified. - Multiple image chips could be useful so that one may provide an image chip from the source sensor plus another image chip of the target from another sensor, say, one of higher resolution or of a different modality (e.g. IR).			
Conversion			
NA			
Example Value	Example Encoded LS Value		
NA	NA		

11.16 Location Truncation Pack

11.16.1 Latitude

Data Element Definition			
Element Name	Latitude	Type	Units
		Float	Degrees
Valid Values	The set of real numbers from 90.0 to -90.0 inclusive		Precision
			Refer to MISB ST 1201
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.01.03.28.00.00.00 (CRC 53661)		Pack Tag
			NA
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	4 Bytes	Binary
Notes			
- Latitude in degrees of a point with respect to the WGS84 datum. - For expressing standard deviations, correlation coefficients, velocity, and acceleration, the point represents the origin of a local tangential East-North-Up (ENU) coordinate system.			
Conversion			
IMAPB(-90, 90, 4)			
Example Value	Example Encoded LS Value		
43.00 Degrees	[V] = [0x42 80 00 00]		

11.16.2 Longitude

Data Element Definition			
Element Name	Longitude	Type	Units
		Float	Degrees
Valid Values	The set of real numbers from -180 to 180 inclusive		Precision
			Refer to MISB ST 1201
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01 / 0E.01.01.03.29.00.00.00 (CRC 42793)		Pack Tag
			NA
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	4 Bytes	Binary
Notes			
- Longitude in degrees of a point with respect to the WGS84 datum. - For expressing standard deviations, correlation coefficients, velocity, and acceleration, the point represents the origin of a local tangential East-North-Up (ENU) coordinate system.			
Conversion			
IMAPB(-180, 180, 4)			
Example Value	Example Encoded LS Value		
110.00 Degrees	[V] = [0x48 80 00 00]		

11.16.3 Height

<table>
<tr><th colspan="4">Data Element Definition</th></tr>
<tr><td rowspan="2">Element Name</td><td rowspan="2">Height</td><td>Type</td><td>Units</td></tr>
<tr><td>Float</td><td>Meters</td></tr>
<tr><td rowspan="2">Valid Values</td><td colspan="2" rowspan="2">The set of real numbers from -900 to 19,000 inclusive</td><td>Precision</td></tr>
<tr><td>Refer to MISB ST 1201</td></tr>
<tr><th colspan="4">KLV Encoding</th></tr>
<tr><td rowspan="2">Universal Label</td><td colspan="2" rowspan="2">06.0E.2B.34.01.01.01.01.0E.01.01.03.2A.00.00.00 (CRC 15605)</td><td>Pack Tag</td></tr>
<tr><td>NA</td></tr>
<tr><td>Volatility</td><td>Encoded Type</td><td>Length</td><td>Format</td></tr>
<tr><td>Dynamic</td><td>Unsigned Integer</td><td>2 Bytes</td><td>Binary</td></tr>
<tr><td colspan="4">Notes</td></tr>
<tr><td colspan="4">- Height in meters of a point with respect to the WGS-84 ellipsoid (Height Above the Ellipsoid).
- For expressing standard deviations, correlation coefficients, velocity, and acceleration, the point represents the origin of a local tangential East-North-Up (ENU) coordinate system.</td></tr>
<tr><td colspan="4">Conversion</td></tr>
<tr><td colspan="4">IMAPB(-900, 19000, 2)</td></tr>
<tr><td>Example Value</td><td colspan="3">Example Encoded LS Value</td></tr>
<tr><td>10,000 meters</td><td colspan="3">[V] = [0x2A 94]</td></tr>
</table>

11.16.4 Location Standard Deviation (Sigma)

<table>
<tr><th colspan="4">Data Element Definition</th></tr>
<tr><td rowspan="2">Element Name</td><td rowspan="2">Sigma_East
Sigma_North
Sigma_Up</td><td>Type</td><td>Units</td></tr>
<tr><td>Float</td><td>Meters</td></tr>
<tr><td rowspan="2">Valid Values</td><td colspan="2" rowspan="2">The set of real numbers ranging from 0.0 to 650.0 inclusive</td><td>Precision</td></tr>
<tr><td>Refer to MISB ST 1201</td></tr>
<tr><th colspan="4">KLV Encoding</th></tr>
<tr><td rowspan="2">Universal Label</td><td colspan="2" rowspan="2">06.0E.2B.34.01.01.01.01.0E.01.01.03.2D.00.00.00 (CRC 28120)
06.0E.2B.34.01.01.01.01.0E.01.01.03.2D.01.00.00 (CRC 23272)
06.0E.2B.34.01.01.01.01.0E.01.01.03.2D.02.00.00 (CRC 952)</td><td>LS Tag</td></tr>
<tr><td>NA</td></tr>
<tr><td>Volatility</td><td>Encoded Type</td><td>Length</td><td>Format</td></tr>
<tr><td>Dynamic</td><td>Unsigned Integer</td><td>2 Bytes</td><td>Binary</td></tr>
<tr><td colspan="4">Notes</td></tr>
<tr><td colspan="4">- Standard deviations of the location of the point with respect to the East, North, and Up axes of the ENU coordinate system.
- Geolocation Standard Deviations must appear in the following order in the element and be encoded the same way.
1) Sigma_East = Standard deviation of the location of the point with respect to the ENU coordinate system East axis.
2) Sigma_North = Standard deviation of the location of the point with respect to the ENU coordinate system North axis.
3) Sigma_Up = Standard deviation of the location of the point with respect to the ENU coordinate system Up axis.</td></tr>
<tr><td colspan="4">Conversion</td></tr>
<tr><td colspan="4">IMAPB(0, 650, 2)</td></tr>
<tr><td colspan="2">Example Value</td><td colspan="2">Example Encoded LS Value</td></tr>
<tr><td colspan="2">Sigma_East = 300 (0x25 80)
Sigma_North = 200 (0x19 00)
Sigma_Up = 100 (0x0C 80)</td><td colspan="2">[0x25 80 19 00 0C 80]</td></tr>
</table>

11.16.5 Location Correlation Coefficients

Data Element Definition			
Element Name	Rho_East_North Rho_East_Up Rho_North_Up	Type: Float	Units: NA
Valid Values	The set of real numbers ranging from -1.0 to 1.0 inclusive		Precision: Refer to MISB ST 1201
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.01.03.2E.00.00.00 (CRC 62980) 06.0E.2B.34.01.01.01.01.0E.01.01.03.2E.01.00.00 (CRC 49460) 06.0E.2B.34.01.01.01.01.0E.01.01.03.2E.02.00.00 (CRC 39012)		LS Tag: NA
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	2 Bytes	Binary

Notes

- Correlation coefficients for the location of the point with respect to the ENU coordinate system.
- Geolocation correlation coefficients must appear in the following order in the element and be encoded the same way.
    1) Rho_East_North = Correlation coefficient between the East and North components.
    2) Rho_East_Up = Correlation coefficient between the East and Up components.
    3) Rho_North_Up = Correlation coefficient between the North and Up components.

Conversion

IMAPB(-1, 1, 2)

Example Value	Example Encoded LS Value
Rho_East_North = 0.75 (0x70 00) Rho_East_Up = 0.50 (0x60 00) Rho_North_Up = 0.25 (0x50 00)	[0x70 00 60 00 50 00]

11.17 Velocity Truncation Pack

11.17.1 Velocity

Data Element Definition			
Element Name	East_Component North_Component Up_Component	Type: Float	Units: Meters/Second
Valid Values	The set of real numbers ranging from -900.0 to 900.0 inclusive		Precision: Refer to MISB ST 1201
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.01.03.2B.00.00.00 (CRC 19009) 06.0E.2B.34.01.01.01.01.0E.01.01.03.2B.01.00.00 (CRC 32113) 06.0E.2B.34.01.01.01.01.0E.01.01.03.2B.02.00.00 (CRC 9249)		LS Tag: NA
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	2 Bytes	Binary
Notes			
- Velocity with respect to the three coordinate axes of the East-North-Up coordinate system specified by the Location Truncation Pack for the location of the moving object. - Velocity Measured Values must appear in the following order in the group and be encoded the same way 1) East_Component = the value measured along the East axis 2) North_Component = the value measured along the North axis 3) Up_Component = the value measured along the Up axis			
Conversion			
IMAPB(-900, 900, 2)			
Example Value		Example Encoded LS Value	
East_Component = 300 (0x4B 00) North_Component = 200 (0x44 C0) Up_Component = 100 (0x3E 80)		[0x4B 00 44 C0 3E 80)]	

11.17.2 Velocity Standard Deviation (Sigma)

Data Element Definition			
Element Name	Sigma_East Sigma_North Sigma_Up	Type: Float	Units: Meters/Second
Valid Values	The set of real numbers ranging from 0.0 to 650.0 inclusive		Precision: Refer to MISB ST 1201
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.01.03.2D.03.00.00 (CRC 13448) 06.0E.2B.34.01.01.01.01.0E.01.01.03.2D.04.00.00 (CRC 45336) 06.0E.2B.34.01.01.01.01.0E.01.01.03.2D.05.00.00 (CRC 34344)		LS Tag: NA
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	2 Bytes	Binary
Notes			
- Standard deviations of Velocity with respect to the East, North, and Up axes of the ENU coordinate system. - Velocity Standard Deviations must appear in the following order in the element and be encoded the same way. 1. Sigma_East = Standard deviation of Velocity with respect to the ENU coordinate system East axis. 2. Sigma_North = Standard deviation of Velocity with respect to the ENU coordinate system North axis. 3. Sigma_Up = Standard deviation of Velocity with respect to the ENU coordinate system Up axis.			
Conversion			

IMAPB(0, 650, 2)	
Example Value	Example Encoded LS Value
Sigma_East = 300 (0x25 80) Sigma_North = 200 (0x19 00) Sigma_Up = 100 (0x0C 80)	[0x25 80 19 00 0C 80]

11.17.3 Velocity Correlation Coefficients

Data Element Definition			
Element Name	Rho_East_North Rho_East_Up Rho_North_Up	Type Float	Units NA
Valid Values	The set of real numbers ranging from -1.0 to 1.0 inclusive		Precision Refer to MISB ST 1201
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.01.03.2E.03.00.00 (CRC 44884) 06.0E.2B.34.01.01.01.01.0E.01.01.03.2E.04.00.00 (CRC 10948) 06.0E.2B.34.01.01.01.01.0E.01.01.03.2E.05.00.00 (CRC 7668)		LS Tag NA
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	2 Bytes	Binary
Notes			
- Correlation coefficients for Velocity with respect to the ENU coordinate system. - Velocity correlation coefficients must appear in the following order in the element and be encoded the same way. 1. Rho_East_North = Correlation coefficient between the East and North components. 2. Rho_East_Up = Correlation coefficient between the East and Up components. 3. Rho_North_Up = Correlation coefficient between the North and Up components.			
Conversion			
IMAPB(-1, 1, 2)			
Example Value		Example Encoded LS Value	
Rho_East_North = 0.75 (0x70 00) Rho_East_Up = 0.50 (0x60 00) Rho_North_Up = 0.25 (0x50 00)		[0x70 00 60 00 50 00]	

11.18 Acceleration Truncation Pack

11.18.1 Acceleration

Data Element Definition			
Element Name	East_Component North_Component Up_Component	Type: Float	Units: Meters per Second Squared
Valid Values	The set of real numbers ranging from -900.0 to 900.0 inclusive		Precision: Refer to MISB ST 1201
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.01.03.2C.00.00.00 (CRC 7020) 06.0E.2B.34.01.01.01.01.0E.01.01.03.2C.01.00.00 (CRC 11356) 06.0E.2B.34.01.01.01.01.0E.01.01.03.2C.02.00.00 (CRC 29964)		LS Tag: NA
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	2 Bytes	Binary
Notes			
- Acceleration with respect to the three coordinate axes of the East-North-Up coordinate system specified by the Location Truncation Pack for the location of the moving object. - Acceleration Measured Values must appear in the following order in the group and be encoded the same way. 1) East_Component = the value measured along the East axis 2) North_Component = the value measured along the North axis 3) Up_Component = the value measured along the Up axis			
Conversion			
IMAPB(-900, 900, 2)			
Example Value		Example Encoded LS Value	
East_Component = 300 (0x4B 00) North_Component = 200 (0x44 C0) Up_Component = 100 (0x3E 80)		[0x4B 00 44 C0 3E 80)]	

11.18.2 Acceleration Standard Deviation (Sigma)

Data Element Definition			
Element Name	Sigma_East Sigma_North Sigma_Up	Type: Float	Units: Meters per Second Squared
Valid Values	The set of real numbers ranging from 0.0 to 650.0 inclusive		Precision: Refer to MISB ST 1201
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.01.03.2D.06.00.00 (CRC 57208) 06.0E.2B.34.01.01.01.01.0E.01.01.03.2D.07.00.00 (CRC 59464 06.0E.2B.34.01.01.01.01.0E.01.01.03.2D.08.00.00 (CRC 50297)		LS Tag: NA
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	2 Bytes	Binary
Notes			
- Standard deviations of Acceleration with respect to the East, North, and Up axes of the ENU coordinate system. - Acceleration Standard Deviations must appear in the following order in the element and be encoded the same way. 1. Sigma_East = Standard deviation of Acceleration with respect to the ENU coordinate system East axis. 2. Sigma_North = Standard deviation of Acceleration with respect to the ENU coordinate system North axis. 3. Sigma_Up = Standard deviation of Acceleration with respect to the ENU coordinate system Up axis.			
Conversion			

IMAPB(0, 650, 2)	
Example Value	**Example Encoded LS Value**
Sigma_East = 300 (0x25 80) Sigma_North = 200 (0x19 00) Sigma_Up = 100 (0x0C 80)	[0x25 80 19 00 0C 80]

11.18.3 Acceleration Correlation Coefficients

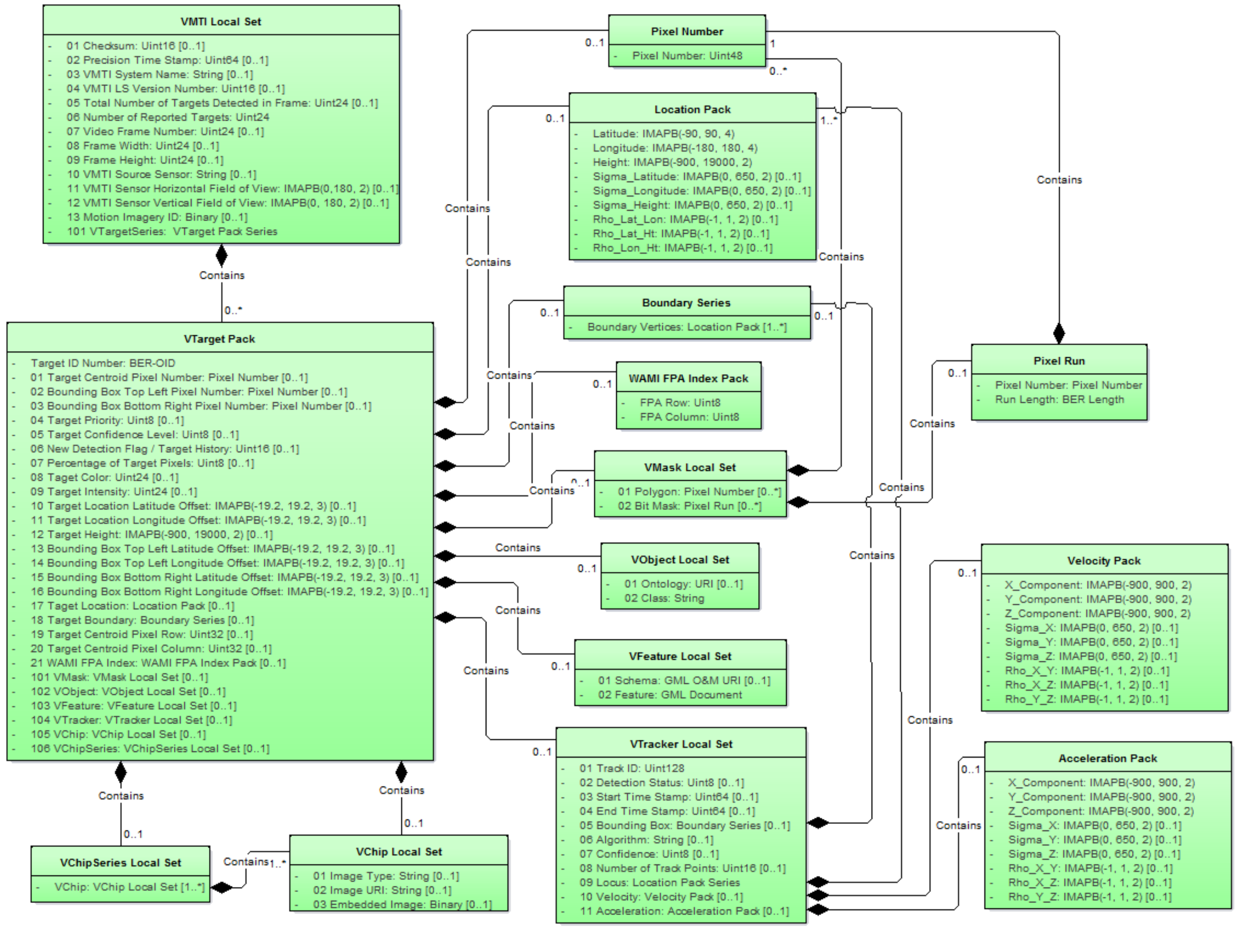
Data Element Definition			
Element Name	Rho_East_North Rho_East_Up Rho_North_Up	Type: Float	Units: NA
Valid Values	The set of real numbers ranging from -1.0 to 1.0 inclusive		Precision: Refer to MISB ST 1201
KLV Encoding			
Universal Label	06.0E.2B.34.01.01.01.01.0E.01.01.03.2E.06.00.00 (CRC 17572) 06.0E.2B.34.01.01.01.01.0E.01.01.03.2E.07.00.00 (CRC 29588) 06.0E.2B.34.01.01.01.01.0E.01.01.03.2E.08.00.00 (CRC 24485)		LS Tag: NA
Volatility	Encoded Type	Length	Format
Dynamic	Unsigned Integer	2 Bytes	Binary
Notes			
- Correlation coefficients for Acceleration with respect to the ENU coordinate system. - Acceleration correlation coefficients must appear in the following order in the element and be encoded the same way. 1. Rho_East_North = Correlation coefficient between the East and North components. 2. Rho_East_Up = Correlation coefficient between the East and Up components. 3. Rho_North_Up = Correlation coefficient between the North and Up components.			
Conversion			
IMAPB(-1, 1, 2)			

Example Value	Example Encoded LS Value
Rho_East_North = 0.75 (0x70 00) Rho_East_Up = 0.50 (0x60 00) Rho_North_Up = 0.25 (0x50 00)	[0x70 00 60 00 50 00]

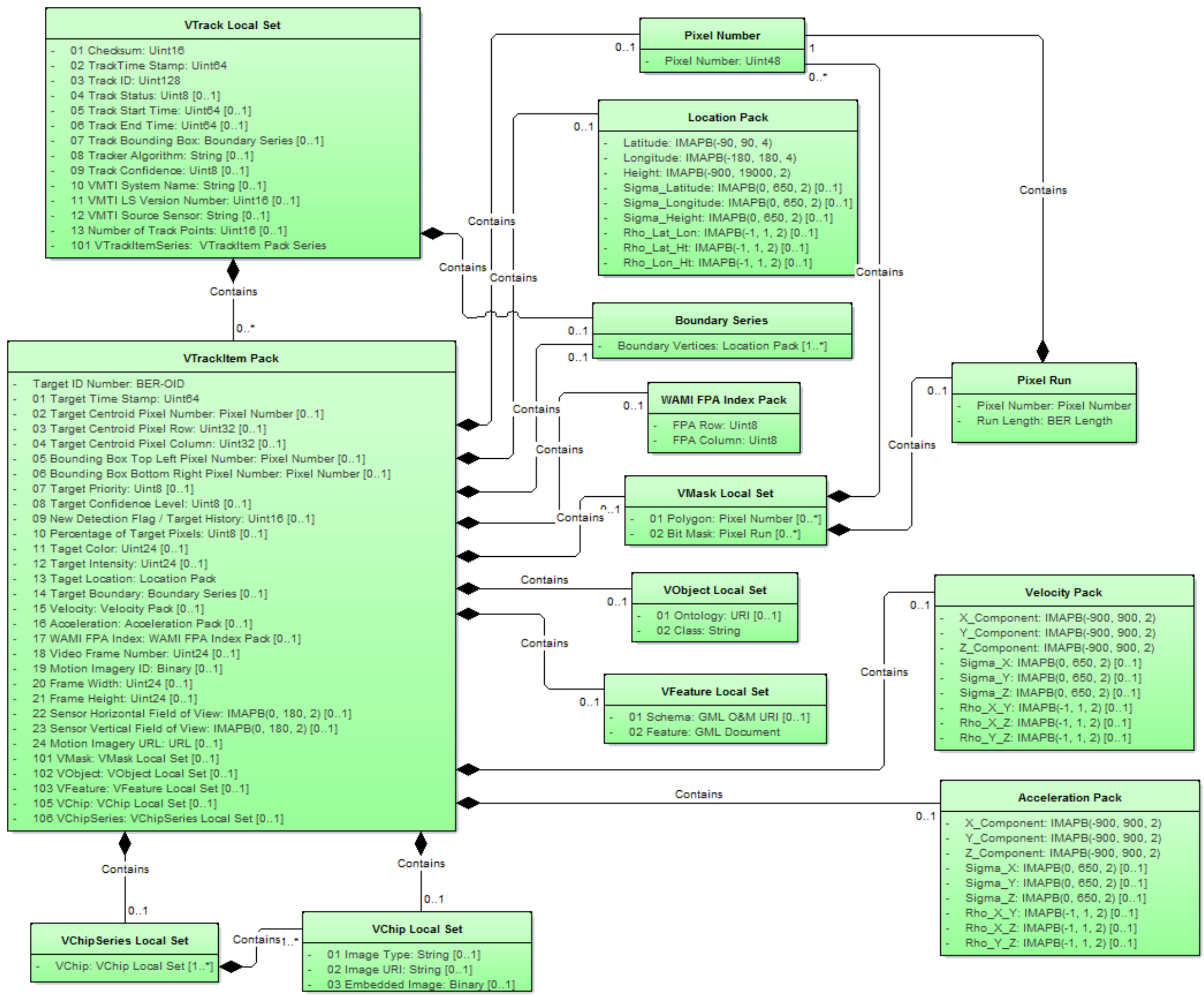
11.19 Boundary Type

Data Element Definition			
Element Name	Boundary	Type	Units
		Array	NA
Valid Values	Any valid structure of type Location		Precision
			NA
KLV Encoding			
Universal Label	06.0E.2B.34.02.04.01.01.0E.01.03.03.17.00.00.00 (CRC 11851)		LS Tag
			NA
Volatility	Encoded Type	Length	Format
Dynamic	Series	Variable	Binary
Notes			
- None			
Conversion			
NA			
Example Value	Example Encoded LS Value		
NA	NA		

12 Appendix B – VMTI LS UML Data Model [Informative]



13 Appendix C – VTrack LS UML Data Model [Informative]



14 Appendix D – Operational Considerations [Informative]

14.1 Bandwidth

Bandwidth management is an important issue affecting all systems. It is of particular importance for VMTI (and tracking) systems, which produce a large amount of dynamic data at frame rate. Thus, careful consideration has been given to efficient representation of the data.

In its simplest implementation, the VMTI LS may send thousands of targets to downstream systems by providing a Target ID Number and a Target Centroid Pixel Number within a Motion Imagery frame for each target. At the other end of the scale, the VMTI LS has scope to include multiple features about each target, image chips of the target, tracking information about the target, and numerous descriptive elements. The bandwidth overhead required to include all this information is very large – especially at 60 frames per second (FPS) or higher.

Motion Imagery sensors with frame rates of up to 60 FPS are in use operationally, and faster systems are expected in the future. It follows that VMTI rates will follow the same trend. In order to conserve bandwidth, a distinction is made between dynamic data, periodic data, and static data. Dynamic data change continuously and are only valid at a specific instant in time. Periodic data change periodically and are valid for a period of time. Static data rarely, if ever, change within a single mission. The expected refresh rates for these three classes of data are listed in Table 17.

Table 17: Volatility Refresh Rates

Volatility	Refresh Rate
Dynamic	Every VMTI frame
Periodic	Every two (2) seconds or first available time after the value changes
Static	Every two (2) seconds or as available from an external source

VMTI data does not have to be delivered at the frame rate of the Motion Imagery. Data that rarely changes should only be delivered often enough to assure that it is included in any clip extracted from the Motion Imagery stream. Dynamic data should be delivered at a rate that is appropriate to the granularity of the intelligence provided. For example, for a target moving at 3 meters per second, a rate of 60 updates a second provides very little value over a rate of 20 updates per second. In that case, while the Motion Imagery frame rate might be 60 FPS, the VMTI update rate need only be 20 FPS.

The VMTI LS includes a large number of elements that may not be available from onboard VMTI processors. It is expected that downstream processes will contribute “value add” elements to a basic VMTI LS stream. Calculations of bandwidth requirements should take into account where in the VMTI workflow the data is being added to the stream and the available bandwidth at that stage.

Bandwidth implications and bandwidth management must be considered in the design of systems that generate VMTI LS data. Reduction of metadata to a minimal effective configuration is recommended. Although the LS provides scope for many elements, it is undesirable to populate elements just because Tags exist to support the data.

Every effort has been made not to repeat metadata elements that are found in other metadata LS, particularly MISB ST 0601. However, some metadata elements (VMTI Source Sensor, VMTI HFOV and VFOV) in the VMTI LS are comparable to those in MISB ST 0601 LS (Image Source Sensor, HFOV, and VFOV). They become relevant when the VMTI process is run on different Motion Imagery from that described by and/or included with the MISB ST 0601 data. Consider, for example, two bore-sighted sensors, where MISB ST 0601 metadata describes the Motion Imagery from one of the MISB ST 0601 sensors, but MISB ST 0903 metadata describes VMTI detections from the Motion Imagery of the other sensor. (Note that MISB ST 0601 metadata is allowed to contain only one VMTI LS, precluding the carriage within it of detections from multiple Motion Imagery essences.)

Each VMTI process from a given sensor requires its own individual VMTI LS. That is, a VMTI LS should never contain a mixture of moving targets detected by different sensors. (The VChipSeries for a given detection may, however, contain image chips from multiple sensors.)

14.2 Co-located Bore-sighted Sensors

A system with multiple bore-sighted imagers within a single turret may send a Motion Imagery stream from one camera with a given field of view, synchronously with VMTI hits from other sensors with different fields of view. For example, a system containing a narrow field of view (FOV) visible light sensor (EON), a wide FOV visible light sensor (EOW), and an infrared (IR) sensor may be transmitting the a stream from the EON sensor and simultaneously include VMTI hits from both the EOW sensor and the IR sensor. This situation is supported by providing a separate VMTI packet stream, consisting of distinct MISB ST 0903 Local Sets for the IR and EOW cameras, multiplexed into a MPEG-2 transport stream containing the EON Motion Imagery.

VMTI streams should be distinguished within the multiplexed MPEG-2 transport stream by the VMTI Source Sensor field plus the VMTI Sensor Horizontal Field of View (HFOV) field. (See Section 11.10 and Section 11.11 for definitions.)

Sophisticated VMTI systems may use the same Target ID Number to identify a common target detected by different sensors and retain the use of same Target ID Number temporally (that is, from one detection to another). Also, downstream processes (e.g. trackers and fusion systems) may reassign Target ID Numbers to identify a common target.

14.2.1 Independent Sensors

Each independent sensor system requires a separate MISB ST 0601 stream. The extra elements required in the VMTI LS to support multiple non-bore-sighted sensors would disproportionally increase bandwidth requirements for inclusion within a single MISB ST 0601 LS packet. Given that MISB ST 0601 does not support such cases anyway, the most appropriate solution is to generate individual VMTI LSs and MISB ST 0601 streams for these sensors.

14.2.2 Large Volume Motion Imagery

Large Volume Motion Imagery (LVMI) systems present a problem not normally encountered with “traditional” airborne Motion Imagery sensors. LVMI systems often cover large geographic extents and can detect thousands of simultaneous moving objects over several square kilometers of area, but the volume of Motion Imagery collected is far beyond the downlink capabilities of the communications channel. A standalone stream of VMTI or Track information (transmitted independent of any Motion Imagery essence) could describe all of the detected moving objects and be used to cue analysts as to which objects to monitor actively and which to leave, say, to automated processes. This information can be used to task “spotlights” that specify regions of particular interest to the analyst, for which Motion Imagery is actually downloaded, reducing potential bandwidth requirements. These spotlights in turn can carry VMTI or Track data for the moving objects within the scope of the spotlight imagery.

VMTI and Track data for the spotlight streams will be similar to the independent sensors paradigm (See Section 14.2.1) in their packaging and processing. However, VMTI and Track data used for cueing takes a different approach. In this case the existence of an associated Motion Imagery stream cannot be assumed. Cueing VMTI or Track must therefore be self-contained, with no dependencies on other data streams.