VRT Spectrum Survey Interoperability Specification (V49a) for Dummies

Volume 2: *Context Geolocation and Extension*

This document is not VITA or ANSI Approved[i]

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1 Contents

2 Introduction

The VITA Radio Transport (VRT), also known as the VITA 49 (V49) standard, defines a mechanism for the transport of digitized signal data and the accompanying contextual information. The V49 standards support a very broad range of applications and as such cannot be practically supported by a single Application Program Interface (API). It is expected that application-specific specifications be defined around the V49 framework and definitions provided in the V49 base standards.

Vita-49A is a specification that is applicable to spectrum-survey applications. It is a subset of the V49.0 specification and intended to foster high-throughput and adaptable processing in a large-scale environment by a reduced scope implementation of V49. It specifically considers the needs of devices based around 32-/64-bit general-purpose processors (GPP) and field programmable gate arrays (FPGAs) that utilize Internet Protocol (IP) as the underlying transport between processing devices.

This guide is intended to be used as a "quick-start" to understanding the V49A specification and references the official ANSI/Vita-49.0 and ANSI/Vita-49A standards. It is recommended that this guide be used in conjunction with the official ANSI/Vita standards whenever possible.

A brief description of the Vita-49 family of standards and taxonomy is shown below.

Standard	Common Name	Description	Status
ANSI/VITA 49.0-2015	VITA Radio Transport (VRT)	This standard defines a transport-layer protocol designed to promote interoperability between RF (radio frequency) receivers and signal processing equipment in a wide range of applications.	ANSI Ratified
ANSI/VITA 49.1-2015	VITA Radio Link Layer (VRL)	This standard specifies an optional encapsulation protocol for VITA-49.0 (VRT) packets.	ANSI Ratified
ANSI/VITA 49.2-2017	VITA Radio Transport (VRT) Electromagnetic Spectrum: Signals and Applications	This standard supports all of the features of V49.0 and provides additional features for enhanced spectrum sensing applications and precision control of RF emissions across distributed systems to include: spectral data, command/control, stimulus/exciter, enhanced context and diagnostics packets.	ANSI Ratified
ANSI/VITA 49a-2015	Spectrum Survey Interoperability	This specification describes an interoperability standard that is an application-specific subset of the ANSI/VITA 49 family of standards that specifically identifies the set of features that must be supported in order to meet the needs of a given application. Specifically the support of high-throughput systems utilizing 32-/64-bit general-purpose processors and FPGAs.	ANSI Ratified

Table 2-1: Vita-49 Family of Standards

It should also be noted that this document only covers *Vita-49A Context Geolocation and Extension Packets.* Signal IF Data and Signal IF Context (except geolocation) are covered in Volume 1 of this series.

3 VRT Packet Classes

A VRT Packet Class is the specification of the name, structure, and function of the packets in a VRT Packet Stream. Specifically, it specifies the name, numeric code, structure and function of the packet class. In Vita-49.0 there are four categories of packet classes: IF Data Packet Class, Extension Data Packet Class, IF Context Packet Class and Extension Context Packet Class. They are defined as follows:

IF Data Packet: a VRT Packet Stream that conveys IF Data.

Extension Data Packet: a VRT Packet Stream that conveys data in a user-defined format.

IF Context Packet Stream: a VRT Packet Stream that conveys information (context) about the corresponding IF Data Packet Stream.

Extension Context Packet Stream: a VRT Packet Stream that conveys information (context) about the corresponding Extension Data Packet Stream. The table below describes the four packet stream types.

Contents	**Standard Formats**	**Custom Formats**
Data	**IF Data** Conveys a digitized IF signal (IF Data) • Real/complex data • Fixed/floating-point formats	**Extension Data** Conveys any signal or any data derived from a signal • Any type of data • Custom packet format
Context	**IF Context Packet Stream** Conveys common Context for IF Data • Frequency • Power • Timing • Geolocation	**Extension Context** Conveys additional Context for IF Data or Extension Data. • Any kind of Context • Custom packet format

Table 3-1: Packet Stream Types in VRT

4 Extension Data Packet

An Extension Data Packet Stream conveys a data payload that is unique to a particular application. Examples of data that could be placed in an Extension Data packet include pulse descriptor words and FFT data. The general format of the packet is shown below:

31 ... 0
Header (One word, mandatory)
Stream Identifier (One word, mandatory)
Class Identifier (Two words, mandatory)
Integer-seconds Timestamp (One word, optional)
Fractional-seconds Timestamp (Two words, optional)
User-Defined Data Payload (Variable, mandatory)
Trailer (One word, mandatory)

Figure 4-1: Extension Data Packet Template

Header

All VRT packets must have a properly formatted header as shown below.

VRT Packet Header

Word	31–28	27	26	25–24	23–22	21–20	19–16	15–0
1	Packet Type	C	T	*R R*	TSI	TSF	Packet Count	Packet Size

Figure 4-2: VRT Extension Data Packet Header Detail

For VRT Extension data packets the packet header, stream ID, class ID, payload and trailer are all mandatory in V49A. The bit fields are described in ***Table 4-1***.

Bits	Field	Value	Description
31-28	Type	0x0001, 0x0011	Signal or Extension Data packet with Stream ID
27	C	0x0, 0x1	0x0:Class ID not present, 0x1:Class ID present. Class ID must be present in Vita-49A
26	T	0x1	0x1; Trailer is present. Trailer must be present in Vita-49A
25-24	Reserved	0x0, 0x0	Reserved = set to zero by default
23-22	TSI		Time Stamp Integer Field (see Table 4-6)
21-20	TSF		Time Stamp Fractional Field (see Table 4-6)
19-16	Count	0x0 – 0xF	Rolling packet count (Rolls over from 0xF to 0x0)
15-0	Size	0x0 - 0xFFFF	Total number of 32-bit words in the IF Data packet, including the header, payload and any optional fields. A value of 0x0 indicates a "No Data" Packet[1].

Table 4-1: VRT Extension Data Packet Header Bit Fields

The VRT packet header must indicate the type of packet shown below, the most common being Signal Data and Context. Note that a Stream Identifier is required for Vita-49A.

Packet Type	Meaning
0000 (0)	Signal Data Packet without Stream Identifier[2]
0001 (1)	Signal Data Packet with Stream Identifier
0010 (2)	Extension Data Packet without Stream Identifier [2]
0011 (3)	Extension Data Packet with Stream Identifier
0100 (4)	Context Packet
0101 (5)	Extension Context packet
0110 (6) – 1011 (11)	Reserved

Table 4-2: VRT Packet Types

Stream ID

A Stream Identifier (Stream ID) is a 32-bit number assigned to a VRT Packet Stream. Each packet in a Packet Stream contains the Stream ID for that Packet Stream. This identifies all the packets in the Packet Stream as belonging to it. In most cases each VRT Packet Stream will have a unique Stream ID, and the different Stream IDs used in different Packet Streams enable a receiver of those packets to separate them into their respective Packet Streams. The Stream ID **shall** be in the range of 0x00000001 and 0x7FFFFFFF inclusive.

Bits	Field	Value	Description
31-0	Stream ID	0xXXXXXXXX	Unique 32 bit Stream ID for each data stream

Table 4-3: Packet Stream ID

1 A "No Data" Packet must use the Class ID of FF-FF-FA:2011.0002 (See Rule 6.4-3 of VITA 49A-2015)
2 Not allowed in Vita-49A

Class ID

The Class Identifier (Class ID) field makes it possible for the receiver of a VRT Packet Stream to determine the identity of both the Information Class used for the application and the Packet Class from which each received packet was made. The generic Class ID field is shown in **Figure 4-3**.

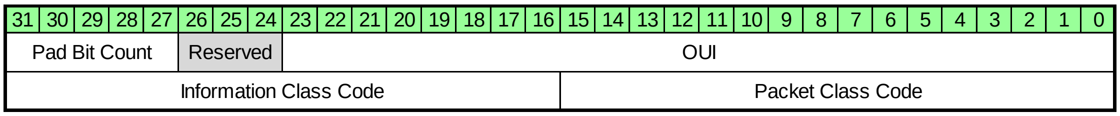

Figure 4-3: Generic Class Identifier Field

In an effort to facilitate interoperability Vita-49A defines a **Standard Data Packet**. The Standard Data Packet is a specific set of Class Identifiers in the range FF-FF-FA:0000.0000 to FF-FF-FA:00FF.FFFF that can be used with the IF Data and Extension Data packets that conform to this specification. Rather than enumerate all possible Class Identifiers that can be used, an algorithmic approach is taken to assign them. The Standard Data Packet **shall** be used with IF Data packets and Extension Data packets, the Class ID for the Standard Data packet is shown in **Figure 4-4**.

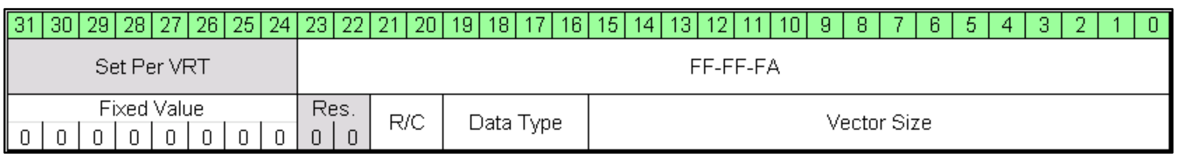

Figure 4-4: Standard Data Packet Class Identifier

Bits	Field	Value	Description (Word 1)
31-27	Pad Bit Count	0x0 - 0x1F	Number of Pad bits at the end of the payload.
26-24	Reserved		Reserved = set to zero by default
23 - 0	OUI	0xFFFFFA	OUI: FF-FF-FA

Bits	Field	Value	Description (Word 2)
31-24	Fixed Value	0x0	Fixed Value bits set to zero
23-22	Reserved	0x0 , 0x0	Reserved = set to zero by default
21-20	R/C	0x00. 0x01	0x00: Real, 0x01: Complex Cartesian
19-16	Data Type	0x1 - 0xD	See Table 4-5 for Data Type Codes
15-0	Vector Size		Unsigned that is one less than actual Vector Size[3]

Table 4-4: Standard Data Packet Class Identifier

[3] The Vector Size indicator is a 16-bit field to maintain consistency with that used with VRT (Vita-49.0) rule 7.1.5.18-11 on the Data Packet Payload Format

Data Type	Format	Data Type	Format
0001	4-bit Signed Fixed Point	1000	1-bit Unsigned Fixed Point
0010	8-bit Signed Fixed Point	1001	4-bit Unsigned Fixed Point
0011	16-bit Signed Fixed Point	1010	8-bit Unsigned Fixed Point
0100	32-bit Signed Fixed Point	1011	16-bit Unsigned Fixed Point
0101	64-bit Signed Fixed Point	1100	32-bit Unsigned Fixed Point
0110	32-bit IEEE 754 Single Precision	1101	64-bit Unsigned Fixed Point
0111	64-bit IEEE 754 Double Precision		

Table 4-5: Standard Data Packet Data Type Format Codes

Timestamp

The Timestamp in an Extension Data packet is divided into two components: an integer-seconds component and a fractional-seconds component. Together these two components precisely specify the Reference-Point Time of the first Data Sample contained in the packet.

The *Integer-seconds Timestamp* specifies the Reference-Point Time only to one-second resolution, while the fractional-seconds part adds additional resolution. The *Integer-seconds Timestamp* consists of a single 32-bit word. It may be used to convey UTC time, GPS time, or some user-specified time-code. The type of time conveyed by this word is indicated by the value of the TSI bits.

The "TSI" (Time Stamp-Integer) field is an encoded field indicating which, if any, type of Integer-seconds Timestamp is present in the packet. The "TSF" (Time Stamp-Fractional) field is an encoded field indicating which, if any, type of Fractional-seconds Timestamp is present in the packet.

The *Fractional-seconds Timestamp* conveys the Reference-Point Time to a higher resolution than does the Integer-seconds Timestamp. There are three types of Fractional-second Timestamps:

- The "Sample-Count" Timestamp
- The "Real-Time" Timestamp
- The "Free-Running Count" Timestamp.

The first two of these typically serve to add resolution to the Integer-seconds Timestamp, so that together they provide a range of years and a precision down to either the sample-period or one picosecond respectively. The third Fractional-seconds Timestamp, the Free-Running Count Timestamp, provides an incrementing sample count from any chosen starting time. It has no constant relationship to the Integer-seconds Timestamp. Each of the three Fractional-seconds Timestamps consists of an unsigned 64-bit integer which occupies two consecutive 32-bit words.

The **Sample Count Timestamp** extends the resolution of the Integer-seconds Timestamp down to one Data Sample period. It accomplishes this by conveying the sample number, as counted at the Reference Point, of the first Data Sample in the IF Data packet relative to the time of the last Integer-seconds Timestamp increment. Thus it is reset to zero at each increment of the Integer-seconds Timestamp. In the case where the Integer-seconds Timestamp is not in use, this timestamp still resets to zero when it reaches the number of Data Samples in one second. The timing of these events is not specified in this case however.

The **Real-Time Timestamp** extends the resolution of the Integer-seconds Timestamp down to one picosecond. It accomplishes this by conveying the Reference-Point Time of the first Data Sample in the IF

Data packet, in picoseconds, relative to the time of the last Integer-seconds Timestamp increment. Thus it is reset to zero at each increment of the Integer-seconds Timestamp. In the case where the Integer-seconds Timestamp is not in use, this timestamp still resets to zero when it reaches the number of picoseconds in one second. The timing of these events is not specified in this case however.

The **Free Running Count Timestamp** conveys the Reference-Point Time of the first Data Sample in the IF Data packet, in sample counts, relative to any chosen starting time. The Free Running Counter rolls over modulo-*N*, i.e. from *N*-1 to zero, where *N* can be any positive number up to 2^{64}. The Free Running Count has no constant relationship to the Integer-seconds Timestamp.

TSI Code	Meaning	TSF Code	Meaning
00	No Integer-seconds Timestamp field included	00	No Fractional-seconds Timestamp field included
01	UTC	01	Sample Count Timestamp
10	GPS time	10	Real-Time (Picoseconds) Timestamp
11	Other	11	Free Running Count Timestamp

Table 4-6: TSI and TSF Codes

Trailer

The IF Data packet trailer is a mandatory field whose presence is identified by the "T" bit in the header, as previously described. The trailer contains fields that indicate the validity of the Data and the status of the processes producing that Data. It also contains a field that indicates whether related Context is being sent in one or more separate "Context packets."

VRT Signal Data Packet Trailer

<table>
<tr><td>Word</td><td>31</td><td>30</td><td>29</td><td>28</td><td>27</td><td>26</td><td>25</td><td>24</td><td>23</td><td>22</td><td>21</td><td>20</td><td>19</td><td>18</td><td>17</td><td>16</td><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td colspan="12">Enables</td><td colspan="12">State and Event Indicators</td><td>E</td><td colspan="7">Associated Context Packet Count</td></tr>
</table>

Figure 4-5: Signal Data Packet Trailer

Together, the Enables field and the State and Event Indicators field provide the capability to mark an IF Data packet with one or more Data events or state updates to be communicated from a VRT emitter to a VRT receiver. An Event Indicator might indicate a system synchronization signal or other event that affects some portion, or all, of the IF Data packet payload. A state update might be an indication of tuner phase-lock, for example. When these fields are used, no provision is made for indicating the precise time of the events or state changes. The Enables field contains an enable bit for each Indicator bit in the State and Event Indicators field. Some of the Indicators (and their enable bits) are predefined and some are user-defined.

Enable Bit Position	Indicator Bit Position[4]	Indicator Name
31	19	Calibrated Time Indicator
30	18	Valid Data Indicator
29	17	Reference Lock Indicator
28	16	AGC/MGC Indicator
27	15	Detected Signal Indicator
26	14	Spectral Inversion Indicator
25	13	Over-range Indicator
24	12	Sample Loss Indicator
23,22	11,10	Sample Frame Indicators, User-Defined
[21..20]	[9..8]	User-Defined Indicators

Table 4-7: Trailer Enable and Indicator Bit Positions and Meanings

When the “E” bit (position 7 in Figure 4-5) is set to **one** the “Associated Context Packet Count” shall provide a count of all of the transmitted Context packets that are directly or indirectly associated with the IF Data packet, OR a count of some special subset of these. When the “E” bit is **zero**, the “Associated Context Packet Count” is undefined.

[4] Each Indicator functions as indicated, but only when the corresponding Enable bit is set otherwise, the Indicator bit is undefined.

5 Extension Context Packet

Extension Context Packet Streams are intended to be used to communicate metadata for which no provision has been made in the IF Context packet. The general format of the packet is shown below:

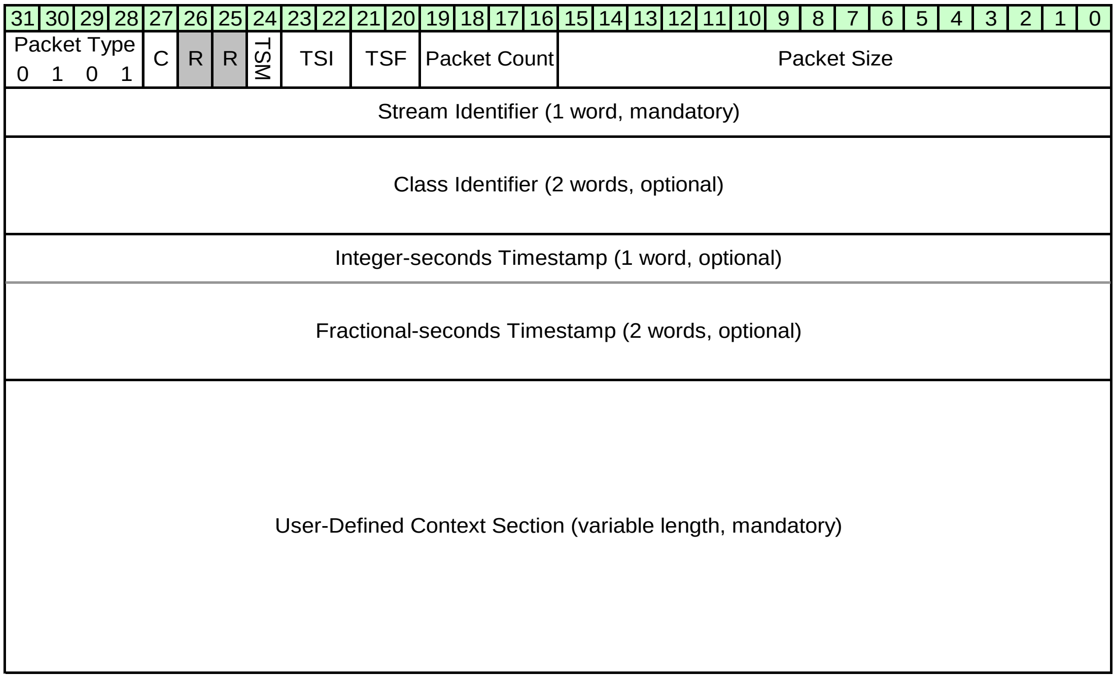

Figure 5-1: Template for Extension Context Packet Classes

Header

The header of the Extension Context packet is the same as the header of the Extension Data packet with the exception of the omission of the T bit and the addition of the TSM bit. The format of the IF Context packet header is shown below:

Bits	Field	Value	Description
31-28	Type	0x0101	Extension Context packet with Stream ID
27	C	0x0, 0x1	0x0: Class ID not present, 0x1 Class ID present
26-25	Reserved	0x0, 0x0	Reserved = set to zero by default
24	TSM	0x1, 0x0	Timestamp Mode - 0x0: precise event timing, 0x1: general event timing
23-22	TSI		Time Stamp Integer Field (see Table 4-6)
21-20	TSF		Time Stamp Fractional Field (see Table 4-6)
19-16	Count	0x0 – 0xF	Rolling packet count (Rolls over from 0xF to 0x0)
15-0	Size	0x0 - 0xFFFF	Total number of 32-bit words in the IF Data packet, including the header, payload and any optional fields. A value of 0x0 indicates a “No Data” Packet[5].

Table 5-1: VRT Context Packet Header Bit Fields

5 A “No Data” Packet must use the Class ID of FF-FF-FA:2011.0002 (See Rule 6.4-3 of VITA 49A-2015)

Stream ID

Stream Identifiers (Stream IDs) in the Extension Context Packet Class are used in the same fashion as in IF and Extension Data Packet Classes to identify particular packets as belonging to certain Packet Streams. In addition, the Stream ID in a Context Packet Stream may serve to pair it with a Data Packet Stream or to associate it with another Context Packet Stream.

Class ID

The Class Identifier (Class ID) is used to identify the Information Class and Packet Class to which the Context packet belongs. It contains an OUI subfield which specifies the organization that specified the Information Class and Packet Class to which the Context Packet Stream belongs. It also contains codes that uniquely identify the Information Class and Packet Class from that organization.

Word	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	Reserved								Class Specifier OUI																							
2	Information Class Code																Packet Class Code															

Figure 5-2: Context Class Identifier Field

The **Standard Context Packet** is a Context packet that can be used in any generic Context Stream that conforms to Vita-49A. For the Standard Context Packet the OUI is FF-FF-FA, Information Class Code is 0x2011 (8209), and Packet Class Code is 0x0003 (3).

Timestamp

The options and formats for Extension Context packet Timestamp fields are identical to those in an Extension Data packet. However, the interpretation of the Timestamp in the Context Packet is dependent on the TSM bit in the header. When the Timestamp Mode is set to fine resolution (the TSM bit is set to zero) the Context packet Timestamp conveys the *precise* timing of events related to the Described Signal. This timing may be as precise as the resolution of the Fractional-Seconds Timestamp supports, i.e. either sample-period or picosecond resolution. It may also be less precise than this if the timing of the event is not known to this level of precision.

When the TSM bit is set to coarse resolution (the TSM bit is set to one) the Context packet Timestamp conveys *general* timing of events related to the Described Signal. That is, the Context packet conveys events that occurred sometime within the Data Sampling Interval of some Data packet in the paired Data Packet Stream.[6] To identify which Data Sampling Interval, the Context packet Timestamp must match the Timestamp of that Data packet in the paired Data Packet Stream. The less precise timing indication available with this TSM mode might be used because more precise information about the time of an event is not available, or not necessary, or because multiple events that occurred at different times within the Data packet sampling interval are grouped into a single Context packet for the sake of simplicity or efficiency.

[6] *This mode cannot be used when the Described Signal is analog.*

Context (Payload) Section

Unlike the IF Context packet, the Extension packet is user defined. It is *recommended* (but not required) that the Extension packet be formatted in the same fashion as an IF Context packet to facilitate interoperability, re-use, etc. The Extension Context Packet Class documentation **shall** describe the format of the user-defined Context section of the Extension Context packet, as well as the meaning of all included fields.

6 Geolocation Context Information

Geolocation related context indicator fields (CIFs) of the IF context packet are described in this section.

CIF #	Context Field	Number of Words in Context Field	Period of Validity	Bit Positions
17	Formatted GPS Geolocation	11	Persistent	See VRT Figure 7.1.5.19-1
18	Formatted INS Geolocation	11	Persistent	See VRT Figure 7.1.5.19-1
19	ECEF Ephemeris	13	Persistent	See VRT Figure 7.1.5.21-2
20	Relative Ephemeris	13	Persistent	See VRT Figure 7.1.5.21-2
21	Ephemeris Reference Identifier	1	Persistent	See VRT Figure 7.1.5.23-1
22	GPS ASCII	Variable	Persistent	See VRT Figure 7.1.5.24-1
23	Context Association List	Variable	Persistent	See VRT Figure 7.1.5.25-1

Table 6-1: Geolocation Context Indicator Fields

Global Positioning System

The GPS (Global Positioning System) and INS (Inertial Navigation System) Geolocation fields share the same format, shown below.

Word	31 30 29 28	27 26	25 24	23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
1	Reserved	TSI	TSF	GPS/INS Manufacturer OUI
2	Integer-second Timestamp of Position Fix (31..0)			
3	Fractional-second Timestamp of Position Fix (63..32)			
4	Fractional-second Timestamp of Position Fix (31..0)			
5	Latitude (31..0), degrees			
6	Longitude (31..0), degrees			
7	Altitude (31..0), meters			
8	Speed over Ground (31..0), meters/second			
9	Heading Angle (31..0), degrees			
10	Track Angle (31..0), degrees			
11	Magnetic Variation (31..0), degrees			

Figure 6-1: Format of the GPS and INS Geolocation Fields

The definitions of the TSI and TSF subfield codes in the Formatted GPS and INS Geolocation Fields match that of the IF Data packet except that the '00' code is redefined to mean that the corresponding

Timestamp field is included in the packet but it's contents are not specified. With this redefinition, the Geolocation field maintains a constant length which is helpful when parsing IF Context packets. See the *Timestamp* section for TSI/TSF definitions.

The Geolocation Angle Format describes angles in units of degrees. The Geolocation Angle Format uses the 32-bit, two's-complement[7] format shown below and is used for latitude, longitude, heading and track angle.

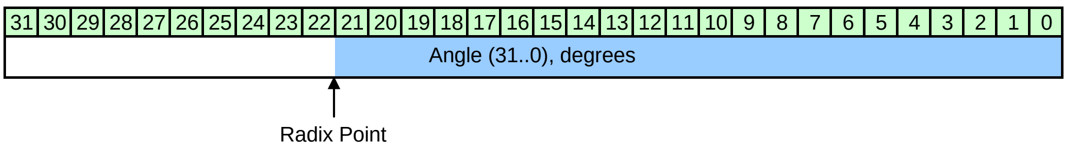

Figure 6-2: Geolocation Angle Subfield Format

The Geolocation Angle Format has a possible range of ±512 degrees and a resolution of 2.38e-7 degrees. Particular angular measurements allow various ranges such as 0 to 360 degrees, ±180 degrees, or ±90 degrees. This field has an integer and a fractional part with the radix point to the right of bit 22.

Example: A Geolocation Angle value of 0x0040 0000 represents an angle of 1 degree. A Geolocation Angle value of 0xFFFF FFFF represents an angle of -2.38e-7 degrees. A Geolocation Angle value of 0x0000 0001 represents an angle of +2.38e-7 degrees.

The Altitude subfield in the GPS Geolocation Field **shall** use the 32-bit, two's-complement format shown below. The value of the Altitude subfield **shall** be expressed in units of meters. This field has an integer and a fractional part with the radix point to the right of bit 5

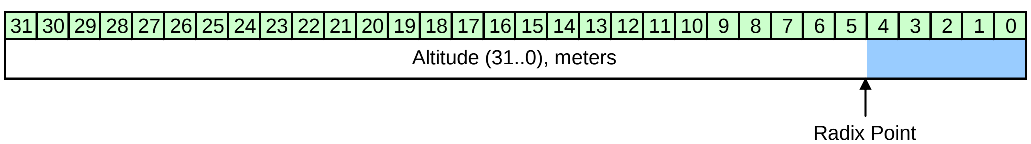

Figure 6-3: Altitude Subfield Format

Example: An Altitude value of 0x0000 0020 represents an altitude of 1 meter. An Altitude value of 0xFFFF FFFF represents an altitude of -0.03125 meters. An Altitude value of 0x0000 0001 represents an altitude of 0.03125 meters.

The Speed Over Ground subfield **shall** use the 32-bit, two's-complement format shown below. The value of the Speed Over Ground subfield **shall** be expressed in units of meters per second. This field has an integer and a fractional part with the radix point to the right of bit 16. The Speed Over Ground subfield has a range of 0 to 65636 m/s and a resolution of 1.5e-5 m/s. Negative values of Speed Over Ground are not valid.

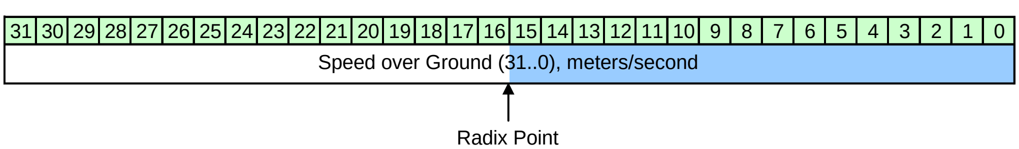

Figure 6-4: Speed Over Ground Subfield Format

[7] 2's complement: invert bit-wise then add 1

Example: A speed over ground value of 0x0001 0000 represents a speed over ground of 1 m/s. A speed over ground value of 0x0000 0001 represents a speed over ground of 1.526e-5 m/s.

Both the *Heading* and *Track* Angle subfields **shall** use the Geolocation Angle Format shown in **Figure 6-2** The Heading Angle **shall** express the platform's orientation with respect to true North in decimal degrees. The Track Angle **shall** express the platform's direction of travel with respect to true North in decimal degrees. The Heading and Track Angle value **shall** range from 0.0 to +359.999999761582 degrees.

The figure below illustrates the definition of several navigation terms. The course is the direction from the starting point to the destination. The bearing is the direction from the current platform location to the destination. While the platform is moving the bearing may change but the course does not. The track is the actual path the platform takes while moving from the starting point to the destination. The Track Angle is the direction the platform is moving (at the rate indicated by the Speed Over Ground subfield) and the Heading Angle is the direction the platform is pointed. External forces on the platform such as wind or water currents may cause the Track Angle to differ from the Heading Angle. Only the Heading Angle and Track Angle are conveyed in the Formatted GPS/INS Geolocation field.

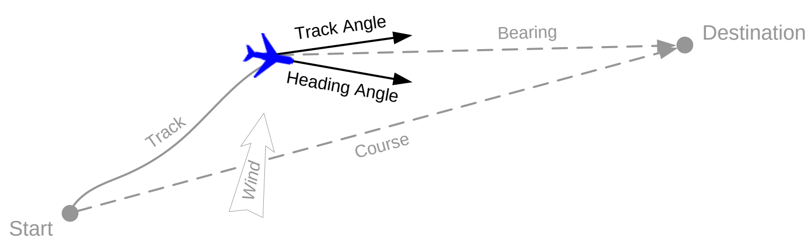

Figure 6-5: Navigation Angles

The Magnetic Variation subfield **shall** use the Geolocation Angle Format shown in **Figure 6-2.** The Magnetic Variation subfield **shall** express magnetic variation from true North in decimal degrees. The Magnetic Variation value **shall** range from -180.0 (West) to +180.0 (East) degrees.

Earth-Centered, Earth-Fixed (ECEF) Ephemeris

The ECEF Ephemeris field provides a format to convey location in Earth-Centered, Earth-Fixed Cartesian coordinates. It also contains a Cartesian decomposition of velocity and attitude.

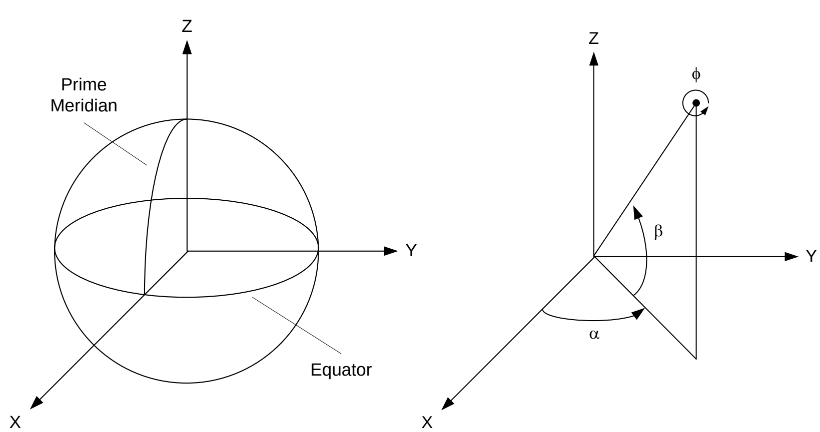

Figure 6-6: ECEF Ephemeris Coordinates

The position and velocity coordinates of the ECEF Ephemeris fields **shall** be specified in the Earth Centered, Earth Fixed Coordinate System as shown in **Figure 6-6**, interpreted as follows:

- The XY-plane is the Earth's equator.
- The Z-axis is directed along the Earth's rotational axis and is positive north.
- The positive X-axis is the intersection of the planes defined by the equator and prime meridian.
- The Y-axis completes a right-handed orthogonal system, 90 degrees east of the X-axis.
- The X, Y, and Z coordinates are referenced to the center of mass of the WGS-84 ellipsoid

The attitude coordinates of the ECEF Ephemeris fields **shall** be specified in the Earth Centered, Earth Fixed Coordinate System as shown in **Figure 6-6**, interpreted as follows:

- The angle alpha is about the Z-axis. Positive rotation is X to Y, with alpha equal to zero at the X-axis.
- The angle beta is about the Y-axis. Positive rotation is X to Z, with beta equal to zero at the XY-plane.
- The angle phi is about the X-axis. Positive rotation is Y to Z with phi equal to zero at the Y-axis.
-

The ECEF (Earth-Centered, Earth-Fixed) field and Relative Geolocation field share the same format, shown below.

<table>
<tr><th>Word</th><th>31</th><th>30</th><th>29</th><th>28</th><th>27</th><th>26</th><th>25</th><th>24</th><th>23</th><th>22</th><th>21</th><th>20</th><th>19</th><th>18</th><th>17</th><th>16</th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>1</td><td colspan="4">Reserved</td><td colspan="2">TSI</td><td colspan="2">TSF</td><td colspan="24">GPS/INS Manufacturer OUI</td></tr>
<tr><td>2</td><td colspan="32">Integer-second Timestamp of Position Fix (31..0)</td></tr>
<tr><td>3</td><td colspan="32">Fractional-second Timestamp of Position Fix (63..32)</td></tr>
<tr><td>4</td><td colspan="32">Fractional-second Timestamp of Position Fix (31..0)</td></tr>
<tr><td>5</td><td colspan="32">Position X (31..0), meters</td></tr>
<tr><td>6</td><td colspan="32">Position Y (31..0), meters</td></tr>
<tr><td>7</td><td colspan="32">Position Z (31..0), meters</td></tr>
<tr><td>8</td><td colspan="32">Attitude Alpha (31..0), degrees</td></tr>
<tr><td>9</td><td colspan="32">Attitude Beta (31..0), degrees</td></tr>
<tr><td>10</td><td colspan="32">Attitude Phi (31..0), degrees</td></tr>
<tr><td>11</td><td colspan="32">Velocity dX (31..0), meters/second</td></tr>
<tr><td>12</td><td colspan="32">Velocity dY (31..0), meters/second</td></tr>
<tr><td>13</td><td colspan="32">Velocity dZ (31..0), meters/second</td></tr>
</table>

Figure 6-7: ECEF and Relative Ephemeris Fields

The TSI, TSF, OUI, and Timestamp of Position Fix fields **shall** follow the rules of the corresponding Formatted GPS Geolocation fields given in the *Timestamp* section.

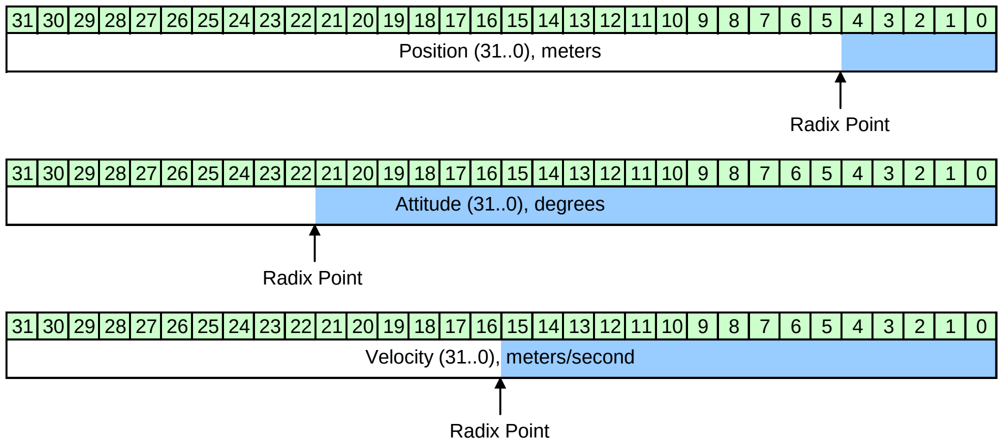

Figure 6-8: Position, Attitude and Velocity Coordinate Formats

The *position coordinates* of the ECEF Ephemeris field **shall** use the 32-bit, two's-complement "Position" format shown above. The position values **shall** be expressed in units of meters. This field has an integer and a fractional part with the radix point to the right of bit 5.

The *attitude coordinates* of the ECEF Ephemeris field **shall** use the 32-**bit, two's-complement "Attitude" format shown above. The attitude values shall be expressed in units of** decimal degrees. This field has an integer and a fractional part with the radix point to the right of bit 22.

The *velocity coordinates* of the ECEF Ephemeris field **shall** use the 32-bit, two's-complement "Velocity" format shown above. The velocity values **shall** be expressed in units of meters per second. This field has an integer and a fractional part with the radix point to the right of bit 16.

Relative Ephemeris

The Relative Ephemeris Geolocation field shares the same format as the ECEF Ephemeris field described above. However, the ECEF Ephemeris coordinate system is always the Earth-Centered Earth-Fixed coordinate system whereas the reference frame of the Relative Ephemeris coordinate system is user-defined. The ECEF and Relative Ephemeris coordinate systems may be used together if the transformation between coordinate systems is specified.

The Relative Ephemeris field provides a format to convey relative location, velocity, and attitude in Cartesian coordinates. This field may be useful, for example, in applications where it is important to know the locations and attitudes of multiple antennas on a platform. The origin and axis orientation for the Relative Ephemeris coordinate system are equipment provider specified. If desired, the Relative Ephemeris origin may be given in the ECEF Ephemeris field of the process pointed to by the Ephemeris Reference Identifier described in the next section (Ephemeris Reference Identifier).

	Aircraft Orientation	Antenna Orientation
Alpha	Yaw	Azimuth
Beta	Pitch	Elevation
Phi	Roll	Polarization

Table 6-2: Common Attitude Coordinate Interpretations

Ephemeris Reference Identifier

When Relative Ephemeris is reported, the Ephemeris Reference Identifier serves to identify the process whose location serves as the origin for the Relative Ephemeris and uses the format below.

Word	31..0
1	Ephemeris Reference Identifier

Figure 6-9: Ephemeris Reference Identifier Format

The Ephemeris Reference Identifier, when used, **shall** contain the Stream ID of the VRT Context Packet Stream whose ECEF Ephemeris is necessary to translate the Relative Ephemeris given in this Context Packet Stream to ECEF coordinates.

GPS ASCII Field

Some GPS devices output their information in the form of formatted ASCII strings, known as GPS "sentences." The sentences from a GPS device that emits ASCII strings (such as an NMEA-0183 compliant GPS device) may be conveyed in their original ASCII format using this field. The GPS ASCII field **shall** follow the format shown below.

Word	31..24	23..16	15..8	7..0
1	Reserved	GPS/INS Manufacturer OUI		
2	Number of Words			
3	Byte 1	Byte 2	Byte 3	Byte 4
⋮	⋮	⋮	⋮	⋮
N+2	Byte 4N-3	Byte 4N-2	Byte 4N-1	Byte 4N

Figure 6-10: GPS ASCII Field

The GPS/INS Manufacturer OUI field **shall** follow the rules of the corresponding Formatted GPS Geolocation fields, given in the GPS section.

The Number of Words subfield **shall** be represented as a 32-bit unsigned integer. It **shall** express the total number of 32-bit words required to convey the ASCII sentences.

The GPS ASCII Sentence subfield (words 3…N+2 in the above figure) **shall** only contain complete ASCII sentences, such as defined in NMEA-0183 or other valid GPS output format**.** Multiple ASCII sentences **may** be concatenated and sent in a single Context packet.

The GPS ASCII field **shall** be padded with null characters so that the total number of ASCII sentence characters plus null characters equals four (4) times the value in the Number of Words subfield.

7 Other Information

The following publications are used in conjunction with this specification. In the event that one of these publications is revised, the revised publication should be used unless it conflicts with this specification.

- VRT – VITA Radio Transport Protocol (Vita-49.0), August 2015
- VRL – VITA Radio Link Layer (Vita-49.1) , August 2015
- ANSI/VITA 49A-2015 Spectrum Survey Interoperability Specification, August 2015
- RFC 768 – User Datagram Protocol, IETF, 28 August 1980

- RFC 1112 – Host Extensions for IP Multicasting, IETF, August 1989
- RFC 2460 – Internet Protocol, Version 6 (IPv6) Specification, IETF, December 1998

8 Standard Packets

Standard packets provide a way to increase interoperability by providing a reduced set of options while maintaining core features or functionality.

Extension Context Packet Class Options Table		
Class Name	"Timestamp Accuracy Packet"	
Packet Stream Purpose	To convey the accuracy of the timestamps used in the associated Information Stream	
Packet Header		
Parameter	**Allowed Options**	**Comments**
Packet Type	Extension Context	
Stream Identifier	Used	
Class Identifier	FF-FF-FA:2011.0004	
Integer-seconds Timestamp	Used	UTC or GPS preferred
Fractional-seconds Timestamp	Used	Real-time preferred
Timestamp Precision	As specified in "Timestamp Accuracy" field	
Packet Payload		
Total Payload Length = 2 words **Payload as shown in Figure 7.3-1**		

Table 8-1: Timestamp Accuracy Packet

Extension Context Packet Class Options Table		
Class Name	"Ephemeris Packet"	
Packet Stream Purpose	To provide additional ECEF ephemeris information beyond that which can be included in the ECEF Ephemeris field of the IF Context Packet	
Packet Header		
Parameter	**Allowed Options**	**Comments**
Packet Type	Extension Context	
Stream Identifier	Used	
Class Identifier	FF-FF-FA:2011.ECEF	
Integer-seconds Timestamp	Used	UTC or GPS preferred
Fractional-seconds Timestamp	Used	Real-time preferred
Timestamp Precision	As specified in "Timestamp Accuracy Packet"	
Packet Payload		
Total Payload Length = 14+ words **Payload as shown in Figure 7.4-1**		

Table 8-2: ECEF Ephemeris Packet

9 Key Rules for Vita-49A (Extension and Geolocation)

The key rules for Vita-49A (Extension and Geolocation) are summarized in this section. The rules are grouped into classes of compliance that facilitate different levels of interoperability. These compliance levels are defined as follows:

Major (substantive) Violation: violation of a rule to the degree that interoperability is not possible or is rendered incompatible with compliant Vita-49A devices. The following rules are nominated as such.

Rule 6.2-1: Every Extension Data packet **shall** be organized the same as an IF Data packet, except that in the Extension Data packet the data payload is user-defined.[8]
Rule 6.2-2: The Packet Type code 0010 **shall not** be used.[9]
Rule 6.2-3: All Extension Data Packets **shall** include a Stream Identifier.[10]

VRT Rule 7.1.5.20-1: The Formatted INS Geolocation field **shall** follow the same rules as the Formatted GPS Geolocation field.

Compliance Rules and Definitions

Compliance with V49A means adherence to all the rules in the specification. It also means following recommendations wherever practicable and documenting deviations from recommendations. Examples below illustrate instances where this may occur. The key compliance rules from V49A are as follows:

Rule 5-1: All implementations of this specification **shall** comply with all rules in this specification.
Rule 5-3: An implementation of this specification **shall** be considered compliant with the rules in VRT regarding the documentation of packet classes (see VRT Section 8.2.5) for those packet classes defined within this specification.
Rule 5-4: An implementation of VRT that does not conform with this specification, but which documents use of the packet classes defined within this specification **shall** be considered compliant with the rules in VRT regarding the documentation of packet classes (see VRT Section 8.2.5) for those packet classes defined within this specification.

Major (substantive) Violation: violation of a rule to the degree that interoperability is not possible or is rendered incompatible with compliant Vita-49A devices.

Examples:

- Streams without a Stream ID present a problem for systems with more than one information stream as it makes multiple streams impossible or difficult to identify. (**Rule 6.1.1-1, Rule 6.1.1-2)**
- Streams without a Class ID complicate parsing of the Extension Data Packet payload and require prior processing of a corresponding Extension Context packet to determine how to parse the data type. (**Rule 6.1.3-1)**

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[8] This is a restatement of VRT Rule 6.2-1, but is included here to reiterate that all previous rules in this specification apply the same as they do in the VRT standard.

[9] This derived from Rule 6.2-3 (i.e. the requirement to include a stream identifier precludes the use of packet types without a stream identifier).

[10] This parallels Rule 6.1.2-1 for IF Data Packets and therefore derived from Rule 6.2-1; it is simply included here for clarity given Rule 6.2-2.

Minor (nominal) Violation: violation of a rule rendering non-compliance with V49A, but interoperability and compatibility with compliant Vita-49A devices can be maintained.

Example(s):

- Emitting an Extension Data or Context packet at a minimum of no less than 1 per 10 seconds of actual time does not present a compatibility problem if not followed, but is not compliant with V49A and could trigger time-out mechanisms in some systems, for instance. (**Rule 8-4, Rule 8-5).**

Warning: can be rendered compliant with proper documentation (Rule 5-4).

Example(s):

- Use of a VRT packet class other than the Standard Data Packet Class ID or Standard Context Packet Class ID provided that the purpose, allowed fields and options and the meaning of the enabled fields are all properly documented would still be considered compliant with this specification. (**Rule 5-4** *and* **VRT Rules 8.2.5.1, 8.2.5.2).**

Definitions

VRT: Vita Radio Transport Standard 49.0-2015
V49A: Vita-49A-2015 Spectrum Survey Interoperability Specification (SSIS)

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[i] This document and publications discussed are intended solely for information purposes. The information contained in this document has been obtained from sources believed to be reliable. The author does not guarantee the accuracy or completeness of any information published herein and shall not be responsible for any errors, omissions, or claims for damages, including exemplary damages, arising out of use, inability to use, or with regard to the accuracy or sufficiency of the information contained in this document.