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Interface Control Document for the Common Image Generator Interface (CIGI)

Version 3.1

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| Revision | Page(s) Affected* | Remarks | Revised By |
|----------|-------------------|--|------------|
| New | | | |
| 3.1 | 44 | The caption of Figure 28 has been changed to "Conformal Clamped Entity Control Packet Structure." | L. Durham |
| | 67-68 | The reference data listed in Table 13 for the linear and angular rates of entities were incorrectly given as "Entity coordinate system." These have been changed to "Geodetic reference plane." | L. Durham |
| | 81-82 | Added examples of using environmental regions to create gridded or tiled weather cells. | L. Durham |
| | 85 | The range of valid values for the <i>Transition Perimeter</i> parameter has been changed to ≥ 0 . | L. Durham |
| | 93-94 | The parameters in Table 19 have been rearranged to reflect the order in which the data appear in the Maritime Surface Conditions Control packet. | L. Durham |
| | 121-122 | The reference data for <i>Acceleration X</i> , <i>Acceleration Y</i> , and <i>Acceleration Z</i> parameters have been defined as the ellipsoid-tangential NED reference coordinate system. | L. Durham |
| | 122 | The units of the <i>Retardation Rate</i> parameter have been changed to m/s^2 . The description for this parameter has been clarified. | L. Durham |
| | 157-158 | The 4 th byte of the first word of the Environmental Conditions Request packet was incorrectly designated as Reserved. This parameter is now correctly labeled as <i>Request ID</i> and a description for this parameter has been added to Table 34. | L. Durham |
| | 177-179 | The use of the <i>Gate X Position</i> and <i>Gate Y Position</i> parameters has been clarified. | L. Durham |
| | 177 | The caption of Figure 86 has been changed to "Sensor Response Packet Structure." | L. Durham |
| | 178 | The caption of Table 40 has been changed to "Sensor Response Parameter Definitions." | L. Durham |
| | 182 | The use of the <i>Gate X Position</i> and <i>Gate Y Position</i> parameters has been clarified. | L. Durham |
| | 196 | The range of the <i>Surface Conditions ID</i> parameter in Table 46 has been defined. | L. Durham |
| | 204 | Figure 103 has been corrected to show the <i>Message ID</i> parameter. | L. Durham |

* As numbered in the prior revision.

1. INTRODUCTION

1.1 Scope

This document describes Version 3 of the open-source Common Image Generator Interface (CIGI). This document does not contain any proprietary notices as this interface is intended for unrestricted public use.

1.2 Purpose

This Interface Control Document (ICD) has been written for software engineers involved in the integration of a host simulator with an image generator (IG). This document contains descriptions of all data parameters, event sequences, and input/output (I/O) protocols necessary to accomplish this task using the Common Image Generator Interface (CIGI).

1.3 Instructions for Revising this Document

The CIGI version number contains a major and a minor revision number. Whenever a change is made to this document that affects data formatting, the major version number must be incremented. A change in the minor revision number of the ICD indicates that corrections or enhancements have been made to the document, but not to the message structures or data formats themselves.

The major version number is contained within the **IG Control** and **Start of Frame** data packets. This version number will always correspond to the major version number of the appropriate CIGI Interface Control Document.

1.4 Conventions Used in This Document

The following typographic conventions are used in this document:

- Data packet parameter names are *italicized*.
- Data packet names are in **boldface** type.
- Variable names are in *italicized Times Roman* typeface.
- Coordinate system axes are labeled or referenced using **boldface Times Roman** typeface.

Hexadecimal (base-16) notation is indicated by a lower-case “h” following a numerical value (e.g., 8000h).

Bit positions within each byte are numbered from right to left, indicating that the leftmost bit in each byte is the most significant bit. The leftmost byte in each word has the lowest physical address.

2. INTERFACE THEORY

The Common Image Generator Interface (CIGI) is a standardized interface between a real-time simulator host and an image generator. CIGI is an open interface offered to promote commonality in the visual simulation industry.

CIGI is a data packaging protocol and thus does not depend upon a specific physical communications medium or transport protocol. Any suitable physical medium may be used, including Ethernet, Token Ring, optical fiber, shared memory, etc. The transport protocol(s) used should depend upon performance and what is appropriate to the communications hardware. This document assumes the use of the User Datagram Protocol (UDP) over Ethernet for ease of discussion.

The connection between the host computer, henceforth referred to as “Host,” and the IG should be a dedicated bi-directional Ethernet connection, as illustrated in Figure 1 and Figure 2. The connection may be made using an Ethernet hub or switch, or using a single crossover cable (i.e. a patch cable with the transmit and receive signals crossed).

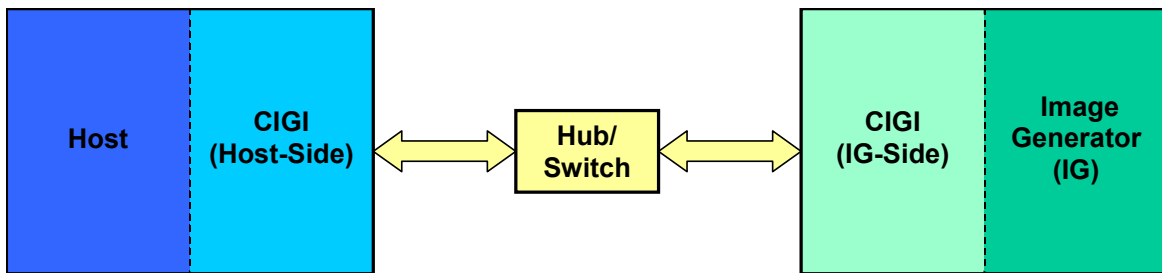


Figure 1 – Connection Using Ethernet Hub/Switch

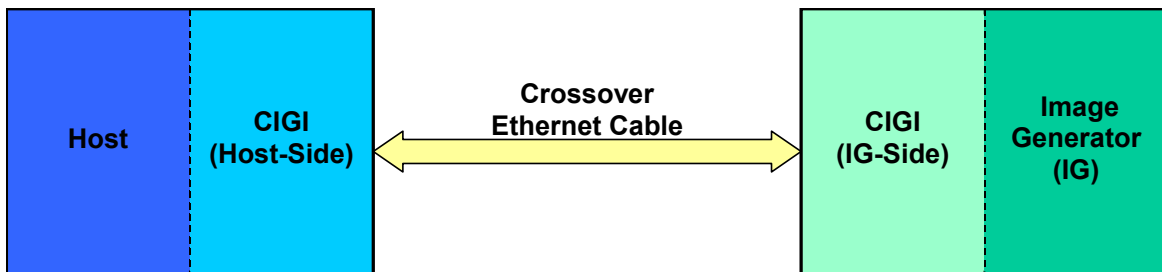


Figure 2 – Connection Using Crossover Cable

The remainder of Section 2 details the synchronization between the IG and the Host, message structure, device behavior when transitioning between operational modes, and provisions for extending and updating the interface.

2.1 Message Protocol

2.1.1 Message Synchronization

CIGI supports both synchronous and asynchronous operation. Each of these modes is described below.

2.1.1.1 Asynchronous Operation

During asynchronous operation, the Host sends data to the IG at a predetermined rate. The message may occur in response to a system timer or some other event within the Host. The IG may in turn send messages to the Host containing IG status and mission function data; however, the interval between host messages is determined by the host itself.

Meanwhile, the IG maintains its own frame rate, which is typically bound by the vertical sync signal from the display system. During each frame, the IG first checks its buffer for incoming CIGI messages. It then updates the scene graph based on the contents of the CIGI message along with any previously defined rates and trajectories, dynamic environmental attributes, and other factors. Finally, the IG renders the scene.

Because the Host might send a message at any point during the IG's frame, positional and other state changes might not be applied until the beginning of the *next* frame. This introduces a latency of up to almost one additional frame, as shown in Figure 3.

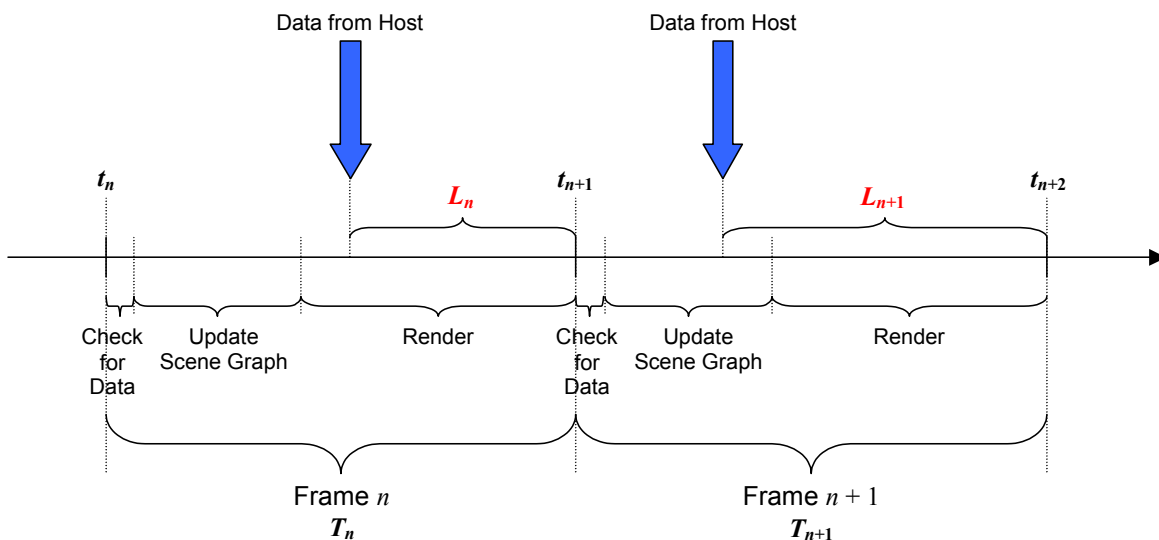


Figure 3 – Latencies Caused by Asynchronous Operation

In this example, the IG begins frame n at time t_n . At some time during that frame, the IG receives a message from the Host. Because the IG has already checked for incoming data, the message is not actually read until the start of the next frame at time t_{n+1} . By this time, the data within the message is old by a margin of L_n and will not be represented in the scene until at least t_{n+2} , bringing the total delay to $L_n + T_{n+1}$. This may cause a noticeable lag in the scene.

Note that latency L_{n+1} is larger than L_n . This “creeping” of the frame offset is a common phenomenon that occurs when the Host and IG frame rates are not exactly equal. Depending upon the direction of the creep, this will frequently cause the IG to receive either zero or two Host-to-IG messages during a frame, causing frame jitter.

To reduce the effects of lag and jitter, the IG may extrapolate positional data each frame. The **IG Control** and **Start of Frame** packets (see Sections 4.1.1 and 4.2.1, respectively) include a *Timestamp* parameter that the IG

can use when performing the extrapolation. This parameter indicates the amount of time that has elapsed since some initial reference time. By determining entities' velocities and accelerations from prior frames, or preferably from the **Rate Control** and **Trajectory Definition** packets (see Sections 4.1.8 and 4.1.20), the IG can calculate the probable positions of those entities during the current frame.

Because entities can be extremely dynamic, such extrapolations are prone to error. Asynchronous operation, therefore, is recommended only in low-fidelity applications or when synchronous operation is not possible.

2.1.1.2 Synchronous Operation

During synchronous operation, the IG sends a start-of-frame (SOF) message to the Host to signal the beginning of each frame. This message, which is usually driven by a vertical sync signal from the display system, functions as a "heartbeat" that dictates the timing of data transfers between the IG and Host. The SOF message also contains mission function responses, event notifications, and other IG data.

The Host immediately responds to each SOF message with its own message containing entity positions and orientation, component states, and other data describing changes to the scene during the previous frame. The Host then begins its next computational cycle, while the IG updates and renders the scene.

This mechanism makes the host data available at the beginning of every IG frame, eliminating the additional latency represented by L_n in Figure 3. Also, because the Host's frame rate is regulated by the IG, this prevents jitter caused by the creeping effect of misaligned frames.

Figure 4 illustrates the sequence described above:

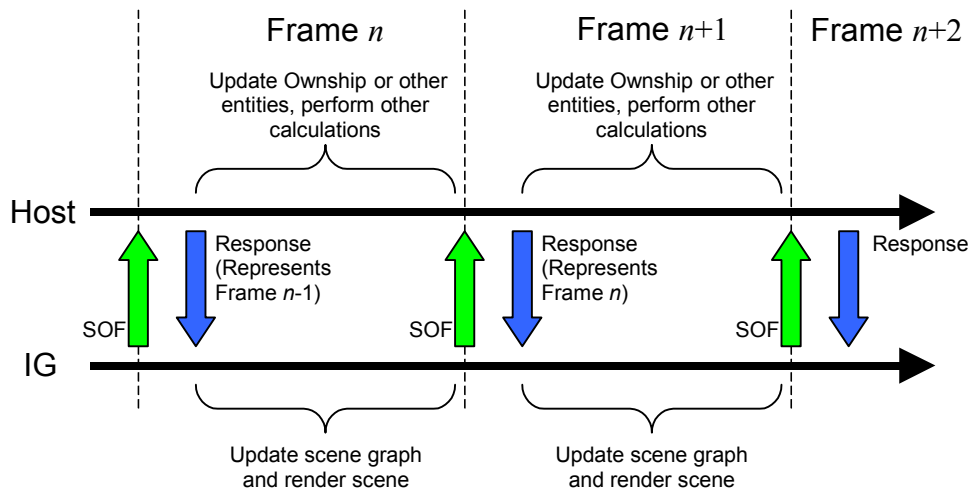


Figure 4 – Synchronous Start-of-Frame/Response Cycle

Depending upon bandwidth limitations and the amount of Ethernet traffic present on the system, the IG may not receive a response in time to finish rendering the scene before the start of the next frame. To alleviate this situation, a time offset can be introduced so that the IG sends each SOF message slightly *before* the beginning of the next IG frame. This technique allows data to arrive from the Host at such a time as to allow the IG its entire frame time for computations and rendering. Because the available Ethernet bandwidth may vary from frame to frame, this offset can be adjusted to allow for worst-case network loads. Figure 5 illustrates the start-of-frame offset technique:

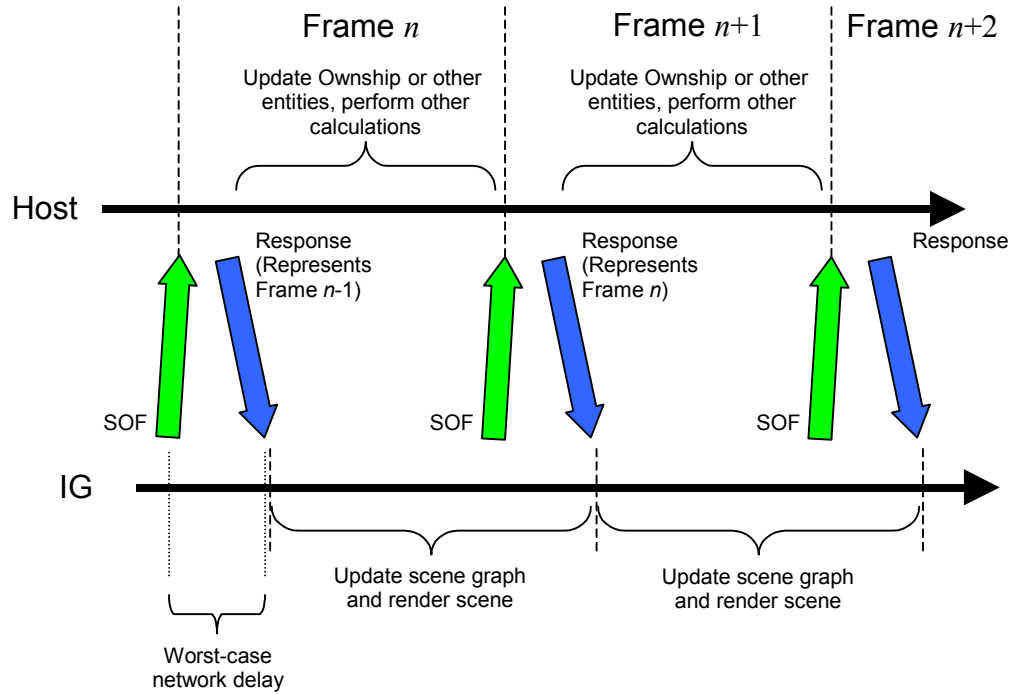


Figure 5 – Synchronous Message Timing Offset

To enable tracking of Ethernet messages and to ensure one-to-one correspondence, both the SOF and Host response messages are tagged with sequence numbers. The sequence number originates within the IG and is passed to the Host in the *Frame Counter* parameter of the **Start of Frame** data packet. Before sending its response message, the Host should extract the number from the **Start of Frame** packet and place it into the *Frame Counter* parameter of the **IG Control** data packet.

2.1.2 Ethernet Message Frequency

Although the IG software can be configured to run at any reasonable frequency, it is typically bound to some multiple of the display refresh rate. This makes the data frame rate very stable, and it alleviates tearing and other undesirable video anomalies. Common update rates are 30, 50, and 60 Hz, depending upon locale.

For synchronous operation, this means that the Host must also run at a multiple of the display update rate or must extrapolate its data each frame to meet the specified IG update rate.

2.1.3 Byte Order

When a processor stores or performs an operation on a multiple-byte datum, the datum can be represented in one of two ways. In a “big-endian” configuration, the lowest-addressed, or “leftmost,” byte is the high-order byte. Motorola and some other RISC architectures use this method. In “little-endian” architectures such as those used by Intel, the leftmost byte is the low-order byte.

Figure 6 illustrates the byte layout of signed and unsigned 16- and 32-bit data types on big-endian architectures:

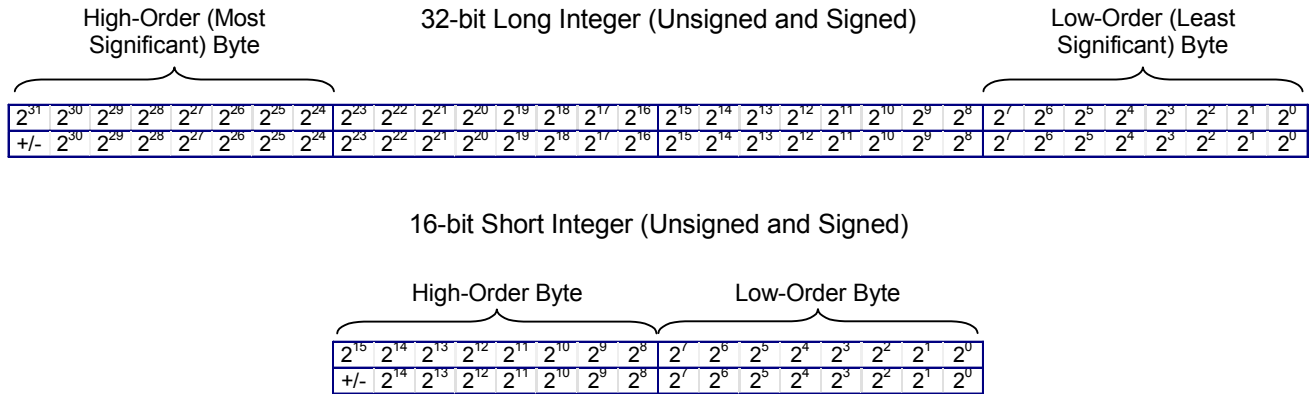


Figure 6 – Big-Endian Byte Order

Figure 7 illustrates the byte layout of the same data types on little-endian architectures:

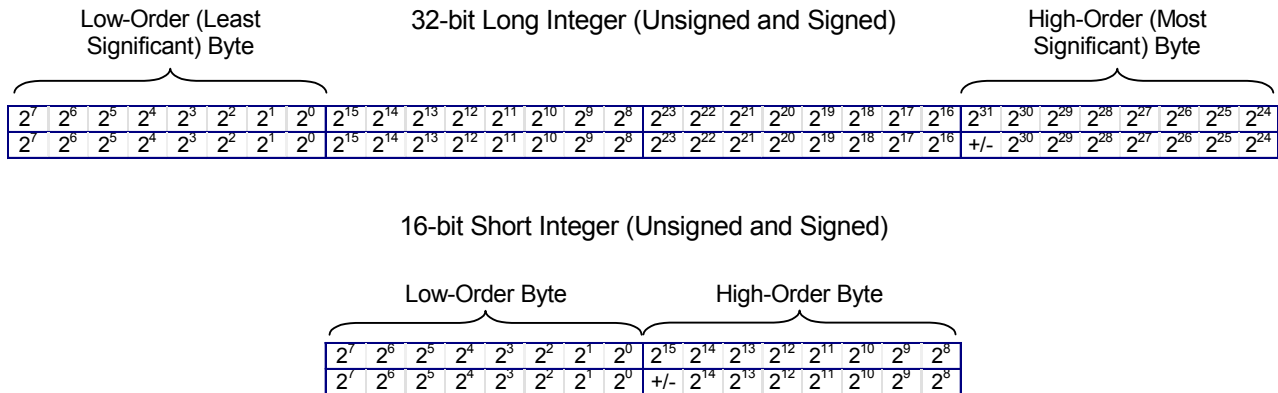


Figure 7 – Little-Endian Byte Order

CIGI 3 does not impose a byte order upon either the IG or the Host. Instead, the receiver has the responsibility of performing byte swapping if necessary. This has several advantages over one device performing all byte swapping. First, it distributes the additional processing between the IG and Host. It also eliminates the need to perform handshaking between the two devices. It enables the mechanism to work in either synchronous or asynchronous mode. Finally, it simplifies coding, since only the device’s unpacking routines need to account for byte order.

The **IG Control** and **Start of Frame** packets both contain a 16-bit *Byte Swap* parameter that indicates whether the receiver should byte-swap the incoming message. The sender sets the most significant bit of the high byte and clears all other bits. When the receiver examines this parameter, it must byte-swap the entire message if the most significant bit of the *low* byte is set. Figure 8 illustrates the bit locations for each state.

Big-Endian Receiver

| 2^{15} | 2^{14} | 2^{13} | 2^{12} | 2^{11} | 2^{10} | 2^9 | 2^8 | 2^7 | 2^6 | 2^5 | 2^4 | 2^3 | 2^2 | 2^1 | 2^0 |
|----------|----------|----------|----------|----------|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

⇒ 8000h **No Swap**
 ⇒ 80h **Swap**

Little-Endian Receiver

| 2^7 | 2^6 | 2^5 | 2^4 | 2^3 | 2^2 | 2^1 | 2^0 | 2^{15} | 2^{14} | 2^{13} | 2^{12} | 2^{11} | 2^{10} | 2^9 | 2^8 |
|-------|-------|-------|-------|-------|-------|-------|-------|----------|----------|----------|----------|----------|----------|-------|-------|
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

⇒ 80h **Swap**
 ⇒ 8000h **No Swap**

Figure 8 – Use of CIGI Byte Swap Parameter

Refer to Sections 4.1.1 and 4.2.1 for additional details on the **IG Control** and **Start of Frame** packets.

2.2 Data Packaging

2.2.1 Message Structure

CIGI messages are comprised of one or more data packets. During synchronous operation, there is exactly one IG-to-Host (SOF) message and one Host-to-IG response message per frame.

The first two bytes of each packet are the packet header. The first byte of this header contains an opcode that uniquely identifies the packet type; the second byte contains the size in bytes of the packet. The remainder of each packet contains data that pertain to that particular packet. Note that all packet data that are used to uniquely identify an object on the IG or Host (e.g., a moving model or a view) are contained within the first eight bytes of each packet.

All 16-bit data begin on half-word (16-bit) boundaries. All 32-bit and 64-bit data begin on word (32-bit) and double-word (64-bit) boundaries, respectively.

All packets must begin and end on 64-bit boundaries. Packets will be padded as necessary so that the packet size will be an even multiple of eight (8) bytes.

The first data packet in each message from the IG to the Host must be a **Start of Frame** packet (see Section 4.2.1). The message may also contain other IG-to-Host packets as listed in Table 1.

The first packet in each response message from the Host to the IG must be an **IG Control** packet (see Section 4.1.1). Zero or more Host-to-IG packets (see Table 1) may follow within the message.

Entities, regions, and other objects must be created before they can be otherwise referenced. For example, if a **Component Control** packet references an entity, that packet must follow the **Entity Control** data packet in which the entity is instantiated. If both packets occur in the same message, the **Entity Control** packet must precede the **Component Control** packet.

Other than the requirements described above, no restrictions are imposed on packet ordering.

To reduce the risk of overloading the IG computational frame, an attempt should be made to minimize the amount of data contained in each message. Therefore, unless a packet is mandatory (see Table 1), only those packets containing new data should be contained within each message. For example, if an entity's position, orientation, or other attributes have not changed since the previous frame, the Host should not send an **Entity Control** packet.

Table 1 – Data Packet Summary

| Opcode | Data Packet Name | Mandatory Each Frame | Section |
|----------------------------------|--|------------------------|---------|
| HOST TO IG | | | |
| 1 | IG Control | Yes | 4.1.1 |
| 2 | Entity Control | No | 4.1.2 |
| 3 | Conformal Clamped Entity Control | No | 4.2.3 |
| 4 | Component Control | No | 4.1.4 |
| 5 | Short Component Control | No | 4.1.5 |
| 6 | Articulated Part Control | No | 4.1.6 |
| 7 | Short Articulated Part Control | No | 4.1.7 |
| 8 | Rate Control | No | 4.1.8 |
| 9 | Celestial Sphere Control | No | 4.1.9 |
| 10 | Atmosphere Control | No | 4.1.10 |
| 11 | Environmental Region Control | No | 4.1.11 |
| 12 | Weather Control | No | 4.1.12 |
| 13 | Maritime Surface Conditions Control | No | 4.1.13 |
| 14 | Wave Control | No | 4.1.14 |
| 15 | Terrestrial Surface Conditions Control | No | 4.1.15 |
| 16 | View Control | No | 4.1.16 |
| 17 | Sensor Control | No | 4.1.17 |
| 18 | Motion Tracker Control | No | 4.1.18 |
| 19 | Earth Reference Model Definition | No | 4.1.19 |
| 20 | Trajectory Definition | No | 4.1.20 |
| 21 | View Definition | No | 4.1.21 |
| 22 | Collision Detection Segment Definition | No | 4.1.22 |
| 23 | Collision Detection Volume Definition | No | 4.1.23 |
| 24 | HAT/HOT Request | No | 4.1.24 |
| 25 | Line of Sight Segment Request | No | 4.1.25 |
| 26 | Line of Sight Vector Request | No | 4.1.26 |
| 27 | Position Request | No | 4.1.27 |
| 28 | Environmental Conditions Request | No | 4.1.28 |
| IG TO HOST | | | |
| 101 | Start of Frame | Yes | 4.2.1 |
| 102 | HAT/HOT Response | No | 4.2.2 |
| 103 | HAT/HOT Extended Response | No | 4.2.3 |
| 104 | Line of Sight Response | No | 4.2.4 |
| 105 | Line of Sight Extended Response | No | 4.2.5 |
| 106 | Sensor Response | See Packet Description | 4.2.6 |
| 107 | Sensor Extended Response | See Packet Description | 4.2.7 |
| 108 | Position Response | No | 4.2.8 |
| 109 | Weather Conditions Response | No | 4.2.9 |
| 110 | Aerosol Concentration Response | No | 4.2.10 |
| 111 | Maritime Surface Conditions Response | No | 4.2.11 |
| 112 | Terrestrial Surface Conditions Response | No | 4.2.12 |
| 113 | Collision Detection Segment Notification | No | 4.2.13 |
| 114 | Collision Detection Volume Notification | No | 4.2.14 |
| 115 | Animation Stop Notification | No | 4.2.15 |
| 116 | Event Notification | No | 4.2.16 |
| 117 | Image Generator Message | No | 4.2.17 |
| USER-DEFINED DATA PACKETS | | | |
| 201 – 255 | User-Defined Data Packets | Application-Dependent | 4.3 |

Only a subset of these data packets are typically required in any given message to describe data changes to the IG. Figure 9 shows a hypothetical sequence of Host-to-IG messages. Note that each message begins with an **IG Control** packet.

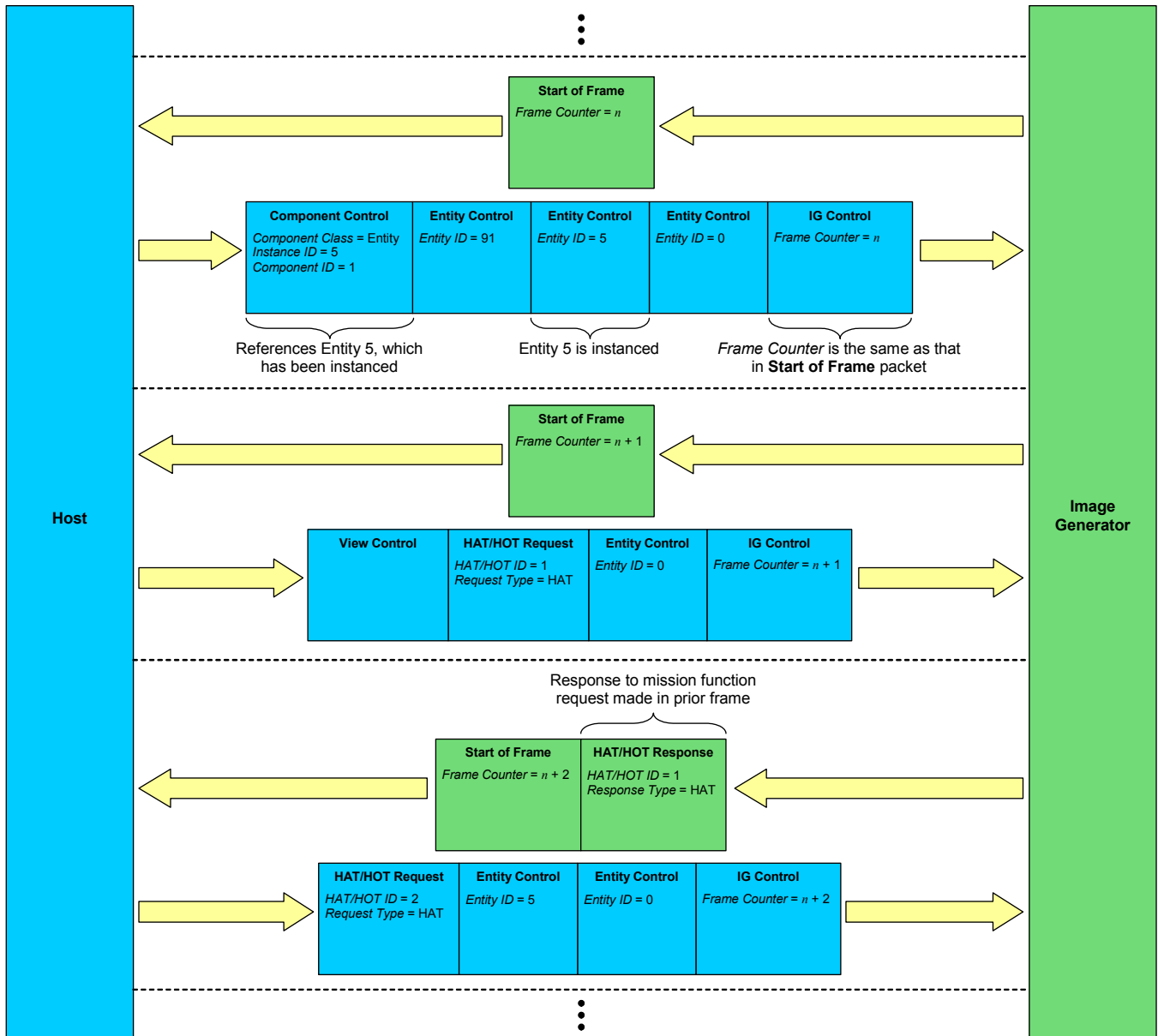


Figure 9 – Example of Message Exchange in Synchronous Mode

2.2.2 Data Types

CIGI is platform- and language-independent. Therefore, this document uses a generic nomenclature for data types. Although some languages may use the same data type (and keyword) to represent more than one kind of datum, this document distinguishes between semantic uses.

All data are stored as two's complement binary values. If a Host or IG uses an alternate representation, that device must convert all data it writes to and reads from the interface.

2.2.2.1 Integral Types

Real values are stored as signed single- or double-precision floating-point numbers as defined in ANSI/IEEE STD 754-1985. This document uses the names **single float** and **double float** to refer to single- and double-precision numbers.

Integer values are stored as signed or unsigned 8-bit, 16-bit, or 32-bit fields. This document refers to these data types as **int8**, **int16**, and **int32**, respectively. Integers may also be represented by unsigned bit fields as described in Section 2.2.2.2.

Alphanumeric characters are stored as signed 8-bit **char** fields. These values use the ANSI (American National Standards Institute) character set.

Generic values with no explicitly defined type are indicated as 32-bit **word** fields. Word fields may be used as the developer sees fit; however, they will be treated by the interface as unsigned int32 data. Any arithmetic operations performed on word data will be carried out as if on unsigned 32-bit integers. In addition, if byte swapping is necessary, word fields will be byte-swapped as 32-bit integers.

Table 2 – Integral Data Type Summary

| Data Type Name | Bytes | Precision | Minimum Value | Maximum Value |
|----------------|-------|-----------|--|--|
| char | 1 | N/A | -128 | 127 |
| int8 | 1 | N/A | -128 | 127 |
| unsigned int8 | 1 | N/A | 0 | 255 |
| int16 | 2 | N/A | -32,768 | 32,767 |
| unsigned int16 | 2 | N/A | 0 | 65,535 |
| int32 | 4 | N/A | -2,147,483,648 | 2,147,483,647 |
| unsigned int32 | 4 | N/A | 0 | 4,294,967,295 |
| word | 4 | N/A | 0 | 4,294,967,295 |
| single float | 4 | 7 digits | $1.4012980 \times 10^{-45*}$ $-3.4028235 \times 10^{38†}$ | $3.4028235 \times 10^{38*}$ $-1.4012980 \times 10^{-45†}$ |
| double float | 8 | 15 digits | $4.940656458412465 \times 10^{-324*}$ $-1.797693134862315 \times 10^{308†}$ | $1.797693134862315 \times 10^{308*}$ $-4.940656458412465 \times 10^{-324†}$ |

* indicates range for positive values

† indicates range for negative values

2.2.2.2 Bit Fields

To reduce packet size and Ethernet traffic, Booleans, enumerated values, and integers with small ranges typically use only the bits they need. Memory may be divided into bit fields to allow the data to be "packed" into as small a space as possible. The following byte diagram shows an example of how several values might be packed into bit fields:

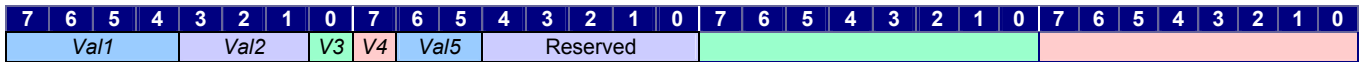


Figure 10 – Example of Multiple Bit Fields

The above word can be broken down as follows:

- Val1 is a 4-bit unsigned integer value with a range of 0 through 2^4 .
- Val2 is a 3-bit unsigned integer value with a range of 0 through 2^3 .
- V3 is a single-bit binary value with possible values 0 and 1.
- V4 is a single-bit binary value with possible values 0 and 1.
- Val5 is a 2-bit unsigned integer value with a range of 0 through 2^2 .
- The bits marked as “Reserved” are unused and must contain zero.
- The remaining two bytes can be used as two 8-bit integers or one 16-bit integer (signed or unsigned).

CIGI 3 arranges all bit fields so that they do not cross byte boundaries.

2.3 Startup and Shutdown Sequences

CIGI supports four IG modes: Reset/Standby, Operate, Debug, and Offline Maintenance.

While the IG initializes, it should disregard any CIGI messages from the Host. During synchronous operation, the Host should communicate with the IG only in response to a start-of-frame message. Because this restriction is not enforced in asynchronous mode, the IG should disregard any data received from the Host during this time.

During initialization, the IG may load a pre-configured default database or test pattern. It may also pre-load entity models so that they may be instanced quickly. The IG should allow a sufficient amount of time to allow the display system and other components to come online. This time may be configurable.

When the IG completes its initialization sequence, it should go into a “ready” or “standby” state and begin sending start-of-frame messages to the Host. The *IG Mode* parameter within each **Start of Frame** packet (see Section 4.2.1) should be set to Reset/Standby to indicate this operational mode. Upon sending its first start-of-frame message, the IG should be considered mission-ready.

The IG will remain in Reset/Standby mode until it receives an **IG Control** packet (see Section 4.1.1) from the Host in which the *IG Mode* parameter is set to Operate. The Host should then wait for the IG to set a **Start of Frame** packet's *IG Mode* parameter set to Operate before sending packets of any other type. The Host should continue to send **IG Control** packets while the IG is in Reset/Standby mode; however, any other data sent during this time will be ignored by the IG.

When the IG sends a **Start of Frame** packet in which the *IG Mode* parameter is set to Operate, the Host can begin sending initialization and/or mission data. Initialization data may include requests to load a new database, modifications to the views, system component controls, etc. Mission data may include entity states, non-system component controls, mission function requests, etc.

After the operational training or gaming session terminates, the Host should command the IG back to the Reset/Standby mode. The IG should then revert to its initial mission-ready condition. All entity instances should be removed from the scene; all in-process mission function requests should be purged; and all views, non-entity components, and environmental and weather conditions should be reset to their default states.

The Offline Maintenance mode can not be initiated through CIGI. This mode is only supported in CIGI to the extent that the *IG Mode* parameter of the **Start of Frame** packet can indicate this as being the current IG state.

2.4 Control Abstraction

Because CIGI is by design a generic interface, not all conceivable functional controls can be given a unique data packet. The **Component Control** packet (see Section 4.1.4) is provided as a general-purpose packet that can be used to control a variety of model, terrain, system, and other components. Given the necessary control function definition documentation, the integration engineer should be able to map virtually any Host or IG function to a component control. Such documentation should contain identifier and parameter assignments for each function.

2.5 Interface Extensions

Although the CIGI is a robust interface, there may be times when a developer wishes to define a unique data packet format for a specific purpose. For this reason, CIGI has been designed to be extensible. Data packet opcodes 201 through 255 have been reserved for user-defined data packets.

Note that when an implementation uses one or more user-defined packets, that implementation is no longer strictly CIGI-compliant. Any host or IG device that uses such extensions may not work with other CIGI devices without significant integration effort.

Refer to Section 4.3 of this document for further details on user-defined data packets.

2.6 Version Compatibility

All CIGI messages contain a version number identifying the version of CIGI to which the packets in that message conform. This version number is contained in the *CIGI Version* parameter of both the **IG Control** (Section 4.1.1) and **Start of Frame** (Section 4.2.1) packets.

When a device receives a CIGI message, it can inspect the version number to ensure that both devices are compatible. Some devices may be capable of automatically reverting to an older version of CIGI if necessary.

A major design goal for CIGI 3 is to build in provisions for cross-version, packet-level compatibility in anticipation of future generations of the interface. This document establishes some guidelines in order to attempt to allow a certain degree of forward- and backward-compatibility between Version 3 and higher:

1. Bit fields begin at the least significant bit available within the byte.
2. All bits marked "Reserved" should be set to zero (0) by the sender.
3. Any parameters added to a packet in future generations of CIGI will utilize existing reserved bits, if appropriate, or be appended to the end of the packet. If the receiver encounters a packet whose *Packet Size* parameter is larger than expected, any bytes beyond that size will be ignored.
4. If a parameter's size must be increased, it will utilize any adjacent Reserved space or be moved the end of the packet as a new parameter. In the latter case, the sender should also populate the obsolete parameter within the limitations imposed by its data type.
5. The unit of measure for a parameter will not change. If a change of unit is required, a new parameter will be appended to the end of the packet.
6. If a packet becomes obsolete, that packet's opcode will not be reused.

These guidelines are not intended to impose limitations that would be detrimental to the interface. Although every attempt will be made to follow these guidelines when making future changes to CIGI, these are not strict rules and should not take precedence over efficient design.

Note that changes made to versions of CIGI prior to Version 3 do not adhere to the above guidelines.

3. BASIC DEFINITIONS AND CONCEPTS

3.1 Entities

An entity as defined in this document exhibits all of the following characteristics:

1. The entity has a distinct dynamic coordinate system (DCS).
2. The entity has a separate and unique tree in the IG scene graph. The tree may or may not include geometry.
3. The entity's tree can be transformed (i.e., translated, rotated, and scaled) independently from the rest of the scene graph.
4. The entity's tree can be moved within the scene graph's hierarchy. In other words, it can be attached to (become a branch of) and later detached from another entity's tree.

Entities can be used to represent both static and dynamic objects. Some examples of dynamic entities are vehicles such as aircraft, ships, and automobiles; animations such as explosions, missile trails, and smoke; and localized weather phenomena such as clouds and fronts. Static objects may include stationary ground targets such as buildings and bridges, and other objects such as video test patterns.

Although terrain, weather layers, views, and articulated parts share many characteristics with entities, they are not treated as such by CIGI.

Terrain has its own tree and coordinate system, but CIGI does not expressly allow terrain to be transformed or attached to other entities. Entities may, however, be used to represent certain parts of the terrain such as dynamic sea states and surface conditions. Although the preferred method of implementing these features is through the **Maritime Surface Conditions Control** and **Terrestrial Surface Conditions Control** packets (Sections 4.1.13 and 4.1.15, respectively), many legacy systems use terrain databases containing holes that are filled by smaller dynamic models.

Even though clouds and other discrete weather phenomena may be implemented as entities, weather layers may not. An IG might generate polygonal surfaces to represent the top and bottom of a weather layer, but these surfaces do not have distinct trees or coordinate systems.

Views and view groups do possess distinct coordinate systems, but they do not have trees *per se*. View groups are a hierarchical collection of views; however, no scene graph nodes exist.

Articulated parts cannot be detached from their respective super-trees and are therefore not entities. Moving parts on a model may be implemented as separate models rather than articulable submodels, however. In these instances, each part would be a child entity of the object containing the part.

See Section 4.1.2 for information on how the Host can instantiate and control entities on the IG with the **Entity Control** packet.

3.1.1 Ownship

The Ownship is a unique entity that represents the object being simulated by a trainer crew station, gaming platform, or other such device. Views attached to the Ownship correspond to the eyepoint of the pilot, driver, or other observer.

The Ownship is an entity, and as such, can be controlled with the **Entity Control** packet (Section 4.1.2).

3.1.2 Animations

An animation is an entity that has a specific pattern of movement, growth, or other behavior. This behavior is typically representative of some real-life phenomenon that, once initiated, cannot be directly controlled. Examples include fire, explosions, smoke, moving water, etc. Aside from an element of randomness introduced by stochastic processing within the IG, animations are typically reproducible for a given environmental state.

Depending upon the nature of the animation, the Host may modify certain characteristics by sending one or more **Component Control** packets (Section 4.1.4). The Host might define the expansion rate of an explosion, for example, or the length of a contrail. The specific behavior of an animation, however, is automated by the IG.

An IG may implement any of a variety of animation types. For example, a dynamic texture animation is a 2-D animation applied to some surface. Each texture may be one of a fixed sequence of images or may be generated procedurally each frame. The IG advances the image at some frame rate. The same concept can be applied to bump map and displacement map animations.

A frame-based geometry animation is an entity with multiple sets of geometry that are displayed sequentially. Each set of geometry is typically attached to a switch node. To display the next set, or "frame," the current switch node is switched off as the next one is switched on. The animation may consist of few frames with simple geometry (e.g., a turning propeller might be implemented as two alternating polygons with temporally aliased textures) or many frames with complex geometry (e.g. a collapsing bridge might have damaged, undamaged, and many intermediate states).

A transformation-based geometry animation, or shape animation, is an entity whose geometry is changed over time. A high-fidelity tree model, for example, might contain sections of geometry that are translated and rotated to simulate movement from wind. A cloud of black smoke produced by flak might expand and drift as its dynamic texture appears to fade. The latter example illustrates a combination of animation techniques.

Other types of animation might include, but are not limited to, motion-path animations, particle systems, and palette animations.

Note that some animated components may be implemented as submodels of an entity model rather than as separate entities. Such components might include flashing lights, aircraft propellers, afterburners, landing gear, tank tracks, wheels, and like items. These components would be controlled with the **Component Control** packet (Section 4.1.4).

3.2 Views

A view is a projection of a three-dimensional volume onto a two-dimensional viewing plane. CIGI 3 supports perspective and orthographic parallel views. Oblique parallel views are not directly supported, but may be implemented by using the **Component Control** packet (Section 4.1.4) to specify the direction of projection relative to the projection plane.

3.2.1 Viewing Volumes

3.2.1.1 Perspective

The viewing volume for a perspective projection is the frustum defined by the near and far clipping planes and the sides of the viewport. The viewport is an area on the view plane onto which objects within the view frustum are projected. The viewport generally corresponds to the display or a window. CIGI therefore assumes its size to be fixed. Figure 11 illustrates the concept of perspective projection of a three-dimensional viewing volume onto a two-dimensional viewport.

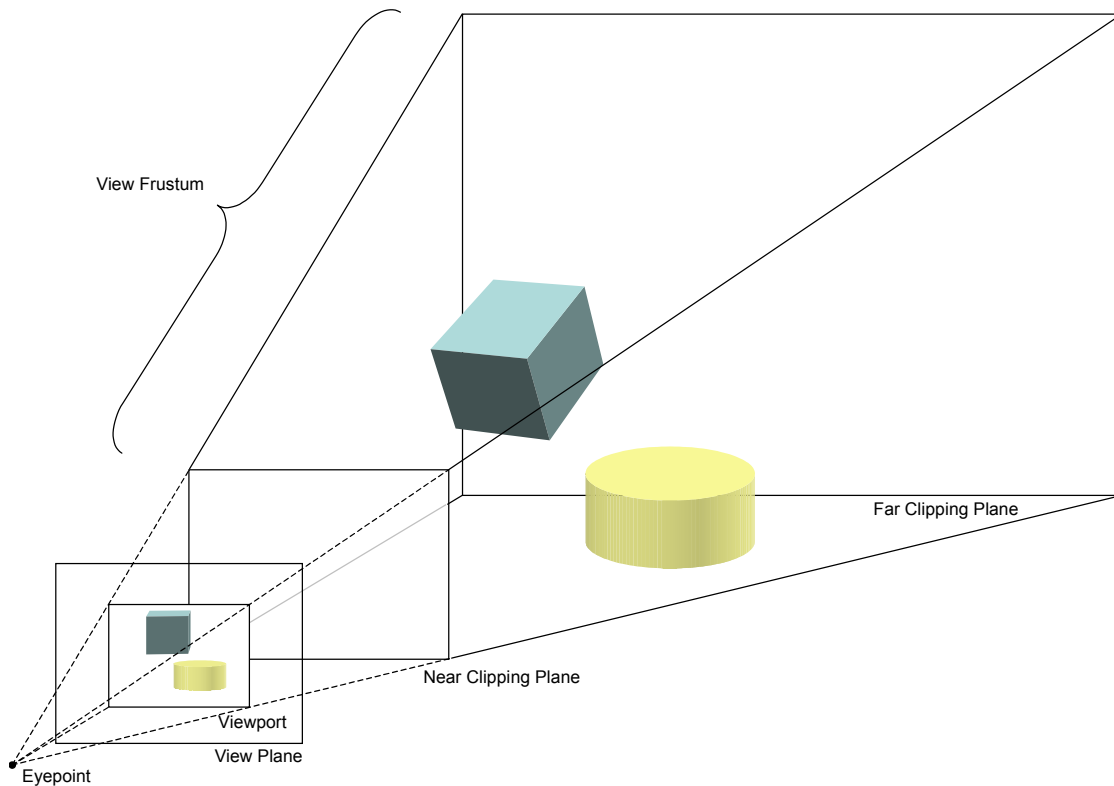


Figure 11 – Perspective Projection onto a Viewport

Because the size of the display (and thus the viewport) is fixed, the dimensions of the view frustum are directly related to the position of the eyepoint. By designing the view eyepoint to correspond to the observer's eye, a projection with an apparent one-to-one scale can be achieved.

Figure 12 illustrates how a view is defined. Angle α is the left half-angle and angle β is the right half-angle. Angles γ and δ represent the top and bottom half-angles, respectively. The viewing vector corresponds to the observer's line of sight and is perpendicular to the view plane.

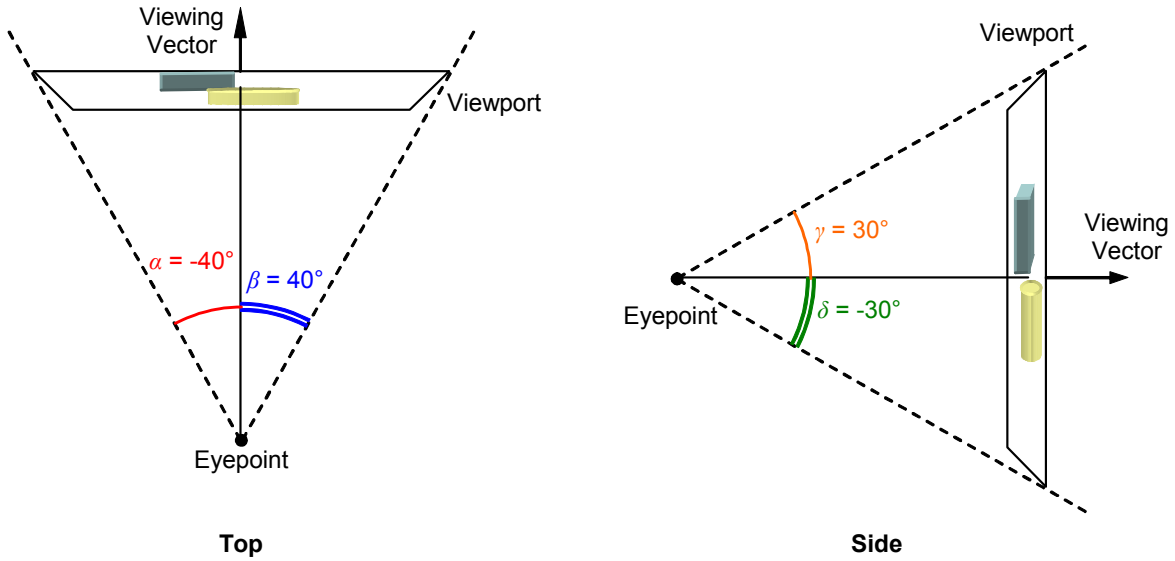


Figure 12 – View Definition Half-Angles

A view may be defined so that the sizes of angles α and β , and of angles γ and δ , are not equal. This produces an oblique view such as the one shown below:

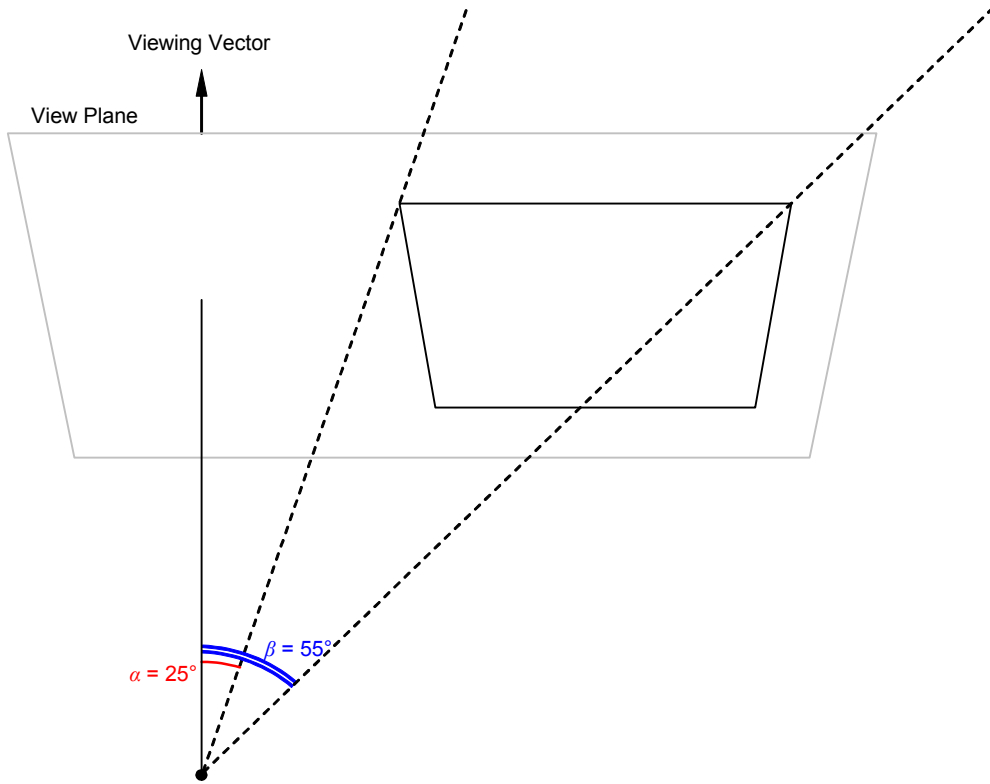


Figure 13 – Example of an Oblique Perspective View

The size of the view frustum can be set via the **View Definition** packet. Refer to Section 4.1.21 for details about this packet.

3.2.1.2 Orthographic Parallel

An orthographic parallel projection is one where the lines of projection are parallel and are perpendicular to the projection plane. The lines are also parallel to the sides of the viewing volume and are perpendicular to the projection plane. This type of view is typically used for two-dimensional views such as “God’s eye” views and heads-down displays. Figure 14 illustrates an orthographic projection of a three-dimensional viewing volume onto a viewport.

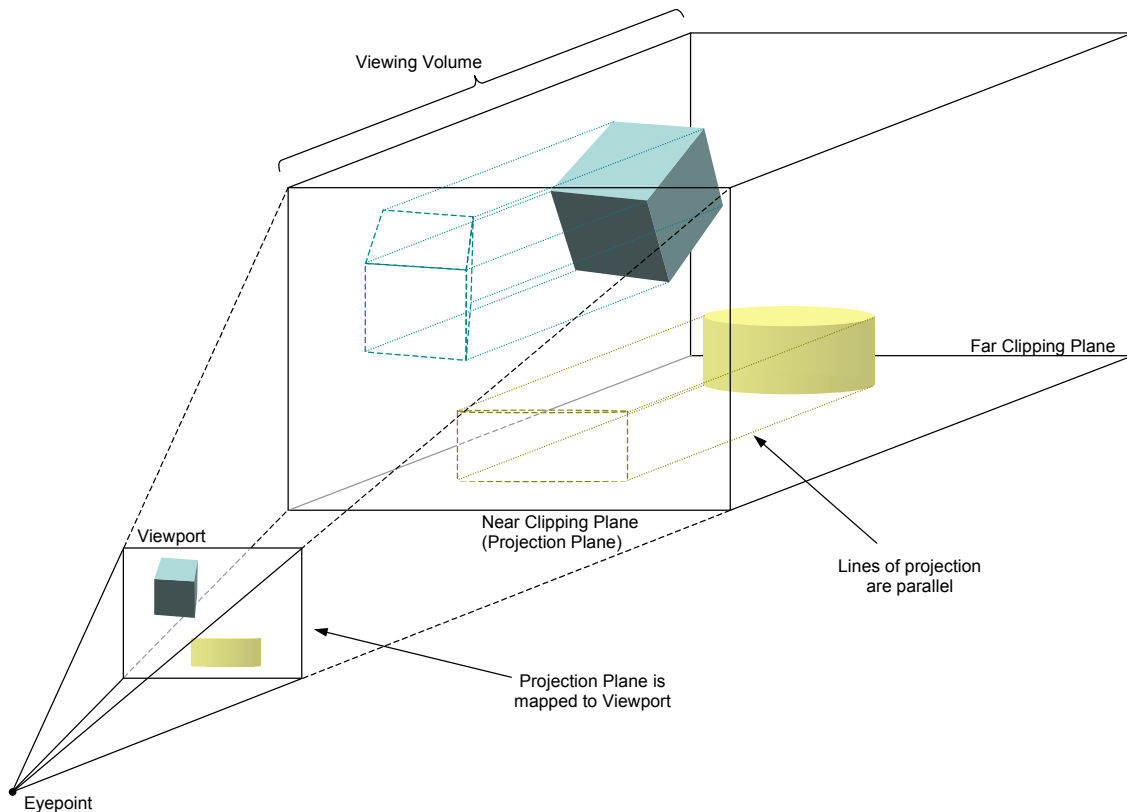


Figure 14 – Orthographic Parallel Projection onto a Viewport

The scene within the viewing volume is projected onto the projection plane. Because the lines of projection are parallel, the apparent sizes of any objects within the viewing volume do not vary with distance from the projection plane.

The projection plane is mapped to the viewport, where the projected scene is displayed.

As with a perspective projection, the width and height of the viewing volume of an orthographic projection is directly proportional to the sizes of the angles formed at the eyepoint between the viewport sides and the viewing vector (see Figure 12). The depth of the volume is the distance between the near and far clipping planes.

3.2.2 View Groups

Figure 15 below shows three views forming a panoramic scene. Certain situations may require the views to be moved spatially or hierarchically with respect to the entity. These changes may be applied to each of the three

views individually. Alternatively, the views may be grouped so that operations can be performed upon them simultaneously.

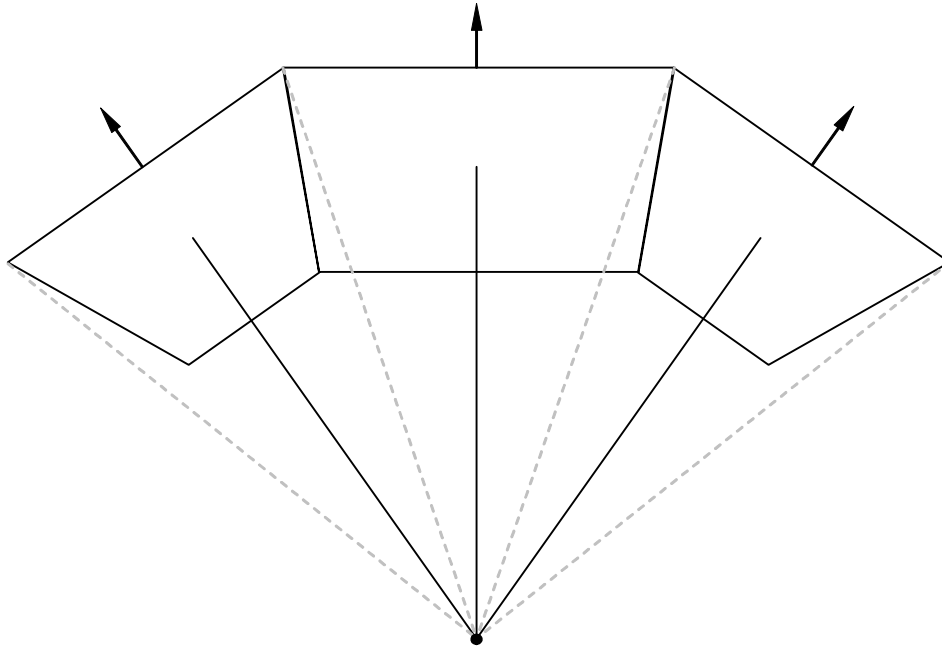


Figure 15 – Example of a View Group

The latter technique has several advantages. Perhaps most importantly, it reduces the network load because a single **View Control** packet (see Section 4.1.13) can be used instead of several. Another advantage is that it guarantees that the spatial relationships between views are maintained. In addition, the Host does not have to keep track of multiple coordinate systems for the views.

A view can be assigned to a view group by setting the *Group ID* parameter of the **View Definition** packet (see Section 4.1.21). Once the group assignment has been made, the view may be controlled with the **View Control** packet (see Section 4.1.16) either individually or as part of the group. Refer to the indicated sections for more information on these packets.

3.3 Coordinate Systems

3.3.1 Geodetic Coordinate System

CIGI 3 specifies a top-level (non-child) entity's position in geodetic coordinates. The coordinates define the position of the entity's reference point, typically the center of gravity. Orientation is specified by yaw, pitch, and roll angles. Sections 3.3.1.1 and 3.3.1.2 describe geodetic position and orientation, respectively.

The default Earth Reference Model (ERM) for CIGI 3 is WGS 84. The Host can define a new reference ellipsoid by sending an **Earth Reference Model Definition** packet (Section 4.1.19) to the IG.

3.3.1.1 Position

The geodetic coordinate system uses an ellipsoidal earth model and specifies a location in terms of latitude, longitude, and altitude as shown in Figure 16.

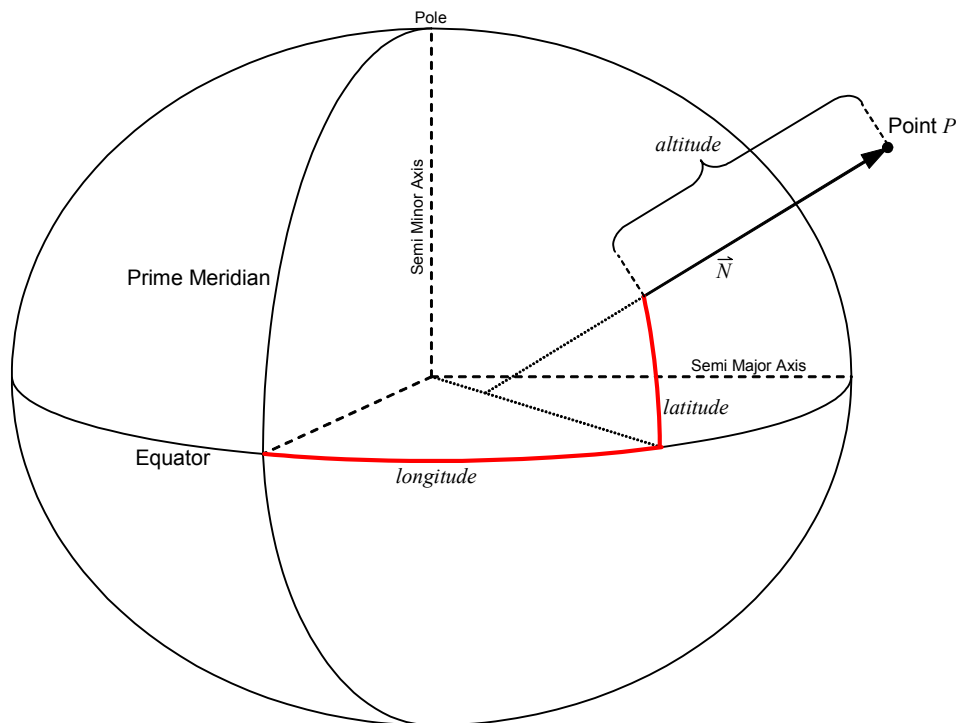


Figure 16 – Position within Geodetic Coordinate System

Given point P , an imaginary vector \vec{N} extends through that point that intersects the equatorial plane and is normal to the ellipsoid's surface. *Latitude* is the size of the angle formed between this vector and the equatorial plane. This is measured in degrees north (positive) or south (negative) of the Equator and is limited to $\pm 90^\circ$.

Longitude is the angle of the arc along the ellipsoid surface from the Prime Meridian to the point on the Equator closest to point P . This is measured in degrees east (positive) or west (negative) of the Prime Meridian and is limited to $\pm 180^\circ$.

Altitude is the distance from P to the point of intersection between the ellipsoid surface and the normal vector. This distance is measured in meters above Mean Sea Level (MSL), which CIGI defines as the reference ellipsoid surface. Negative values indicate that the point is below MSL, or inside the reference ellipsoid.

Note that positive *Altitude* values correspond to negative **Z** values in a North-East-Down (NED) Cartesian coordinate system, which is described in Section 3.3.1.2.

3.3.1.2 Orientation

The orientation of an entity, view, or other object with respect to the geodetic coordinate system is specified relative to a reference plane that is parallel to an ellipsoid-tangential plane. The reference plane passes through the entity's reference point. A right-hand coordinate system can be defined so that the **X**, **Y**, and **Z** axes correspond to North, East, and down (toward the ellipsoid), respectively. This is called a North-East-Down (NED) Cartesian coordinate system and is shown in Figure 17.

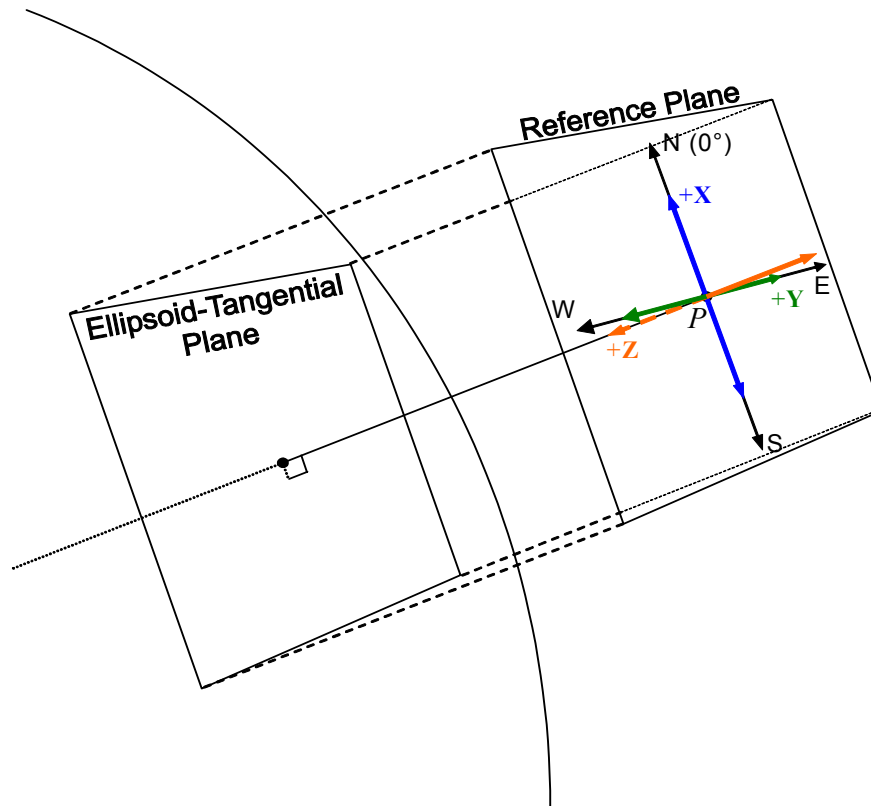


Figure 17 – Local Geodetic Reference Plane with NED Coordinate System

The order of rotation is about the **Z**, **Y**, and then **X** axes (i.e., yaw, pitch, and then roll) as described below. This discussion assumes an entity but also applies to views, submodels, and other objects.

An entity's yaw, ψ , is the measure of the angle formed from True North to the entity's **+X** axis. This angle is specified in degrees and is positive clockwise if looking along the **+Z** axis.

An entity's pitch, θ , is the measure of the angle between the reference plane and the entity's **+X** axis. This angle is specified in degrees and is positive above (away from the ellipsoid) the reference plane.

Roll, ϕ , is the measure of the angle between the reference plane and the entity's **+Y** axis along a plane perpendicular to the entity's **X** axis. In other words, it is the angle of rotation about the **X** axis *after yaw and pitch have been applied*. Roll is also specified in degrees and is positive clockwise from the point of view of looking along the **+X** axis.

Figure 18 illustrates the rotation about each axis. Note that the **Z** axis is labeled in the negative (-) direction (above the reference plane) for clarity. Dashed lines indicate that the line extends below the reference plane.

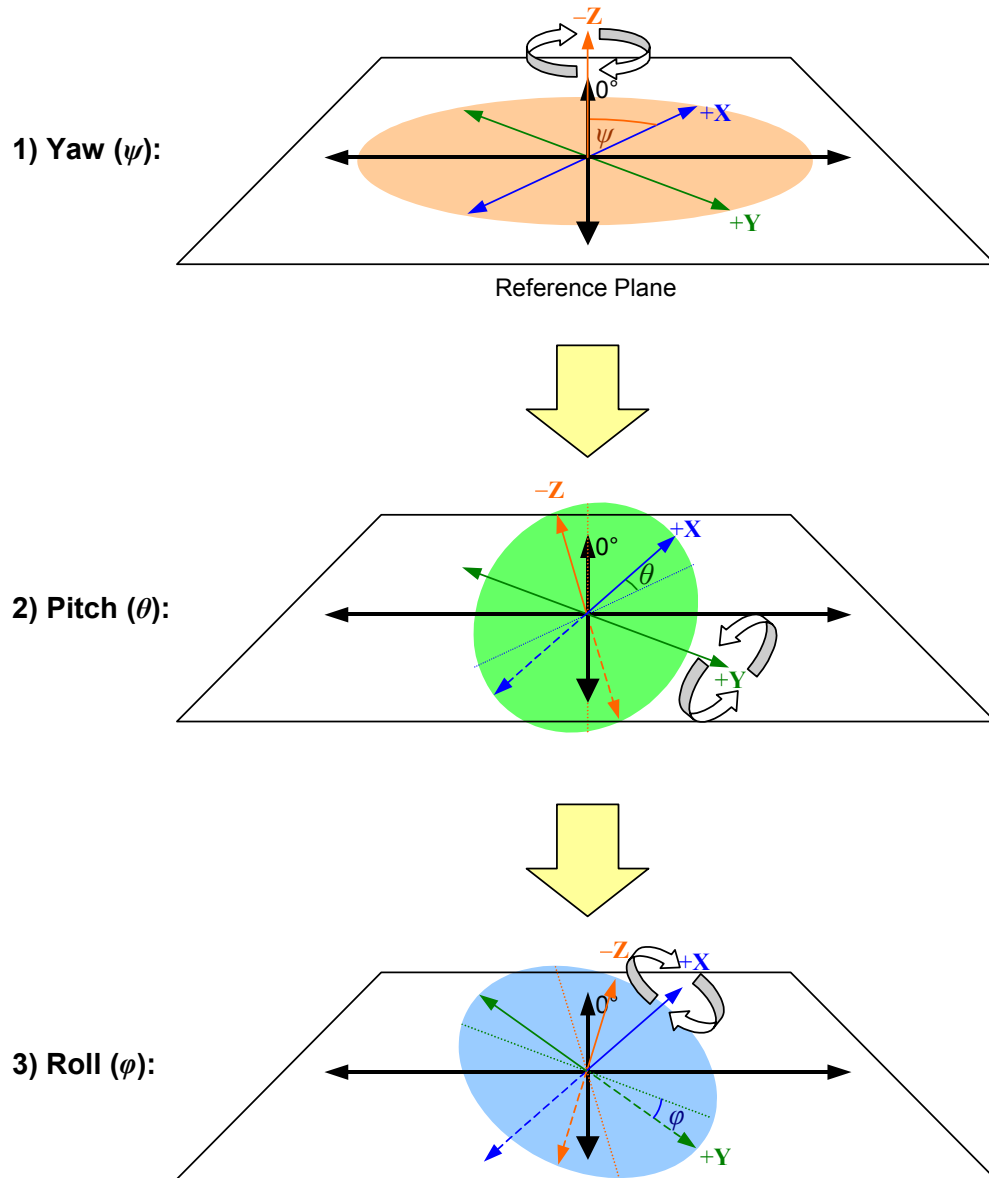


Figure 18 – Rotation in NED Coordinate System

3.3.2 Entity Coordinate Systems

Each entity has a local NED coordinate system as shown below in Figure 19. The origin corresponds to the entity's reference point, typically the center of gravity. The +X axis extends out the "front" of the entity (e.g., the nose of an aircraft). The +Y axis extends out the right side, and the +Z axis extends out the bottom of the entity.

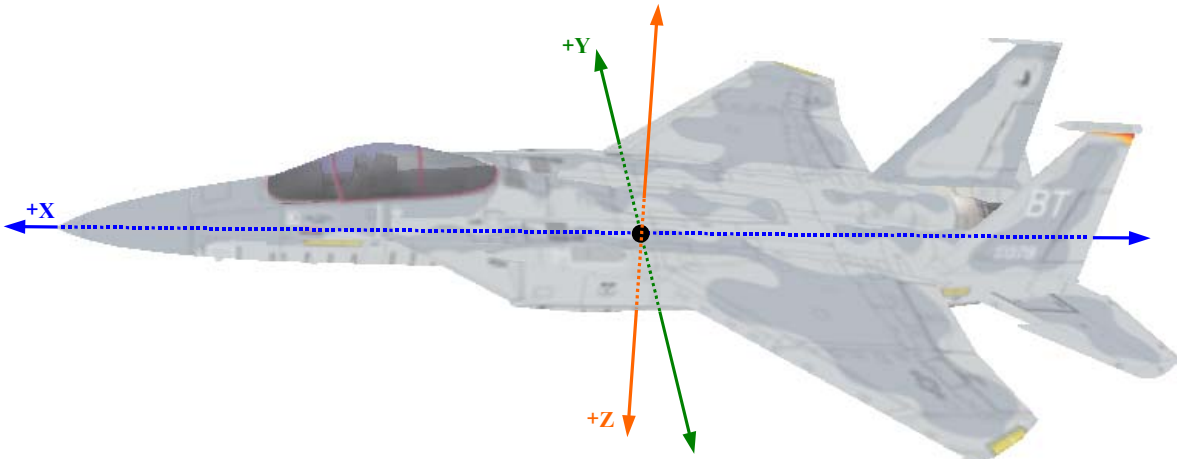


Figure 19 – Local Entity Coordinate System

An entity's local coordinate system is sometimes called its "body" coordinate system.

3.3.2.1 Position

Position with respect to an entity's local coordinate system is specified as the distance in meters from the entity's reference point along its X, Y, and Z axes. The entity's coordinate system is shown in Figure 19.

3.3.2.2 Orientation

Rotation with respect to an entity's coordinate system is specified as yaw, pitch, and roll relative to a local reference plane. This reference plane is parallel to the entity's XY plane and passes through the local origin. The order of rotation is as shown in Figure 18.

3.3.3 Submodel Coordinate Systems

A submodel is a hierarchy of geometry nodes within a model (entity) for which a dynamic coordinate system (DCS) is defined. Transformations performed on the DCS affect the submodel geometry as a whole. For example, a flap on an aircraft might have a local coordinate system defined as shown in Figure 20 so that applying a positive pitch will rotate the flap above the wing.

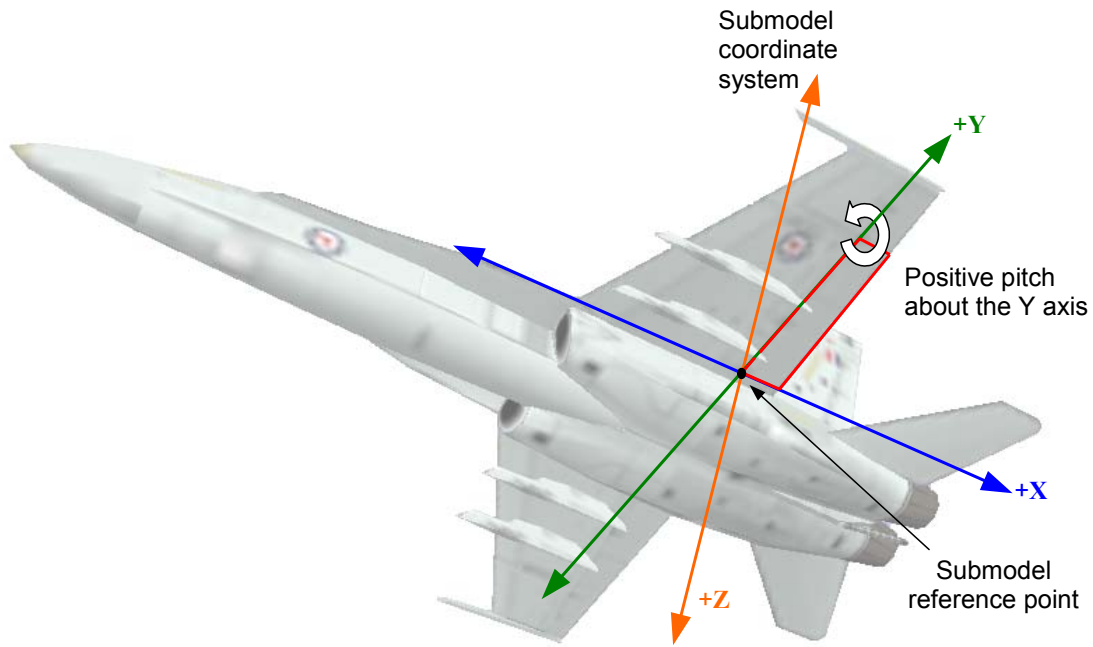


Figure 20 – Submodel Coordinate System

Position and rotation of submodels are defined with respect to this coordinate system. They are not cumulative. The order of rotation is as shown in Figure 18.

Section 4.1.6 describes the use of the **Articulated Part Control** packet in manipulating submodels.

4. DATA PACKET REFERENCE

This portion of the ICD describes each packet in the Common Image Generator Interface. Section 4.1 describes the CIGI packets used in Host-to-IG messages. Section 4.2 describes the packets used in IG-to-Host messages. Section 4.3 discusses user-defined packets, which may be used for either Host-to-IG or IG-to-Host messages.

Each topic contains one or more paragraphs describing the use of the packet. Following this text is a diagram illustrating the structure of the packet. An example of such a diagram is shown in Figure 21.

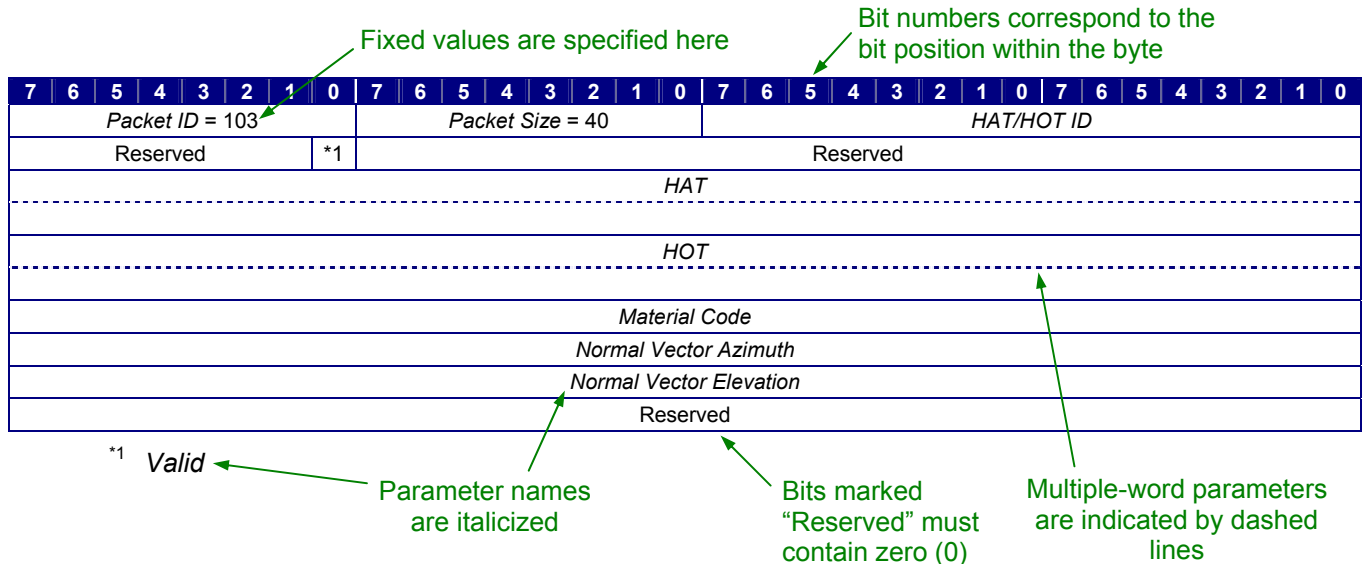


Figure 21 – Example of Packet Structure Diagram

Each row represents a 32-bit word. The topmost row corresponds to the first word in the packet; the memory address increases downward. 64-bit parameters are indicated by a dotted line representing the enclosed word boundary. The parameter name appears in the first of the two rows.

Parameter names are italicized. Parameters whose names will not fit within the space allotted in the table are noted below the diagram. Bits marked "Reserved" are allocated for future use and must be populated with zeros (0).

Bit positions are numbered from right to left. The leftmost bit in each byte is the most significant bit. The leftmost byte in each word has the lowest physical address.

The following illustration shows how the above packet would be stored in memory on both a big-endian and a little-endian computer:

| Little Endian | Low Address | Big Endian |
|--|---------------------|--|
| <i>Packet ID</i> | | <i>Packet ID</i> |
| <i>Packet Size</i> | | <i>Packet Size</i> |
| <i>HAT/HOT ID (LSB)</i> | | <i>HAT/HOT ID (MSB)</i> |
| <i>HAT/HOT ID (MSB)</i> | | <i>HAT/HOT ID (LSB)</i> |
| <i>Valid</i> | | <i>Valid</i> |
| 0 | | 0 |
| 0 | | 0 |
| 0 | | 0 |
| <i>HAT (LSB)</i> | | <i>HAT (MSB)</i> |
| <i>HAT (2nd-order byte)</i> | | <i>HAT (7th-order byte)</i> |
| <i>HAT (3rd-order byte)</i> | | <i>HAT (6th-order byte)</i> |
| <i>HAT (4th-order byte)</i> | | <i>HAT (5th-order byte)</i> |
| <i>HAT (5th-order byte)</i> | | <i>HAT (4th-order byte)</i> |
| <i>HAT (6th-order byte)</i> | | <i>HAT (3rd-order byte)</i> |
| <i>HAT (7th-order byte)</i> | | <i>HAT (2nd-order byte)</i> |
| <i>HAT (MSB)</i> | | <i>HAT (LSB)</i> |
| <i>HOT (LSB)</i> | | <i>HOT (MSB)</i> |
| <i>HOT (2nd-order byte)</i> | | <i>HOT (7th-order byte)</i> |
| <i>HOT (3rd-order byte)</i> | | <i>HOT (6th-order byte)</i> |
| <i>HOT (4th-order byte)</i> | | <i>HOT (5th-order byte)</i> |
| <i>HOT (5th-order byte)</i> | | <i>HOT (4th-order byte)</i> |
| <i>HOT (6th-order byte)</i> | | <i>HOT (3rd-order byte)</i> |
| <i>HOT (7th-order byte)</i> | | <i>HOT (2nd-order byte)</i> |
| <i>HOT (MSB)</i> | | <i>HOT (LSB)</i> |
| <i>Material Code (LSB)</i> | | <i>Material Code (MSB)</i> |
| <i>Material Code (2nd-order byte)</i> | | <i>Material Code (3rd-order byte)</i> |
| <i>Material Code (3rd-order byte)</i> | | <i>Material Code (2nd-order byte)</i> |
| <i>Material Code (MSB)</i> | | <i>Material Code (LSB)</i> |
| <i>Normal Vector Azimuth (LSB)</i> | | <i>Normal Vector Azimuth (MSB)</i> |
| <i>Normal Vector Azimuth (2nd-order byte)</i> | | <i>Normal Vector Azimuth (3rd-order byte)</i> |
| <i>Normal Vector Azimuth (3rd-order byte)</i> | | <i>Normal Vector Azimuth (2nd-order byte)</i> |
| <i>Normal Vector Azimuth (MSB)</i> | | <i>Normal Vector Azimuth (LSB)</i> |
| <i>Normal Vector Elevation (LSB)</i> | | <i>Normal Vector Elevation (MSB)</i> |
| <i>Normal Vector Elevation (2nd-order byte)</i> | | <i>Normal Vector Elevation (3rd-order byte)</i> |
| <i>Normal Vector Elevation (3rd-order byte)</i> | | <i>Normal Vector Elevation (2nd-order byte)</i> |
| <i>Normal Vector Elevation (MSB)</i> | | <i>Normal Vector Elevation (LSB)</i> |
| 0 | | 0 |
| 0 | | 0 |
| 0 | | 0 |
| 0 | High Address | 0 |

Figure 22 – Example of Packet Data Storage

Below the packet structure diagram is a table that lists each parameter and describes its use. This table identifies the parameter's name, data type, and unit of measure. If a parameter's values differ from those listed for the data type in Table 2 on page 9, those values are listed next. If applicable, a default value and reference datum are listed next.

Table 3 describes the general format of a packet parameter definitions table:

Table 3 – Format of Packet Parameter Definitions Table

| Parameter | Description |
|--|--|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 103</p> | <p>This parameter specifies the packet's opcode, which uniquely identifies the packet. In this example, the value 103 indicates that this is a HAT/HOT Extended Response packet. This is a dimensionless value.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 40</p> | <p>This parameter indicates the number of bytes in this type of data packet. The value 40 in this example specifies the number of bytes in a HAT/HOT Extended Response packet.</p> |
| <p>Parameter Name</p> <p>Type: double float</p> <p>Units: degrees</p> <p>Values: -90.0 – 90.0</p> <p>Default: 0.0</p> <p>Datum: Equator</p> | <p>The remaining items in the table describe the rest of the packet's parameters. There is one row per parameter, and the parameters are given in the order in which they appear in the packet (left to right).</p> <p>The parameter is identified by the parameter name. Below this name is the data type. CIGI data types are described in Section 2.2.2.</p> <p>Next is the unit of measure used for the parameter. If the parameter is dimensionless and has no unit, this is indicated by "N/A."</p> <p>The domain may be specified below the unit of measure. This might either be a range of values or an enumerated list of discrete values. If no values are specified, then the domain is the entire range of the data format as listed in Table 2.</p> <p>Below the domain is default value, if applicable, for the parameter. This is the value assigned to the specified attribute during initialization of the IG. Attributes of entities and other objects that are instantiated at runtime will not have a default value.</p> <p>Finally, a reference datum may be specified for the attribute. This is the point or state from which the value is measured.</p> |

4.1 Host-to-IG Packets

4.1.1 IG Control

The **IG Control** packet is used to control the IG's operational mode, database loading, and timing correction. This must be the first packet in the message.

Every Host-to-IG message must contain exactly one **IG Control** packet. If more than one is encountered during a given frame, the resulting IG behavior is undefined.

If the IG uses regional terrain databases, the **IG Control** packet allows the Host to control the loading of terrain. Each database is associated with a number from 1 to 127. The Host will set the *Database Number* parameter to the appropriate value to direct the IG to begin reading the corresponding database into memory. An example is shown in Figure 23:

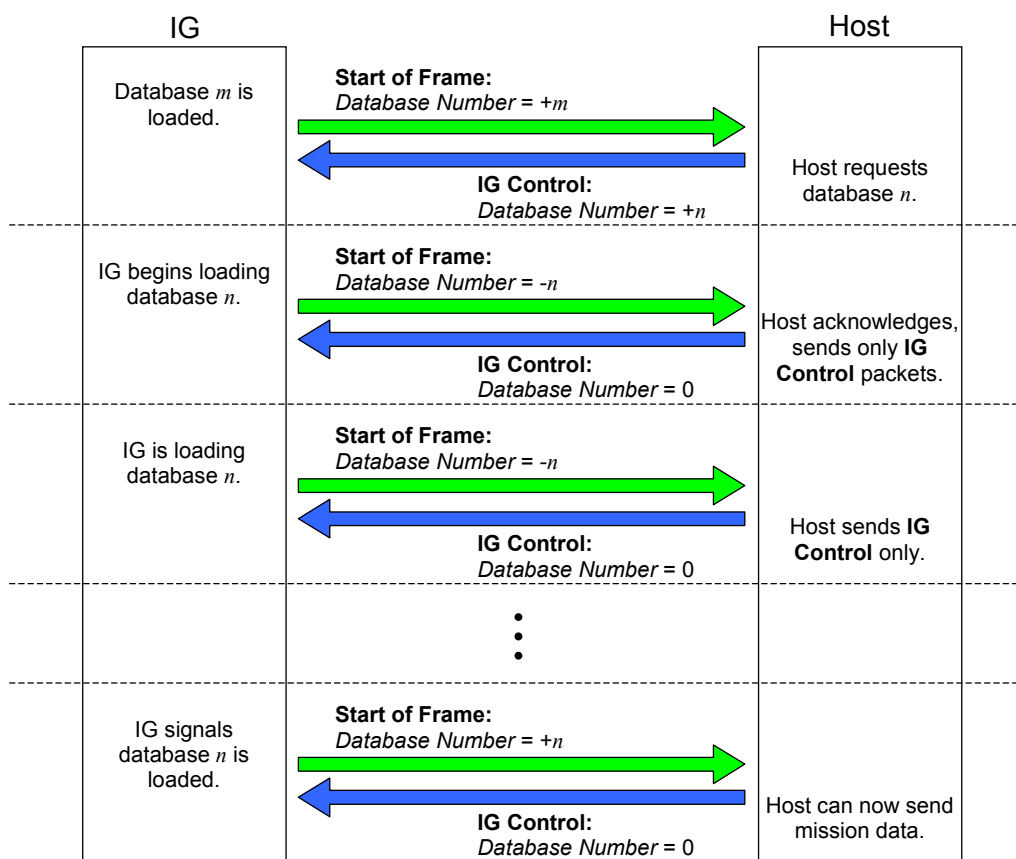


Figure 23 – Database Loading Sequence in Synchronous Mode

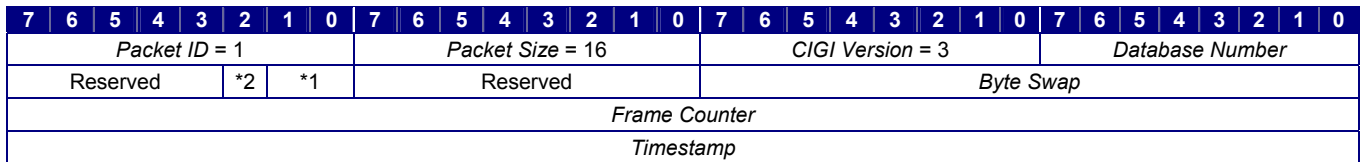
The IG will indicate that the database is being loaded by negating the value and placing it in the *Database Number* parameter of the **Start of Frame** packet. The Host will then acknowledge this change by setting the *Database Number* parameter of the **IG Control** packet to zero (0). Because the IG's resources may be devoted to disk I/O and other functions, the Host should ideally send only **IG Control** packets at this time.

After the IG receives the acknowledgement, it will signal the completion of the database load by setting the *Database Number* parameter of the **Start of Frame** packet to the positive database number. The IG is now considered mission-ready and can receive mission data from the Host.

Note that the IG will ignore the *Database Number* parameter while in Reset/Standby mode.

When using a global database, the IG will set the *Database Number* of the **Start of Frame** packet to zero (0). When the Host detects a zero in this parameter, it should in turn set the *Database Number* parameter of the **IG Control** packet to zero (0).

The contents of the **IG Control** packet are as follows:



*1 IG Mode
 *2 Timestamp Valid

Figure 24 – IG Control Packet Structure

Table 4 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 4 – IG Control Parameter Definitions

| Parameter | Description |
|---|---|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 1</p> | <p>This parameter identifies this data packet as the IG Control packet. The value of this parameter must be 1.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 16</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 16.</p> |
| <p>CIGI Version</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 3</p> | <p>This parameter indicates the version of the CIGI interface that is currently being used by the Host. The IG can use this number to determine concurrency. The value of this parameter must be 3.</p> |

| Parameter | Description |
|--|---|
| <p>Database Number</p> <p>Type: int8</p> <p>Units: N/A</p> <p>Values: 0 No load requested 1 – 127 Identifies desired database</p> <p>Default: 0</p> | <p>This parameter is used to initiate a database load on the IG. Setting this parameter to a non-zero value will cause the IG to begin loading the database that corresponds to that value. If the number corresponds to the current database, the database will be reloaded.</p> <p>The IG will indicate that the database is being loaded by negating the value and placing it in the <i>Database Number</i> parameter of the Start of Frame packet. When the Host receives this notification, it should set the <i>Database Number</i> parameter of the IG Control packet to zero (0) to prevent continuous reloading of the database on the IG.</p> <p>The IG will ignore this parameter while in Reset/Standby mode.</p> <p>Refer to Section 4.2.1 for more information on the Start of Frame packet.</p> |
| <p>IG Mode</p> <p>Type: unsigned 2-bit field</p> <p>Units: N/A</p> <p>Values: 0 Reset/Standby 1 Operate 2 Debug</p> <p>Default: 0</p> | <p>This parameter dictates the IG's operational mode. The Host can initiate a mode change by setting this parameter to the desired mode. When the IG completes the mode change, it will set the <i>IG Mode</i> parameter in the Start of Frame packet accordingly.</p> <p>For information on each of the IG modes, refer to the description of the <i>IG Mode</i> parameter of the Start of Frame packet in Table 35.</p> |
| <p>Timestamp Valid</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Invalid 1 Valid</p> | <p>This parameter indicates whether the <i>Timestamp</i> parameter contains a valid value.</p> <p>Because the <i>Timestamp</i> parameter is required for asynchronous operation, <i>Timestamp Valid</i> must be set to Valid (1) in this mode.</p> |
| <p>Byte Swap</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> <p>Values: 8000h No byte swap (see note at right) 80h Byte swap</p> | <p>This parameter is used by the IG to determine whether it needs to byte-swap incoming data. Refer to Section 2.1.3 for details on this mechanism.</p> <p>Note: The Host <i>must</i> set this value to 8000h, or 32768.</p> |

| Parameter | Description |
|---|--|
| <p>Frame Counter</p> <p>Type: unsigned int32</p> <p>Units: N/A</p> | <p>This parameter contains a number that identifying the frame. This number correlates the Host-to-IG message to the preceding IG-to-Host message.</p> <p>During synchronous operation, when the Host receives a start of frame message from the IG it should (after byte-swapping, if necessary) extract the <i>Frame Counter</i> value from the Start of Frame packet and place it into this parameter before sending the response message. Refer to Section 2.1.1.2 for details on message synchronization in this mode.</p> <p>During asynchronous operation, the Host should increment this value each time it sends a message to the IG.</p> |
| <p>Timestamp</p> <p>Type: unsigned int32</p> <p>Units: 10 microseconds (μs)</p> | <p>This parameter indicates the number of 10μs “ticks” since some initial reference time. This will enable the IG to correct for latencies as described in Section 2.1.1.1.</p> <p>The 10μs unit allows the simulation to run for approximately 12 hours before a timestamp rollover occurs. The IG software should contain logic to detect and correct for rollover.</p> <p>The use of this parameter is required for asynchronous operation.</p> <p>The use of this parameter is optional for synchronous operation. If this parameter does not contain a valid timestamp, the <i>Timestamp Valid</i> parameter should be set to zero (0).</p> |

4.1.2 Entity Control

The **Entity Control** packet is used to control position, attitude, and other attributes describing an entity's state. This packet applies to all entities in the simulation, including the Ownship.

Each entity is identified by a unique identifier called the Entity ID. When the Host sends an **Entity Control** packet to the IG, the IG sets the state of the entity object corresponding to the value of the *Entity ID* parameter. If the specified entity does not exist, the IG will create it.

When the IG creates an entity, it makes a copy of the geometry corresponding to the value of the *Entity Type* parameter. This copy exists as a unique and independent tree within the scene graph; therefore, any operations that modify an entity's tree (e.g., part articulations) affect only that entity and its children.

Figure 25 illustrates unique Entity IDs being assigned to multiple entities of the same type. The number assignments in this example are hypothetical.

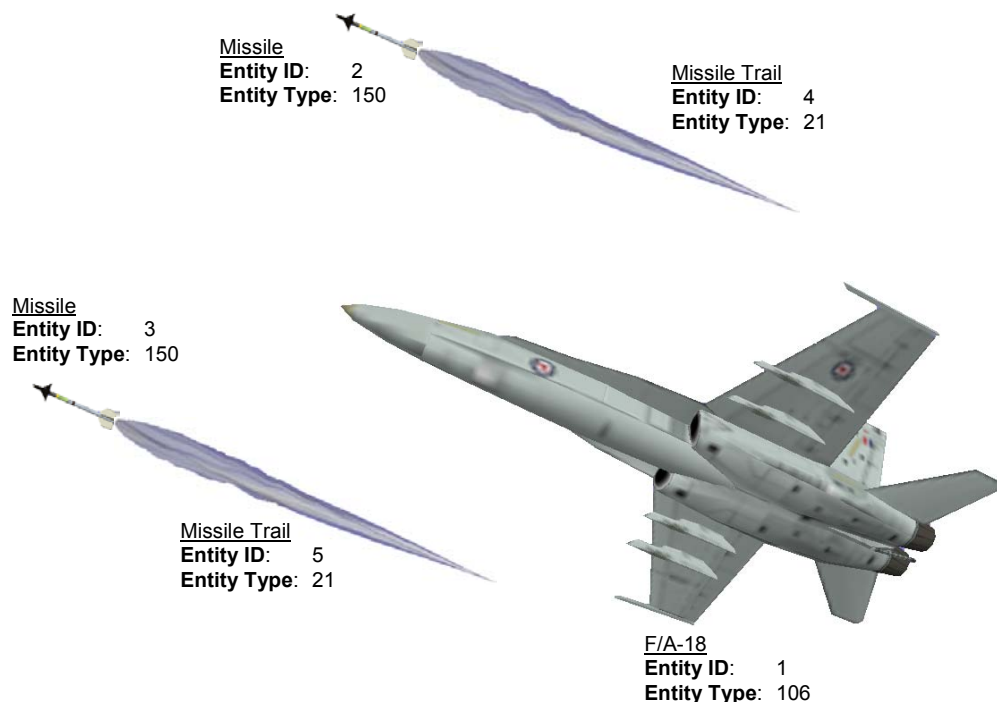


Figure 25 – Example of Entity Definitions

Entities can be attached to one another in a hierarchical relationship. In such a hierarchy, a child entity's position is specified relative to its parent's coordinate system. The Host needs only to control the top-level entity in order to move all entities in the hierarchy as a group. No explicit manipulation of a child entity is necessary unless its position and attitude change with respect to its parent.

In the example above, the missiles and missile trails could be maneuvered in one of two ways. First, each missile and missile trail could be controlled uniquely, requiring the host to provide position and attitude data for each of the four entities. The simpler and typically preferred way would be to establish a parent-child relationship for each missile and missile trail pair. Each missile could be attached to the aircraft until launched, at which time the missile would be detached from its parent and promoted to a top-level entity. Each top-level missile would then possess its own independent hierarchy, which would be manipulated independently from the aircraft. Figure 26 illustrates the parent-child hierarchy before and after a missile is launched:

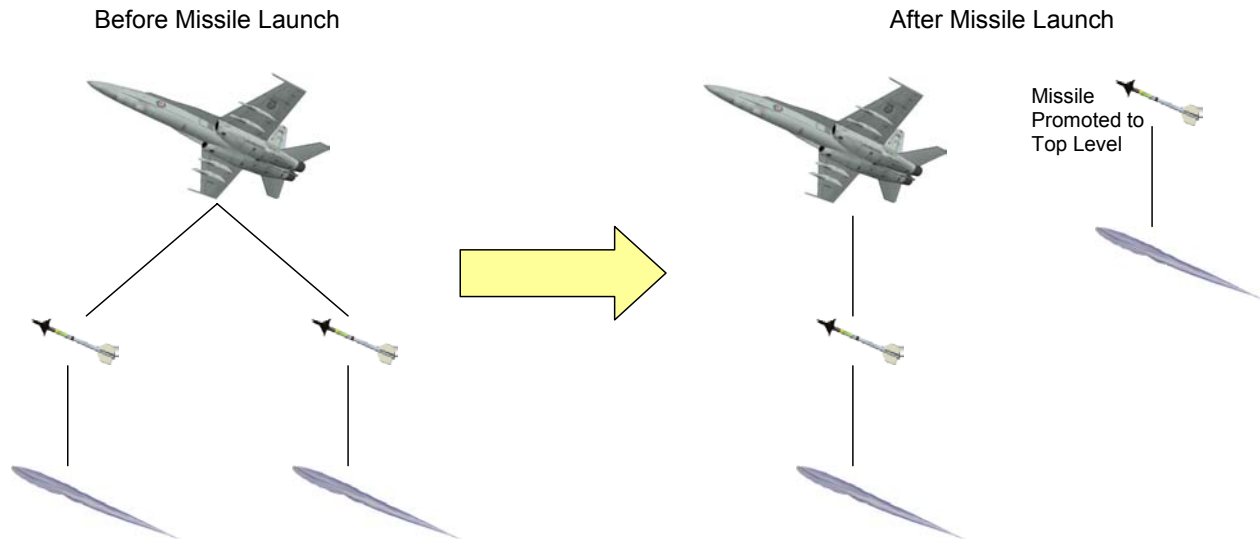


Figure 26 – Example of Child Entity Detachment

The *Attach State* parameter of the **Entity Control** packet determines whether an entity is attached to a parent. If this parameter is set to Attach (1), the entity is attached to the entity specified by the *Parent ID* parameter.

The *Entity State* field is used to control when an entity is visible and when its geometry is loaded and unloaded. When an entity is created, the *Entity State* field can be set to Active to specify that the entity should be added to the scene as soon as the model geometry is loaded. The entity and any children can be made invisible at any time by setting *Entity State* to Inactive/Standby. When the entity is no longer needed, *Entity State* can be set to Destroyed to direct the IG to unload the geometry and free any memory allocated for the entity. Any children attached to the entity are also destroyed.

Models can be preloaded to increase the speed at which they can be initially displayed. For example, when an aircraft fires a missile, a new entity would need to be created for that missile. Unless the missile geometry is cached, the IG must load the model from its hard disk. Because of its tremendous speed, the missile might fly a significant distance (and possibly beyond visual range) before the disk I/O can be completed. By preloading the entity, the geometry can already exist in memory and be instantly activated within the scene graph when needed. To accomplish this, the *Entity State* flag could be set to Inactive/Standby when the missile is created. Later, when the missile is needed, an **Entity Control** packet for that entity would be sent containing the proper positional data and with the *Entity State* flag set to Active.

An entity can also be made invisible by setting the *Alpha* parameter to zero (0). This parameter specifies an alpha value to be applied to the entity's geometry. The *Inherit Alpha* parameter indicates whether a child entity's alpha value is combined with that of its parent. For example, a missile attached to the wing of an aircraft would typically be made invisible when the aircraft is destroyed, so its *Inherit Alpha* attribute would be set to Inherited (1). An explosion or similar animation attached to that aircraft, however, would typically linger after the aircraft's destruction, so its *Inherit Alpha* attribute would be set to Not Inherited (0).

Note that setting the *Entity State* parameter to Inactive/Standby is not equivalent to setting the *Alpha* parameter to zero (0). The *Entity State* parameter enables or disables the entity geometry in the scene graph. The entity would not be included in line of sight and collision testing, nor would any transformations be applied. Any children would also be disabled. The *Alpha* parameter, on the other hand, merely affects the opacity of the specified entity.

The positions of top-level entities (i.e., those entities that are not children) are always specified as a geodetic latitude, longitude, and altitude (see Section 3.3.1.1). The positions of child entities are always specified with respect to the parents' NED body coordinate system (see Section 3.3.2).

In certain instances, it is desirable for the IG to “clamp” the entity to the surface of the terrain. This can be used as an alternative to using HOT requests and responses to determine ground elevation and slope below the entity. If the *Ground/Ocean Clamp* parameter is set to Non-Conformal (1) or Conformal (2), the *Altitude* parameter specifies an offset above the ground or sea surface height. This is useful for specifying the vertical distance from an automobile’s reference point to its wheels, for instance, or from a ship’s reference point to its waterline. Similarly, *Roll* and *Pitch* specify rotational offsets if ground or ocean clamping is enabled.

The *Animation State* parameter is used to control the playback state of animation entities. To start the animation sequence, the Host will send an **Entity Control** packet with its *Entity State* set to Active and its *Animation State* parameter to either Play or Resume. The Host may explicitly stop the animation at any time by setting the *Animation State* to Stop. Setting the parameter to Pause freezes the animation sequence at the current frame. Setting the parameter to Resume in a subsequent frame will resume the animation from its paused state; setting it to Play will play the animation again from its initial state. Setting *Animation State* to Play during playback will restart the animation.

The following table summarizes the animation behavior:

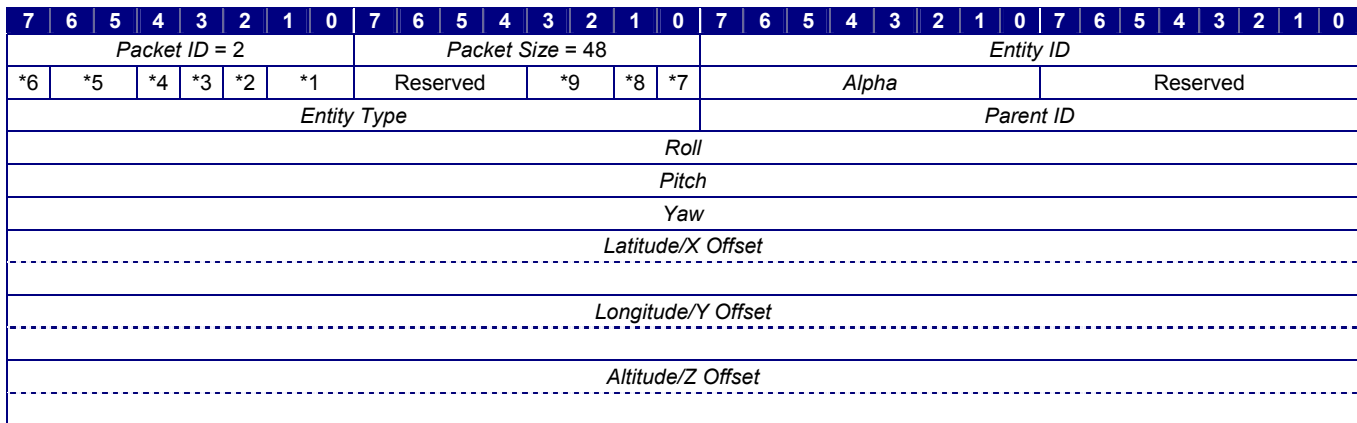
Table 5 – Animation State Summary

| Current State | New Animation State Value | Effect |
|---------------|---------------------------|---------------------------------|
| Stopped | Stop | None |
| | Pause | None |
| | Play | Plays from beginning |
| | Continue | Plays from beginning |
| Playing | Stop | Stops and disappears from scene |
| | Pause | Pauses at current frame |
| | Play | Restarts from beginning |
| | Continue | No action, continues playing |
| Paused | Stop | Stops and disappears from scene |
| | Pause | None |
| | Play | Plays from beginning |
| | Continue | Plays from current frame |

If an animation has been built with a limited duration, and if the *Animation Loop Mode* parameter is set to One-Shot, the animation will stop automatically upon its completion. The IG will indicate this condition by sending an **Animation Stop Notification** packet (Section 4.2.15) to the Host. If the *Animation Loop Mode* parameter is set to Loop, the animation will immediately restart from the beginning and no **Animation Stop Notification** packet will be sent.

Once an **Entity Control** packet describing an entity is sent to the IG, the state of that entity will not change until another **Entity Control** packet specifying that entity ID is received. For example, packets describing the Ownship and a wingman may be sent every frame to indicate continuous positional changes, while a packet describing an inactive SAM site may be sent once during mission initialization.

The contents of the **Entity Control** packet are as follows:



- *1 Entity State
- *2 Attach State
- *3 Collision Detection Request
- *4 Inherit Alpha
- *5 Ground/Ocean Clamp
- *6 Reserved
- *7 Animation Direction
- *8 Animation Loop Mode
- *9 Animation State

Figure 27 – Entity Control Packet Structure

Table 6 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 6 – Entity Control Parameter Definitions

| Parameter | Description |
|---|---|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 2</p> | <p>This parameter identifies this data packet as the Entity Control packet. The value of this parameter must be 2.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 48</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 48.</p> |
| <p>Entity ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the entity to which this packet is applied. A value of zero (0) corresponds to the Ownship.</p> |

| Parameter | Description |
|---|---|
| <p>Entity State</p> <p>Type: unsigned 2-bit field</p> <p>Units: N/A</p> <p>Values: 0 Inactive/Standby 1 Active 2 Destroyed</p> | <p>This parameter specifies whether the entity should be active or destroyed. It may be set to one of the following values:</p> <p>Inactive/Standby – The entity is loaded, but its tree is not enabled in the scene graph. The entity is invisible, and no transformations are applied. Additionally, the entity is excluded from line of sight and collision testing.</p> <p>Active – The entity's tree is enabled in the scene graph. Transformations are applied to the entity and it is included in line of sight and collision testing.</p> <p>Destroyed – The entity's tree is removed from the scene graph. Any children are also destroyed. All other parameters in this packet are ignored.</p> |
| <p>Attach State</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Detach 1 Attach</p> | <p>This parameter specifies whether the entity should be attached as a child to a parent.</p> <p>If this parameter is set to Detach (0), the entity becomes or remains a top-level (non-child) entity. The <i>Parent ID</i> parameter is ignored. The <i>Yaw</i>, <i>Pitch</i>, <i>Roll</i>, <i>Latitude</i>, <i>Longitude</i>, and <i>Altitude</i> parameters all specify the entity's position relative to the geodetic coordinate system (see Section 3.3.1).</p> <p>If this parameter is set to Attach (1), the entity becomes or remains attached to the entity specified by the <i>Parent ID</i> parameter. The parent must already exist, having been created in a prior frame or earlier in the current frame. The <i>Yaw</i>, <i>Pitch</i>, <i>Roll</i>, <i>X Offset</i>, <i>Y Offset</i>, and <i>Z Offset</i> parameters all specify the entity's position relative to the parent's coordinate system (see Section 3.3.2).</p> <p>This parameter may be changed for a given entity at any time. The attachment or detachment takes place immediately and remains in effect until changed with another Entity Control packet.</p> |

| Parameter | Description |
|---|---|
| <p><i>Collision Detection Request</i></p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 No Request 1 Request</p> | <p>This parameter determines whether any collision detection segments and volumes associated with this entity are used as the source in collision testing. If this parameter is set to Request (1), each collision detection segment is tested for intersections with polygons not associated with this entity and each collision detection volume is tested pair-wise with every other volume that is not associated with the entity.</p> <p>If this parameter is set to No Request (0), any collision detection segments defined for the entity are ignored and any collision detection volumes are only tested (as the destination) against volumes defined for entities whose collision detection is enabled.</p> <p>See Sections 4.1.22 and 4.1.23 for details on creating collision detection segments and volumes, respectively.</p> |
| <p><i>Inherit Alpha</i></p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Not Inherited 1 Inherited</p> | <p>This parameter specifies whether the entity's alpha is combined with the apparent alpha of its parent. The following formula will be used to combine the alpha values:</p> $\alpha = \frac{\alpha_0 \cdot \alpha_p}{255}$ <p>where α is the apparent alpha of the child, α_0 is the explicit alpha of the child, and α_p is the apparent alpha of the parent.</p> <p>Note that a change in an entity's alpha affects the entities below it in the hierarchy if those entities inherit their parents' alphas.</p> <p>If <i>Attach State</i> is set to Detach (0), this parameter is ignored.</p> |

| Parameter | Description |
|--|--|
| <p>Ground/Ocean Clamp</p> <p>Type: unsigned 2-bit field</p> <p>Units: N/A</p> <p>Values: 0 No Clamp 1 Non-Conformal 2 Conformal</p> | <p>This parameter specifies whether the entity should be clamped to the ground or water surface. If <i>Attach State</i> is set to Attach (1), this parameter is ignored.</p> <p>No Clamp – The entity is not clamped. The <i>Altitude</i> parameter specifies the entity’s height above Mean Sea Level. The <i>Pitch</i> and <i>Roll</i> parameters specify the entity’s pitch and roll relative to the geodetic reference plane (Figure 17, page 22).</p> <p>Non-Conformal – The entity is clamped. The <i>Altitude</i> parameter specifies an offset above the terrain or sea level. The <i>Pitch</i> and <i>Roll</i> parameters specify the entity’s pitch and roll relative to the geodetic reference plane (Figure 17, page 22).</p> <p>Conformal – The entity is clamped and its attitude conforms to the terrain. The <i>Altitude</i> parameter specifies an offset above the terrain or sea level. The <i>Pitch</i> and <i>Roll</i> parameters specify the entity’s pitch and roll relative to the slope of the terrain or water.</p> |
| <p>Animation Direction</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Forward 1 Backward</p> | <p>This parameter specifies the direction in which an animation plays. This parameter applies only when the value of the <i>Entity Type</i> parameter corresponds to an animation.</p> |
| <p>Animation Loop Mode</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 One-Shot 1 Continuous</p> | <p>This parameter specifies whether an animation should be a one-shot (i.e., should play once and stop) or should loop continuously.</p> |

| Parameter | Description |
|---|--|
| <p>Animation State</p> <p>Type: unsigned 2-bit field</p> <p>Units: N/A</p> <p>Values: 0 Stop 1 Pause 2 Play 3 Continue</p> | <p>This parameter specifies the state of an animation. This parameter applies only when the value of the <i>Entity Type</i> parameter corresponds to an animation.</p> <p>Stop – Stops the animation sequence. Has no effect if the animation is currently stopped.</p> <p>Pause – Pauses playback of an animation. The entity's geometry will remain visible, provided <i>Entity State</i> is set to Active.</p> <p>Play – Begins or restarts playback from the first animation frame.</p> <p>Continue – Continues a playing animation from the current frame of the animation sequence. If the animation is paused, playback is resumed from the current frame. If the animation is stopped, playback is restarted from the first frame of the sequence.</p> |
| <p>Alpha</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter specifies the explicit alpha to be applied to the entity's geometry. A value of zero (0) corresponds to fully transparent; a value of 255 corresponds to fully opaque.</p> |
| <p>Entity Type</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the type for the entity. A value of zero (0) indicates a "null" type with no associated geometry. Such an entity might be used to represent the Ownship or a floating camera.</p> <p>If the specified type is undefined, the data packet will be disregarded.</p> |
| <p>Parent ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the parent for the entity. If the <i>Attach State</i> parameter is set to Detach (0), this parameter is ignored.</p> <p>The value of this parameter may be changed without first detaching the entity from its existing parent.</p> <p>If the specified parent entity is invalid, no change in the attachment will be made.</p> |

| Parameter | Description |
|--|---|
| <p>Roll</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: -180.0 – 180.0</p> <p>Datum: If <i>Attach State</i> = 0 and <i>Ground/Ocean Clamp</i> = 0 or 1: Geodetic reference coordinate system (see Section 3.3.1.2)</p> <p> If <i>Attach State</i> = 0 and <i>Ground/Ocean Clamp</i> = 2: Terrain surface polygon orientation</p> <p> If <i>Attach State</i> = 1: Entity reference coordinate system (see Section 3.3.2.2)</p> | <p>This parameter specifies the roll angle of the entity.</p> <p>For top-level entities for which <i>Ground/Ocean Clamp</i> is set to No Clamp (0) or Non-Conformal (1), this angle is measured from the reference plane described in Section 3.3.1.2.</p> <p>For top-level entities for which <i>Ground/Ocean Clamp</i> is enabled, this angle specifies an angular offset from the terrain surface polygon’s orientation.</p> <p>For child entities, roll is measured from the parent entity’s reference plane as described in Section 3.3.2.2.</p> |
| <p>Pitch</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: -90.0 – 90.0</p> <p>Datum: If <i>Attach State</i> = 0 and <i>Ground/Ocean Clamp</i> = 0 or 1: Geodetic reference plane (see Section 3.3.1.2)</p> <p> If <i>Attach State</i> = 0 and <i>Ground/Ocean Clamp</i> = 2: Terrain surface polygon orientation</p> <p> If <i>Attach State</i> = 1: Entity reference plane (see Section 3.3.2.2)</p> | <p>This parameter specifies the pitch angle of the entity.</p> <p>For top-level entities for which <i>Ground/Ocean Clamp</i> is set to No Clamp (0) or Non-Conformal (1), this angle is measured from the reference plane described in Section 3.3.1.2.</p> <p>For top-level entities for which <i>Ground/Ocean Clamp</i> is enabled, this angle specifies an angular offset from the terrain surface polygon’s orientation.</p> <p>For child entities, pitch is measured with respect to the entity’s reference plane as described in Section 3.3.2.2.</p> |

| Parameter | Description |
|--|--|
| <p>Yaw</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: 0.0 – 360.0</p> <p>Datum: If <i>Attach State</i> = 0: True North If <i>Attach State</i> = 1: Entity Reference Plane's +X axis</p> | <p>For top-level (non-child) entities, this parameter specifies the instantaneous heading of the entity. This angle is measured from a line parallel to the Prime Meridian as described in Section 3.3.1.2.</p> <p>For child entities, this parameter specifies yaw relative to the parent entity and is measured with respect to the +X axis of the entity's reference plane as described in Section 3.3.2.2.</p> |
| <p>Latitude (Top-Level Entities)</p> <p>Type: double float</p> <p>Units: degrees</p> <p>Values: -90 – 90</p> <p>Datum: Equator</p> | <p>For top-level (non-child) entities, this parameter specifies the entity's geodetic latitude.</p> |
| <p>X Offset (Child Entities)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Parent's reference point</p> | <p>For child entities, this parameter specifies the distance from the parent's reference point along its parent's X axis.</p> |
| <p>Longitude (Top-Level Entities)</p> <p>Type: double float</p> <p>Units: degrees</p> <p>Values: -180.0 – 180.0</p> <p>Datum: Prime Meridian</p> | <p>For top-level (non-child) entities, this parameter specifies the entity's geodetic longitude.</p> |
| <p>Y Offset (Child Entities)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Parent's reference point</p> | <p>For child entities, this parameter specifies the distance from the parent's reference point along its parent's Y axis.</p> |

| Parameter | Description |
|--|---|
| <p>Altitude (Top-Level Entities)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: If <i>Ground/Ocean Clamp</i> = 0: Mean Sea Level</p> <p>If <i>Ground/Ocean Clamp</i> = 1 or 2: Ground/sea surface elevation</p> | <p>For top-level (non-child) entities, this parameter specifies the entity's altitude.</p> <p>If the <i>Ground/Ocean Clamp</i> parameter is set to No Clamp (0), this value is the height above Mean Sea Level.</p> <p>If the <i>Ground/Ocean Clamp</i> parameter is set to Non-Conformal (1) or Conformal (2), this value specifies an offset above the terrain height or local sea level (see Section 4.1.13) at the entity's latitude and longitude.</p> |
| <p>Z Offset (Child Entities)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Parent's reference point</p> | <p>For child entities, this parameter specifies the distance from the parent's reference point along its parent's Z axis.</p> |

4.1.3 Conformal Clamped Entity Control

The **Conformal Clamped Entity Control** parameter is used to set spatial data for conformal, ground- or ocean-clamped entities. This packet is offered as a lightweight alternative to the **Entity Control** packet (Section 4.1.2).

Because the entity type and other necessary attributes are not specified in this packet, it may not be used to instantiate (create) an entity. Before using this packet to manipulate an entity, the Host must first instantiate that entity by sending an **Entity Control** packet and should set the *Ground/Ocean Clamp* parameter to Conformal (2). If a non-existent entity is referenced by a **Conformal Clamped Entity Control** packet, the packet will be ignored.

An entity’s current roll, pitch, and altitude offsets (specified in the last **Entity Control** packet referencing the entity) will be maintained when the IG receives a **Conformal Clamped Entity Control** packet describing that entity. If this packet is applied to an unclamped or non-conformal clamped entity, its current absolute roll, pitch, and altitude will be maintained.

The contents of the **Conformal Clamped Entity Control** packet are as follows:

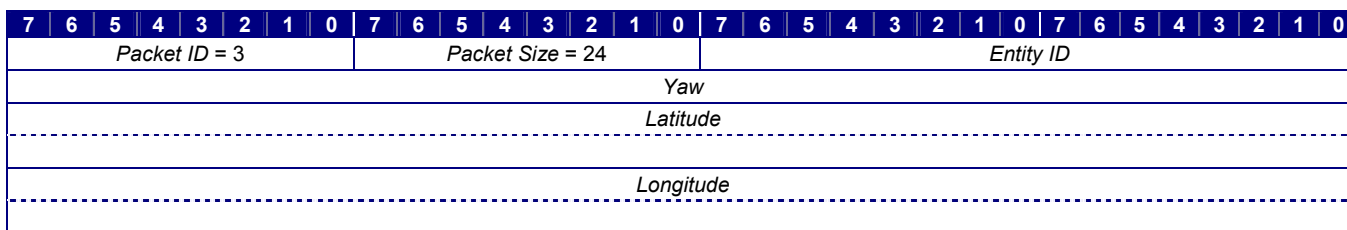


Figure 28 – Conformal Clamped Entity Control Packet Structure

Table 7 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 7 – Conformal Clamped Entity Control Parameter Definitions

| Parameter | Description |
|---|---|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 3</p> | <p>This parameter identifies this data packet as the Conformal Clamped Entity Control packet. The value of this parameter must be 3.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 24</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 24.</p> |
| <p>Entity ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the entity to which this packet is applied. A value of zero (0) corresponds to the Ownship.</p> |

| Parameter | Description |
|---|---|
| Yaw Type: single float Units: degrees Values: 0.0 – 360.0 Datum: True North | This parameter specifies the instantaneous heading of the entity. This angle is measured from True North as described in Section 3.3.1.2. |
| Latitude Type: double float Units: degrees Values: -90 – 90 Datum: Equator | This parameter specifies the entity's geodetic latitude. |
| Longitude Type: double float Units: degrees Values: -180.0 – 180.0 Datum: Prime Meridian | This parameter specifies the entity's geodetic longitude. |

4.1.4 Component Control

The **Component Control** packet is provided as a generic mechanism to control various components within the simulation. Because CIGI is designed to be a general-purpose interface, only the most common attributes of entities, views, and other objects are explicitly represented by parameters within specific data packets. Other attributes can be represented by components.

Components may correspond to parts or properties of entities, views and view groups, sensors, weather and environment, terrain, and even the IG itself. The type of object possessing the component is identified by the *Component Class* parameter. The specific instance of that object is specified by the *Instance ID* parameter. Depending upon the value of the *Component Class* parameter, the instance ID might correspond to an Entity ID, a view ID, an environmental attribute, etc. The *Component ID* parameter uniquely identifies the component for the instance.

Table 8 lists each component class, the identifier to which *Instance ID* corresponds for that class, and examples of component ID assignments with possible values. Note that the table gives only one example of a possible component assignment scheme.

Table 8 – Examples of Component Assignments

| Component Class | Instance ID Corresponds to | Example Component ID Assignments | Example States and Values |
|--------------------------|-----------------------------------|---|--|
| Entity | Entity ID | Anti-collision light Air brake Landing gear Damage Entity Scaling Engine Temperature | On/Off Full/Partial/Closed Up/Down Damaged/No Damage Enable/Disable, X, Y, Z Temperature differential |
| View | View ID | Zoom Viewport Mask Angle of Projection (for an oblique parallel view) | Zoom factor On/Off Angle |
| View Group | Group ID | Zoom | Zoom Factor |
| Sensor | Sensor ID | Gate Cursor | Symbol |
| Regional Sea Surface | Region ID | Littoral Current | Speed, Direction |
| Regional Terrain Surface | Region ID | Light Snow Properties Heavy Snow Properties Mud Properties | Wetness Depth, Wetness Depth, Consistency, Stability |

| Component Class | Instance ID Corresponds to | Example Component ID Assignments | Example States and Values |
|--------------------------|-----------------------------------|--|---|
| Regional Layered Weather | Region ID | Instantaneous Lightning Strike (Layer 1) Instantaneous Lightning Strike (Layer 2) Rain (Layer 4) Aerosol (Layer 10) Aerosol (Layer 11) | Latitude, Longitude, Altitude, Intensity Latitude, Longitude, Altitude, Intensity Rain Density, Slant Color Color |
| Global Sea Surface | – | Surf Zone Breakers Littoral Current | Breaker Height, Direction, Period Speed, Direction |
| Global Terrain Surface | – | Runway Lights Cultural Lights Group 1 Cultural Lights Group 2 Shadows | On/Off, Intensity, Punch-Through On/Off, Intensity, Color On/Off, Intensity, Color On/Off, Contrast |
| Global Layered Weather | Layer ID | Instantaneous Lightning Strike Random Lightning Aerosol | Latitude, Longitude, Altitude, Intensity Enable/Disable, Avg. Freq. Color, Density, Reflectivity |
| Atmosphere | – | Haze | On/Off, Haze Color |
| Celestial Sphere | – | Sky Color | Color |
| Event | Event ID | Event Properties | Enable/Disable, Period |
| System | – | Crash Indicator High-Resolution Targets | On/Off, Color Enable/Disable |

Each component has zero or more discrete states, and/or up to six user-defined values. The user-defined values may either be integers or floating-point real numbers. A light, for instance, might have two discrete states (On and Off), an RGB color value represented as a 32-bit integer, and a real-value intensity level. A component representing the global lightpoint intensity value might have a real-value intensity level and no discrete states.

Regardless of how the six user-defined data fields are formatted, they will be byte-swapped as separate 32-bit values if the Host and IG use different byte ordering schemes. This ensures that all **Component Control** packets are byte-swapped in a consistent manner. The data should be packaged using masks and bit-wise operations so that the values are not changed when the 32-bit words are byte-swapped.

As an example, assume the *Component Data 1* field is used to store two 16-bit integers, i and j ; the *Component Data 2* field is used to store a single 32-bit integer, k ; and the *Component Data 3* and *Component Data 4* fields are combined to store a double-precision floating-point number, m . The two remaining parameters are not used in this instance. Figure 29 illustrates an incorrect and a correct way of formatting the 32-bit user-defined data fields to store these values:

Incorrect:

| <i>Packet ID</i> | <i>Packet Size</i> | <i>Component ID</i> | |
|--------------------|--------------------|------------------------|------------------------|
| <i>Instance ID</i> | | <i>Component Class</i> | <i>Component State</i> |
| <i>i</i> | | <i>j</i> | |
| <i>k</i> | | | |
| <i>m</i> | | | |
| 0 | | | |
| 0 | | | |

Correct:

| <i>Packet ID</i> | <i>Packet Size</i> | <i>Component ID</i> | |
|-------------------------|--------------------|------------------------|------------------------|
| <i>Instance ID</i> | | <i>Component Class</i> | <i>Component State</i> |
| $(i \times 2^{16}) + j$ | | | |
| <i>k</i> | | | |
| <i>m</i> (MSW) | | | |
| <i>m</i> (LSW) | | | |
| 0 | | | |
| 0 | | | |

Figure 29 – Example of Incorrect and Correct Formatting of Component Data

Since *k* is a 32-bit data type, its value can simply be copied to the packet. However, if the Host were to copy the values of *i*, *j*, and *m* as shown in the top structure, these data would be improperly byte-swapped by the IG. For this example, assume that the Host uses little-endian byte ordering and that the IG is a big-endian system. If *i* were 1, *j* were 120, *k* were 3600, and *m* were 100.0, the data would be incorrectly interpreted by the IG as shown in the following diagram:

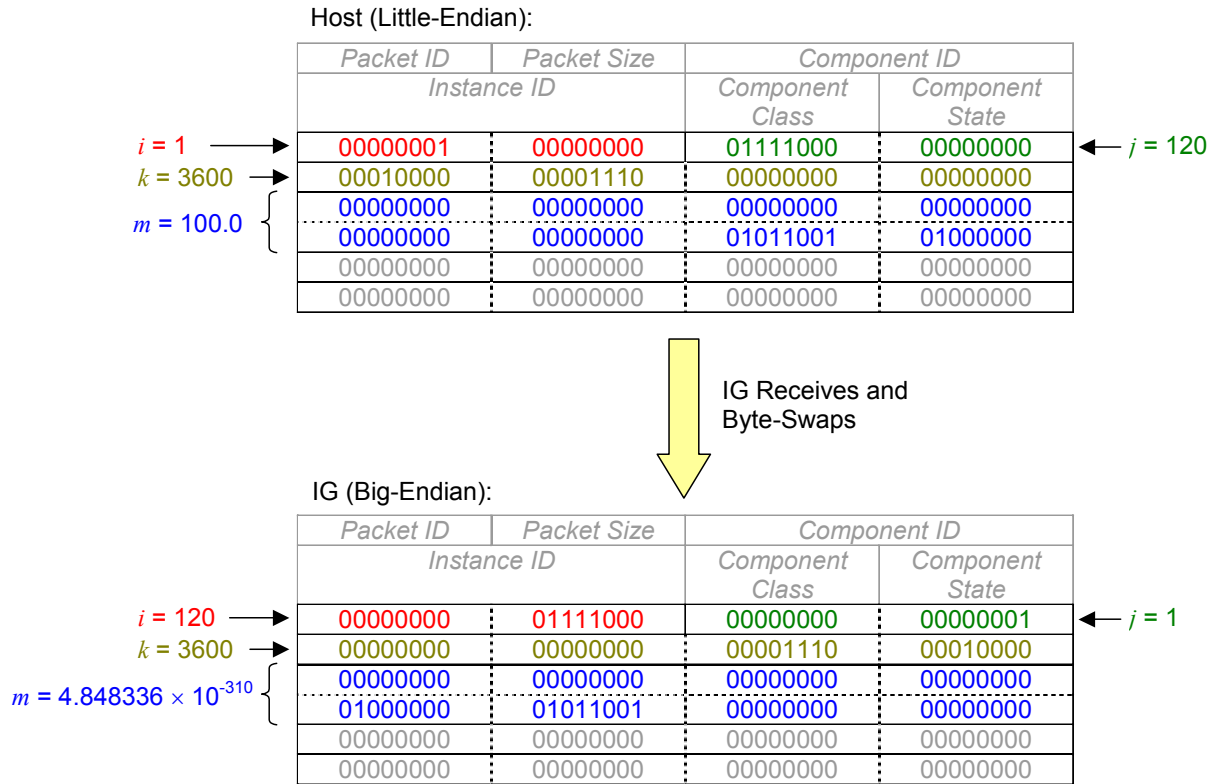


Figure 30 – Example of Incorrect Packaging of Component Data

In this scenario, the values of i and j have been swapped. In addition, the value of the floating-point number m has changed because the most and least significant words have also been swapped.

When the Host packs the data into the **Component Control** packet, it should combine the 16-bit integers into a single 32-bit number, α , by bit-shifting i left 16 bits (or multiplying i by 2^{16}) and adding j . It should then split the 64-bit floating-point number into two 32-bit values, β and γ , which represent the most significant word (MSW) and least significant word (LSW), respectively. The value of β can be found by truncating m after the 32nd bit (2^{31}), and the value of γ by shifting m to the right 32 bits and truncating after the 32nd bit.

The diagram below illustrates the packing of the data into the correct format shown in Figure 29. Note that to find the least-significant word of m , the variable is typecast as an unsigned 64-bit integer.

Pack the 16-bit Integers:

$$\begin{array}{r}
 i: \quad 1 \times 2^{16} \quad 00000000 \quad 00000001 \quad 00000000 \quad 00000000 \\
 j: \quad + \quad 120 \quad 00000000 \quad 00000000 \quad 00000000 \quad 01111000 \\
 \hline
 \alpha: \quad 65656 \quad 00000000 \quad 00000001 \quad 00000000 \quad 01111000
 \end{array}$$

← shift left 16 bits →

Pack the 64-bit Floating-Point Number:

$m = 100.0$ can be represented as `4059000000000000h`, which is treated as an unsigned 64-bit integer

MSW (β):

$$\begin{array}{r}
 4059000000000000h \quad 2^{63} \quad 01000000 \quad 01011001 \quad 00000000 \quad 00000000 \quad 2^{32} \quad 2^{31} \quad 00000000 \quad 00000000 \quad 00000000 \quad 00000000 \quad 2^0 \\
 \downarrow \text{truncate} \quad \beta = 0h
 \end{array}$$

LSW (γ):

$$\begin{array}{r}
 4059000000000000h \div 2^{32} \quad 2^{63} \quad 00000000 \quad 00000000 \quad 00000000 \quad 00000000 \quad 2^{32} \quad 2^{31} \quad 01000000 \quad 01011001 \quad 00000000 \quad 00000000 \quad 2^0 \\
 \leftarrow \text{shift right 32 bits} \quad \downarrow \text{truncate} \quad \gamma = 40590000h
 \end{array}$$

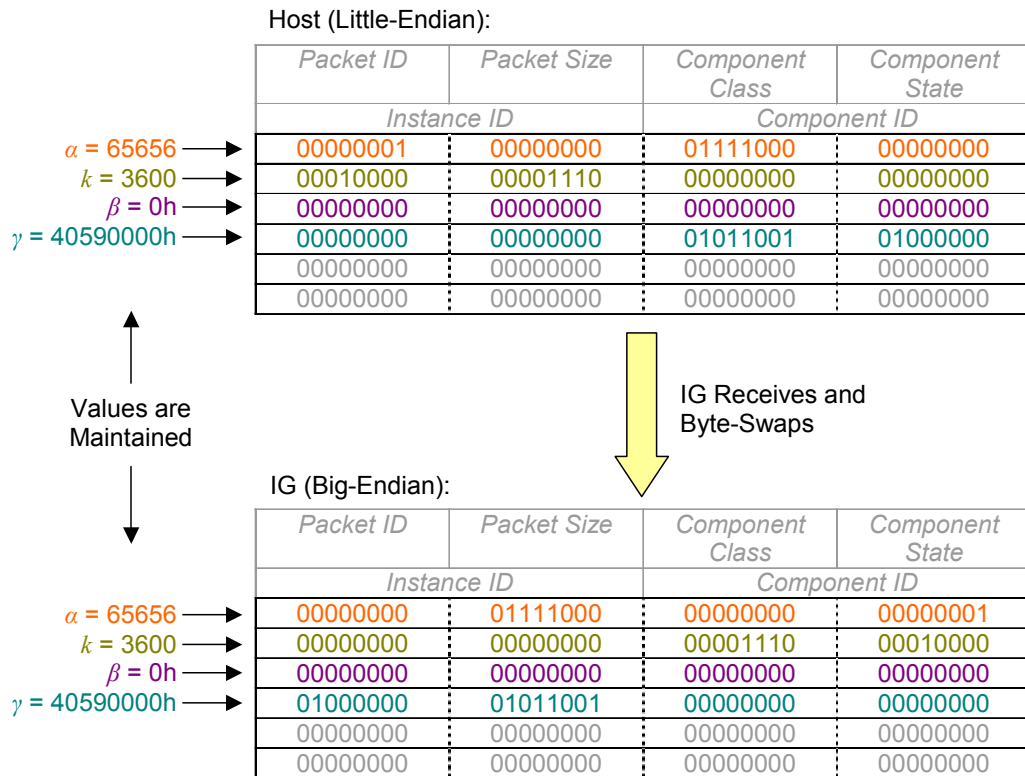


Figure 31 – Example of Correct Packaging of Component Data

k is a 32-bit data type and will be byte-swapped correctly without manipulation. Since α , β , and γ are 32-bit fields, their values will also be maintained when the IG byte-swaps the **Component Control** packet. The IG can

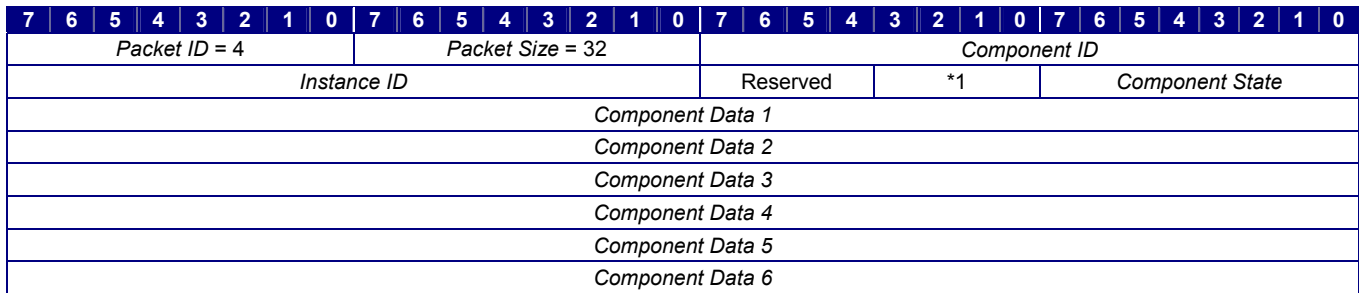
correctly reconstruct the values of i , j , and k by applying the reciprocal operations to α , β , and γ after byte-swapping.

Single-byte int8 and char data would be packed in a method similar to that used for i and j . Each numerical value would be shifted left (multiplied by a power of two) and added to the unsigned 32-bit integer.

Because the method of organizing bit fields varies from one compiler to the next, bit fields should be implemented with a series of bit-wise shifts and logical operations.

This packet uses the same *Component ID* and *Instance ID* mappings as the **Short Component Control** packet (Section 4.1.5). All components that can be controlled with the **Short Component Control** packet can also be controlled with the **Component Control** packet.

The contents of the **Component Control** packet are as follows:



*1 *Component Class*

Figure 32 – Component Control Packet Structure

Table 9 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 9 – Component Control Parameter Definitions

| Parameter | Description |
|---|--|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 4</p> | <p>This parameter identifies this data packet as the Component Control packet. The value of this parameter must be 4.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 32</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 32.</p> |

| Parameter | Description | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--|--|--------|---|------|---|------------|---|--------|---|----------------------|---|--------------------------|---|--------------------------|---|--------------------|---|------------------------|---|------------------------|----|------------|----|------------------|----|-------|----|--------|---|
| <p>Component ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter uniquely identifies the component to which the data in this packet should be applied.</p> <p>If <i>Component Class</i> is set to Regional Layered Weather (6), the weather layer ID is specified by the most significant byte of <i>Component ID</i>.</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>Instance ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter uniquely identifies the object to which the component belongs. This value corresponds to an entity ID, a view or view group ID, a sensor ID, environmental region ID, global weather layer ID, or event ID depending upon the value of the <i>Component Class</i> parameter (see Table 8).</p> <p>This parameter will typically be ignored if <i>Component Class</i> is set to Global Sea Surface (7), Global Terrain Surface (8), Atmosphere (10), Celestial Sphere (11), or System (13).</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>Component Class</p> <p>Type: unsigned 4-bit field</p> <p>Units: N/A</p> <p>Values:</p> <table data-bbox="256 1035 699 1459"> <tr><td>0</td><td>Entity</td></tr> <tr><td>1</td><td>View</td></tr> <tr><td>2</td><td>View Group</td></tr> <tr><td>3</td><td>Sensor</td></tr> <tr><td>4</td><td>Regional Sea Surface</td></tr> <tr><td>5</td><td>Regional Terrain Surface</td></tr> <tr><td>6</td><td>Regional Layered Weather</td></tr> <tr><td>7</td><td>Global Sea Surface</td></tr> <tr><td>8</td><td>Global Terrain Surface</td></tr> <tr><td>9</td><td>Global Layered Weather</td></tr> <tr><td>10</td><td>Atmosphere</td></tr> <tr><td>11</td><td>Celestial Sphere</td></tr> <tr><td>12</td><td>Event</td></tr> <tr><td>13</td><td>System</td></tr> </table> | 0 | Entity | 1 | View | 2 | View Group | 3 | Sensor | 4 | Regional Sea Surface | 5 | Regional Terrain Surface | 6 | Regional Layered Weather | 7 | Global Sea Surface | 8 | Global Terrain Surface | 9 | Global Layered Weather | 10 | Atmosphere | 11 | Celestial Sphere | 12 | Event | 13 | System | <p>This parameter identifies the type of object to which the <i>Instance ID</i> parameter refers. Both of these parameters are used in conjunction with <i>Component ID</i> to uniquely identify a component in the simulation (see Table 8).</p> |
| 0 | Entity | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | View | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | View Group | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | Sensor | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | Regional Sea Surface | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | Regional Terrain Surface | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | Regional Layered Weather | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | Global Sea Surface | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | Global Terrain Surface | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | Global Layered Weather | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | Atmosphere | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | Celestial Sphere | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | Event | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | System | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>Component State</p> <p>Type: unsigned int8</p> <p>Units: Component-specific</p> <p>Values: Component-specific</p> <p>Default: IG-configurable</p> | <p>This parameter specifies a discrete state for the component. If a discrete state is not applicable to the component, this parameter is ignored.</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| Parameter | Description |
|---|---|
| <p>Component Data 1</p> <p>Type: word</p> <p>Units: Component-specific</p> <p>Values: Component-specific</p> <p>Default: IG-configurable</p> | <p>This parameter is one of six 32-bit words used for user-defined component data. If this parameter is not needed by the component, this value is ignored.</p> <p>Note: This parameter will be byte-swapped as a 32-bit value if the receiver and sender use different byte ordering schemes. If the parameter is used to store multiple 8- or 16-bit values, the data should be packed so that byte swapping will be performed correctly.</p> |
| <p>Component Data 2</p> <p>Type: word</p> <p>Units: Component-specific</p> <p>Values: Component-specific</p> <p>Default: IG-configurable</p> | <p>This parameter is one of six 32-bit words used for user-defined component data. If this parameter is not needed by the component, this value is ignored.</p> <p>Note: This parameter will be byte-swapped as a 32-bit value if the receiver and sender use different byte ordering schemes. If the parameter is used to store multiple 8- or 16-bit values, the data should be packed so that byte swapping will be performed correctly.</p> |
| <p>Component Data 3</p> <p>Type: word</p> <p>Units: Component-specific</p> <p>Values: Component-specific</p> <p>Default: IG-configurable</p> | <p>This parameter is one of six 32-bit words used for user-defined component data. If this parameter is not needed by the component, this value is ignored.</p> <p>Note: This parameter will be byte-swapped as a 32-bit value if the receiver and sender use different byte ordering schemes. If the parameter is used to store multiple 8- or 16-bit values, the data should be packed so that byte swapping will be performed correctly.</p> |
| <p>Component Data 4</p> <p>Type: word</p> <p>Units: Component-specific</p> <p>Values: Component-specific</p> <p>Default: IG-configurable</p> | <p>This parameter is one of six 32-bit words used for user-defined component data. If this parameter is not needed by the component, this value is ignored.</p> <p>Note: This parameter will be byte-swapped as a 32-bit value if the receiver and sender use different byte ordering schemes. If the parameter is used to store multiple 8- or 16-bit values, the data should be packed so that byte swapping will be performed correctly.</p> |
| <p>Component Data 5</p> <p>Type: word</p> <p>Units: Component-specific</p> <p>Values: Component-specific</p> <p>Default: IG-configurable</p> | <p>This parameter is one of six 32-bit words used for user-defined component data. If this parameter is not needed by the component, this value is ignored.</p> <p>Note: This parameter will be byte-swapped as a 32-bit value if the receiver and sender use different byte ordering schemes. If the parameter is used to store multiple 8- or 16-bit values, the data should be packed so that byte swapping will be performed correctly.</p> |

| Parameter | Description |
|--|--|
| Component Data 6 Type: word Units: Component-specific Values: Component-specific Default: IG-configurable | This parameter is one of six 32-bit words used for user-defined component data. If this parameter is not needed by the component, this value is ignored. Note: This parameter will be byte-swapped as a 32-bit value if the receiver and sender use different byte ordering schemes. If the parameter is used to store multiple 8- or 16-bit values, the data should be packed so that byte swapping will be performed correctly. |

4.1.5 Short Component Control

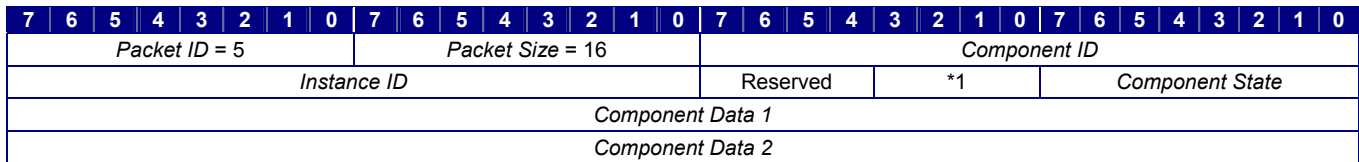
The **Short Component Control** packet, like the **Component Control** packet (Section 4.1.4), is a generic packet used to control a variety of objects or functions on the IG. This packet is provided as a lower-bandwidth alternative to the **Component Control** packet for components that do not require more than two words of component data.

This packet uses the same *Component ID* and *Instance ID* mappings as the **Component Control** packet. If the additional data fields offered by the **Component Control** packet are not necessary for a component, then the two packet types should be interchangeable. In other words, all components that can be controlled with the **Short Component Control** packet can also be controlled with the **Component Control** packet.

When receiving a **Short Component Control** packet, the IG may copy the contents of the packet into a **Component Control** structure, padding the remainder of the packet with zeros (0). The two packet types can then be processed by the same packet-handling routine.

The *Component Data 1* and *Component Data 2* fields will be byte-swapped, if necessary, as 32-bit data types. Data should be packed into 32-bit units as described in Section 4.1.4.

The contents of the **Short Component Control** packet are as follows:



*1 *Component Class*

Figure 33 – Short Component Control Packet Structure

Table 10 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 10 – Short Component Control Parameter Definitions

| Parameter | Description |
|---|--|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 5</p> | <p>This parameter identifies this data packet as the Short Component Control packet. The value of this parameter must be 5.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 16</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 16.</p> |

| Parameter | Description | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|--|--------|---|------|---|------------|---|--------|---|----------------------|---|--------------------------|---|--------------------------|---|--------------------|---|------------------------|---|------------------------|----|------------|----|------------------|----|-------|----|--------|---|
| <p>Component ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter uniquely identifies the component to which the data in this packet should be applied.</p> <p>If <i>Component Class</i> is set to Regional Layered Weather (6), the weather layer ID is specified by the most significant byte of <i>Component ID</i>.</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>Instance ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter uniquely identifies the object to which the component belongs. This value corresponds to an entity ID, a view or view group ID, a sensor ID, environmental region ID, global weather layer ID, or event ID depending upon the value of the <i>Component Class</i> parameter (see Table 8).</p> <p>This parameter will typically be ignored if <i>Component Class</i> is set to Global Sea Surface (7), Global Terrain Surface (8), Atmosphere (10), Celestial Sphere (11), or System (13).</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>Component Class</p> <p>Type: unsigned 4-bit field</p> <p>Units: N/A</p> <p>Values:</p> <table border="0" data-bbox="256 1035 699 1459"> <tr><td>0</td><td>Entity</td></tr> <tr><td>1</td><td>View</td></tr> <tr><td>2</td><td>View Group</td></tr> <tr><td>3</td><td>Sensor</td></tr> <tr><td>4</td><td>Regional Sea Surface</td></tr> <tr><td>5</td><td>Regional Terrain Surface</td></tr> <tr><td>6</td><td>Regional Layered Weather</td></tr> <tr><td>7</td><td>Global Sea Surface</td></tr> <tr><td>8</td><td>Global Terrain Surface</td></tr> <tr><td>9</td><td>Global Layered Weather</td></tr> <tr><td>10</td><td>Atmosphere</td></tr> <tr><td>11</td><td>Celestial Sphere</td></tr> <tr><td>12</td><td>Event</td></tr> <tr><td>13</td><td>System</td></tr> </table> | 0 | Entity | 1 | View | 2 | View Group | 3 | Sensor | 4 | Regional Sea Surface | 5 | Regional Terrain Surface | 6 | Regional Layered Weather | 7 | Global Sea Surface | 8 | Global Terrain Surface | 9 | Global Layered Weather | 10 | Atmosphere | 11 | Celestial Sphere | 12 | Event | 13 | System | <p>This parameter identifies the type of object to which the <i>Instance ID</i> parameter refers. Both of these parameters are used in conjunction with <i>Component ID</i> to uniquely identify a component in the simulation (see Table 8).</p> |
| 0 | Entity | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | View | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | View Group | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | Sensor | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | Regional Sea Surface | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | Regional Terrain Surface | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | Regional Layered Weather | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | Global Sea Surface | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | Global Terrain Surface | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | Global Layered Weather | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | Atmosphere | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | Celestial Sphere | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | Event | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | System | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>Component State</p> <p>Type: unsigned int8</p> <p>Units: Component-specific</p> <p>Values: Component-specific</p> <p>Default: IG-configurable</p> | <p>This parameter specifies a discrete state for the component. If a discrete state is not applicable to the component, this parameter is ignored.</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| Parameter | Description |
|---|---|
| <p>Component Data 1</p> <p>Type: word</p> <p>Units: Component-specific</p> <p>Values: Component-specific</p> <p>Default: IG-configurable</p> | <p>This parameter is one of two 32-bit words used for user-defined component data. If this parameter is not needed by the component, this value is ignored.</p> <p>Note: This parameter will be byte-swapped as a 32-bit value if the receiver and sender use different byte ordering schemes. If the parameter is used to store multiple 8- or 16-bit values, the data should be packed so that byte swapping will be performed correctly.</p> |
| <p>Component Data 2</p> <p>Type: word</p> <p>Units: Component-specific</p> <p>Values: Component-specific</p> <p>Default: IG-configurable</p> | <p>This parameter is one of two 32-bit words used for user-defined component data. If this parameter is not needed by the component, this value is ignored.</p> <p>Note: This parameter will be byte-swapped as a 32-bit value if the receiver and sender use different byte ordering schemes. If the parameter is used to store multiple 8- or 16-bit values, the data should be packed so that byte swapping will be performed correctly.</p> |

4.1.6 Articulated Part Control

Articulated parts are entity features that can be rotated and/or translated with respect to the entity. These features are submodels of the entity model and possess their own coordinate systems as discussed in Section 3.3.3. Examples include wing flaps, landing gear, and tank turrets.

Articulated parts may be manipulated in up to six degrees of freedom. Translation is defined as X, Y, and Z offsets relative to the submodel's reference point. Rotation is defined relative to the submodel coordinate system.

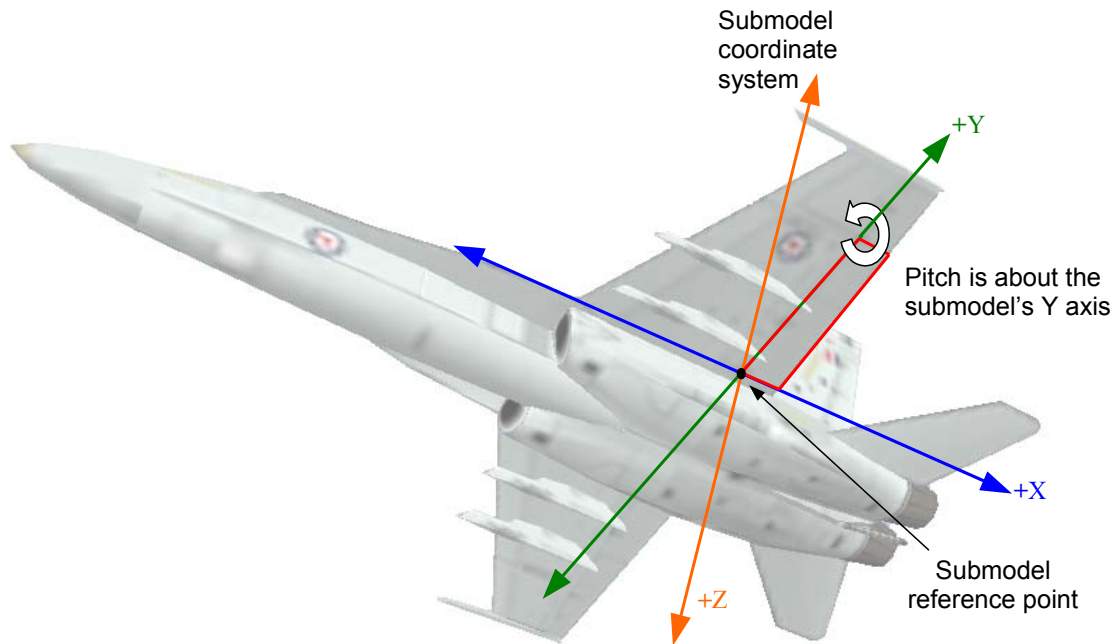
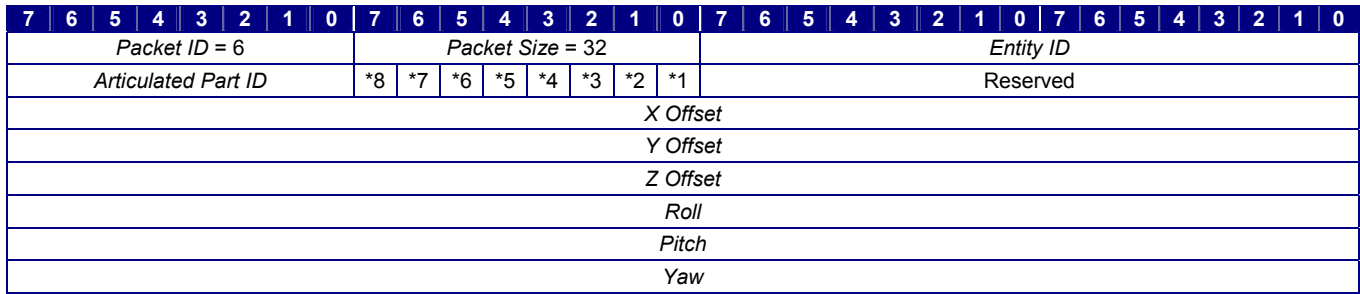


Figure 34 – Manipulation of Articulated Part Submodel

Positional and rotational values are not cumulative. They are absolute values relative to the coordinate system defined within the model.

The contents of the **Articulated Part Control** packet are as follows:



- *1 Articulated Part Enable
- *2 X Offset Enable
- *3 Y Offset Enable
- *4 Z Offset Enable
- *5 Roll Enable
- *6 Pitch Enable
- *7 Yaw Enable
- *8 Reserved

Figure 35 – Articulated Part Control Packet Structure

Table 11 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 11 – Articulated Part Control Parameter Definitions

| Parameter | Description |
|---|---|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 6</p> | <p>This parameter identifies this data packet as the Articulated Part Control packet. The value of this parameter must be 6.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 32</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 32.</p> |
| <p>Entity ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the entity to which the articulated part belongs.</p> |
| <p>Articulated Part ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter specifies the articulated part to which the data in this packet should be applied. When used with the <i>Entity ID</i> parameter, this parameter uniquely identifies a particular articulated part within the simulation.</p> |

| Parameter | Description |
|--|---|
| <p>Articulated Part Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: IG-configurable</p> | <p>This parameter determines whether the articulated part submodel should be enabled or disabled within the scene graph. If this parameter is set to Disable (0), the part is removed from the scene; if the parameter is set to Enable (1), the part is included in the scene.</p> |
| <p>X Offset Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> | <p>This parameter determines whether the <i>X Offset</i> parameter of the current packet should be applied to the articulated part. If this parameter is set to Disable (0), <i>X Offset</i> is ignored and the articulated part remains at its current location along the submodel's X axis.</p> |
| <p>Y Offset Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> | <p>This parameter determines whether the <i>Y Offset</i> parameter of the current packet should be applied to the articulated part. If this parameter is set to Disable (0), <i>Y Offset</i> is ignored and the articulated part remains at its current location along the submodel's Y axis.</p> |
| <p>Z Offset Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> | <p>This parameter determines whether the <i>Z Offset</i> parameter of the current packet should be applied to the articulated part. If this parameter is set to Disable (0), <i>Z Offset</i> is ignored and the articulated part remains at its current location along the submodel's Z axis.</p> |
| <p>Roll Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> | <p>This parameter determines whether the <i>Roll</i> parameter of the current packet should be applied to the articulated part. If this parameter is set to Disable (0), <i>Roll</i> is ignored and the articulated part retains its current roll angle.</p> |
| <p>Pitch Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> | <p>This parameter determines whether the <i>Pitch</i> parameter of the current packet should be applied to the articulated part. If this parameter is set to Disable (0), <i>Pitch</i> is ignored and the articulated part retains its current pitch angle.</p> |

| Parameter | Description |
|---|---|
| <p>Yaw Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> | <p>This parameter determines whether the Yaw parameter of the current packet should be applied to the articulated part. If this parameter is set to Disable (0), Yaw is ignored and the articulated part retains its current yaw angle.</p> |
| <p>X Offset</p> <p>Type: single float</p> <p>Units: meters</p> <p>Default: Model-dependent</p> <p>Datum: Submodel reference point</p> | <p>This parameter specifies the distance of the articulated part along its X axis.</p> |
| <p>Y Offset</p> <p>Type: single float</p> <p>Units: meters</p> <p>Default: Model-dependent</p> <p>Datum: Submodel reference point</p> | <p>This parameter specifies the distance of the articulated part along its Y axis.</p> |
| <p>Z Offset</p> <p>Type: single float</p> <p>Units: meters</p> <p>Default: Model-dependent</p> <p>Datum: Submodel reference point</p> | <p>This parameter specifies the distance of the articulated part along its Z axis.</p> |
| <p>Roll</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: -180.0 – 180.0</p> <p>Default: Model-dependent</p> <p>Datum: Submodel reference coordinate system</p> | <p>This parameter specifies the angle of rotation of the articulated part submodel about its X axis after yaw and pitch have been applied.</p> |

| Parameter | Description |
|--|--|
| <p>Pitch</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: -90.0 – 90.0</p> <p>Default: Model-dependent</p> <p>Datum: Submodel reference coordinate system</p> | <p>This parameter specifies the angle of rotation of the articulated part submodel about its Y axis after yaw has been applied.</p> |
| <p>Yaw</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: 0.0 – 360.0</p> <p>Default: Model-dependent</p> <p>Datum: Submodel reference coordinate system</p> | <p>This parameter specifies the angle of rotation of the articulated part about its Z axis.</p> |

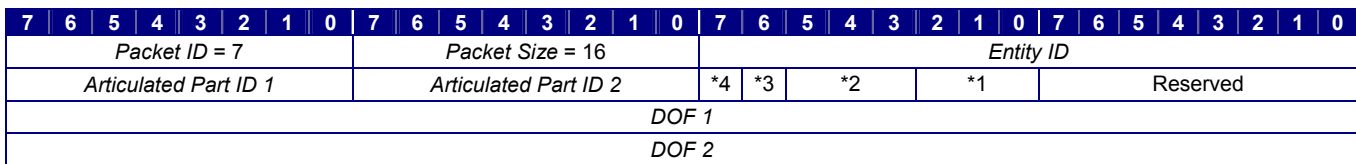
4.1.7 Short Articulated Part Control

The **Short Articulated Part Control** packet is provided as a lower-bandwidth alternative to the **Articulated Part Control** packet (Section 4.1.6). It can be used when manipulation of only one or two degrees of freedom of a submodel is necessary.

This packet allows for up to two articulations. The articulations may be applied to a single articulated part or two separate ones belonging to the same entity. The articulated part or parts are specified by the *Articulated Part ID 1* and *Articulated Part ID 2* parameters. Two floating-point degree-of-freedom parameters, *DOF 1* and *DOF 2*, specify offsets or angular positions for the specified articulated parts. The *DOF Select 1* and *DOF Select 2* parameters specify which degree of freedom each of these floating-point parameters represents.

Note: If *DOF Select 1* and *DOF Select 2* refer to the same degree of freedom for the same articulated part, then *DOF 2* (i.e., the “last-in” value) takes priority over *DOF 1*.

The contents of the **Short Articulated Part Control** packet are as follows:



- *1 *DOF Select 1*
- *2 *DOF Select 2*
- *3 *Articulated Part Enable 1*
- *4 *Articulated Part Enable 2*

Figure 36 – Short Articulated Part Control Packet Structure

Table 12 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 12 – Short Articulated Part Parameter Definitions

| Parameter | Description |
|---|---|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 7</p> | <p>This parameter identifies this data packet as the Short Articulated Part Control packet. The value of this parameter must be 7.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 16</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 16.</p> |

| Parameter | Description |
|--|---|
| Entity ID Type: unsigned int16 Units: N/A | This parameter specifies the entity to which the articulated part(s) belongs. |
| Articulated Part ID 1 Type: unsigned int8 Units: N/A | This parameter specifies one of up to two articulated parts to which the data in this packet should be applied. When used with the <i>Entity ID</i> parameter, this parameter uniquely identifies a particular articulated part within the scene graph. The value of this parameter may be equal to that of <i>Articulated Part ID 2</i> . |
| Articulated Part ID 2 Type: unsigned int8 Units: N/A | This parameter specifies one of up to two articulated parts to which the data in this packet should be applied. When used with the <i>Entity ID</i> parameter, this parameter uniquely identifies a particular articulated part within the scene graph. The value of this parameter may be equal to that of <i>Articulated Part ID 1</i> . |
| DOF Select 1 Type: 3-bit field Units: N/A Values: 0 Not Used 1 X Offset 2 Y Offset 3 Z Offset 4 Yaw 5 Pitch 6 Roll | This parameter specifies the degree of freedom to which the value of <i>DOF 1</i> is applied. If this parameter is set to Not Used (0), both <i>DOF 1</i> and <i>Articulated Part Enable 1</i> are ignored. |
| DOF Select 2 Type: 3-bit field Units: N/A Values: 0 Not Used 1 X Offset 2 Y Offset 3 Z Offset 4 Yaw 5 Pitch 6 Roll | This parameter specifies the degree of freedom to which the value of <i>DOF 2</i> is applied. If this parameter is set to Not Used (0), both <i>DOF 2</i> and <i>Articulated Part Enable 2</i> are ignored. |

| Parameter | Description |
|---|--|
| <p>Articulated Part Enable 1</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: IG-configurable</p> | <p>This parameter determines whether the articulated part submodel specified by <i>Articulated Part ID 1</i> should be enabled or disabled within the scene graph. If this parameter is set to Disable (0), the part is removed from the scene; if the parameter is set to Enable (1), the part is included in the scene.</p> |
| <p>Articulated Part Enable 2</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: IG-configurable</p> | <p>This parameter determines whether the articulated part submodel specified by <i>Articulated Part ID 2</i> should be enabled or disabled within the scene graph. If this parameter is set to Disable (0), the part is removed from the scene; if the parameter is set to Enable (1), the part is included in the scene.</p> |
| <p>DOF 1</p> <p>Type: single float</p> <p>Units: meters or degrees (see description at right)</p> <p>Default: Model-dependent</p> <p>Datum: Submodel reference coordinate system</p> | <p>This parameter specifies either an offset or an angular position for the part identified by <i>Articulated Part ID 1</i>.</p> <p>The application of this value is determined by the <i>DOF Select 1</i> parameter. If the parameter is set to X Offset (1), Y Offset (2), or Z Offset (3), then <i>DOF 1</i> specifies an offset in meters. If <i>DOF Select 1</i> is set to Yaw (4), Pitch (5), or Roll (6), then <i>DOF 1</i> specifies an angular position in degrees.</p> |
| <p>DOF 2</p> <p>Type: single float</p> <p>Units: meters or degrees (see description at right)</p> <p>Default: Model-dependent</p> <p>Datum: Submodel reference coordinate system</p> | <p>This parameter specifies either an offset or an angular position for the part identified by <i>Articulated Part ID 2</i>.</p> <p>The application of this value is determined by the <i>DOF Select 2</i> parameter. If the parameter is set to X Offset (1), Y Offset (2), or Z Offset (3), then <i>DOF 2</i> specifies an offset in meters. If <i>DOF Select 2</i> is set to Yaw (4), Pitch (5), or Roll (6), then <i>DOF 2</i> specifies an angular position in degrees.</p> |

4.1.8 Rate Control

The **Rate Control** packet is used to define linear and angular rates for entities and articulated parts.

The **Rate Control** packet is useful for models and submodels whose behavior is predictable and whose exact positions need not be known each frame by the Host. A rotating radar dish on a ground target, for example, revolves in a consistent manner, and the Host typically does not need to know its instantaneous yaw angle.

Rates may also be used to enable the IG to compensate for transport delays or jitter produced by asynchronous operation. A **Rate Control** packet may be sent each frame in conjunction with an **Entity Control** packet. This provides the IG with enough information to extrapolate the entity’s probable position during the next frame if necessary.

When a rate is specified for an entity or articulated part, the IG maintains that rate until a new rate is specified by the Host. If the Host changes the position and/or orientation of an entity or articulated part, the IG will perform the transformation and extrapolation will continue from that state beginning with the next frame. If the Host sets all rate components to zero, the entity or articulated part will become stationary.

If the entity to which a rate is applied is destroyed, any rates specified for that entity are annulled.

The contents of the **Rate Control** packet are as follows:

| | | | | | | | | | | | | | | | | | | | | | | | |
|----------------------------|---|---|---|---|---|---|---|-------------------------|---|---|---|---|---|---|----|------------------|---|---|---|---|---|---|---|
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| <i>Packet ID = 8</i> | | | | | | | | <i>Packet Size = 32</i> | | | | | | | | <i>Entity ID</i> | | | | | | | |
| <i>Articulated Part ID</i> | | | | | | | | Reserved | | | | | | | *1 | Reserved | | | | | | | |
| <i>X Linear Rate</i> | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Y Linear Rate</i> | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Z Linear Rate</i> | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Roll Angular Rate</i> | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Pitch Angular Rate</i> | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Yaw Angular Rate</i> | | | | | | | | | | | | | | | | | | | | | | | |

*1 Apply to Articulated Part

Figure 37 – Rate Control Packet Structure

Table 13 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 13 – Rate Control Parameter Definitions

| Parameter | Description |
|--|---|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 8</p> | <p>This parameter identifies this data packet as the Rate Control packet. The value of this parameter must be 8.</p> |

| Parameter | Description |
|---|--|
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 32</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 32.</p> |
| <p>Entity ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the entity to which the rate should be applied. If the <i>Apply to Articulated Part</i> flag is set to True (1), the rate is applied to an articulated part belonging to this entity. If the flag is set to False (0), the rate is applied to the whole entity.</p> |
| <p>Articulated Part ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter specifies the articulated part to which the rate should be applied. If the <i>Apply to Articulated Part</i> flag is set to True (1), this parameter refers to an articulated part belonging to the entity specified by <i>Entity ID</i>. If the flag is set to False (0), this parameter is ignored.</p> |
| <p>Apply to Articulated Part</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 False 1 True</p> | <p>This parameter determines whether the rate is applied to the articulated part specified by the <i>Articulated Part ID</i> parameter. If this flag is set to False (0), the rate is applied to the entity.</p> |
| <p>X Linear Rate</p> <p>Type: single float</p> <p>Units: m/s</p> <p>Default: 0</p> <p>Datum: Entities: Geodetic reference plane Articulated Parts: Submodel coordinate system</p> | <p>This parameter specifies the X component of a linear velocity vector.</p> |
| <p>Y Linear Rate</p> <p>Type: single float</p> <p>Units: m/s</p> <p>Default: 0</p> <p>Datum: Entities: Geodetic reference plane Articulated Parts: Submodel coordinate system</p> | <p>This parameter specifies the Y component of a linear velocity vector.</p> |

| Parameter | Description |
|---|---|
| <p>Z Linear Rate</p> <p>Type: single float</p> <p>Units: m/s</p> <p>Default: 0</p> <p>Datum: Entities: Geodetic reference plane Articulated Parts: Submodel coordinate system</p> | <p>This parameter specifies the Z component of a linear velocity vector.</p> |
| <p>Roll Angular Rate</p> <p>Type: single float</p> <p>Units: deg/s</p> <p>Default: Model-dependent</p> <p>Datum: Entities: Geodetic reference plane Articulated Parts: Submodel coordinate system</p> | <p>This parameter specifies the angle of rotation of the articulated part submodel about its X axis after yaw and pitch have been applied.</p> |
| <p>Pitch Angular Rate</p> <p>Type: single float</p> <p>Units: deg/s</p> <p>Default: Model-dependent</p> <p>Datum: Entities: Geodetic reference plane Articulated Parts: Submodel coordinate system</p> | <p>This parameter specifies the angle of rotation of the articulated part submodel about its Y axis after yaw has been applied.</p> |
| <p>Yaw Angular Rate</p> <p>Type: single float</p> <p>Units: deg/s</p> <p>Default: Model-dependent</p> <p>Datum: Entities: Geodetic reference plane Articulated Parts: Submodel coordinate system</p> | <p>This parameter specifies the angle of rotation of the articulated part about its Z axis when its X axis is parallel to that of the entity.</p> |

4.1.9 Celestial Sphere Control

The **Celestial Sphere Control** data packet allows the Host to specify properties of the sky model.

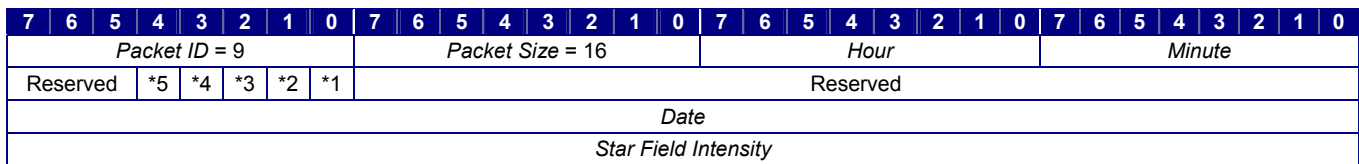
The *Date* parameter specifies the current date and the *Hour* and *Minute* parameters specify the current time of day. The IG uses these parameters to determine ambient light properties, sun and moon positions (and corresponding directional light positions), moon phase, and horizon glow.

An IG typically uses an ephemeris model to continuously update the time of day. A **Celestial Sphere Control** packet need not be sent each minute for the sole purpose of updating the time of day unless the Host has disabled the ephemeris model with the *Ephemeris Model Enable* flag.

Note: If the Host freezes the simulation, it must send a **Celestial Sphere Control** packet with the *Ephemeris Model Enable* parameter set to Disable (0); otherwise, the IG will continue to update the time of day. When the Host resumes the simulation, it must explicitly re-enable the ephemeris model.

The *Date/Time Valid* parameter specifies whether the IG should set the current date and time to the values specified by the *Hour*, *Minute*, and *Date* parameters. This enables the Host to change sky model properties without affecting the ephemeris model.

The contents of the **Celestial Sphere Control** packet are as follows:



- *1 *Ephemeris Model Enable*
- *2 *Sun Enable*
- *3 *Moon Enable*
- *4 *Star Field Enable*
- *5 *Date/Time Valid*

Figure 38 – Celestial Sphere Control Packet Structure

Table 14 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 14 – Celestial Sphere Control Parameter Definitions

| Parameter | Description |
|---------------------|--|
| Packet ID | This parameter identifies this data packet as the Celestial Sphere Control packet. The value of this parameter must be 9. |
| Type: unsigned int8 | |
| Units: N/A | |
| Value: 9 | |

| Parameter | Description |
|---|--|
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 16</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 16.</p> |
| <p>Hour</p> <p>Type: unsigned int8</p> <p>Units: hours</p> <p>Values: 0 – 23</p> <p>Default: 0</p> <p>Datum: Local time</p> | <p>This parameter specifies the current hour of the day within the simulation.</p> |
| <p>Minute</p> <p>Type: unsigned int8</p> <p>Units: minutes</p> <p>Values: 0 – 59</p> <p>Default: 0</p> <p>Datum: Local time</p> | <p>This parameter specifies the current minute of the day within the simulation.</p> |
| <p>Ephemeris Model Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable (Static time of day) 1 Enable (Continuous time of day)</p> <p>Default: 1</p> | <p>This parameter controls whether the time of day is static or continuous. If this parameter is set to Enabled (1), the image generator will continuously update the time of day.</p> |
| <p>Sun Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: IG-configurable</p> | <p>This parameter specifies whether the sun is enabled in the sky model.</p> |

| Parameter | Description |
|---|--|
| <p><i>Moon Enable</i></p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: IG-configurable</p> | <p>This parameter specifies whether the moon is enabled in the sky model. The moon phase is determined by the current date.</p> |
| <p><i>Star Field Enable</i></p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: IG-configurable</p> | <p>This parameter specifies whether the star field is enabled in the sky model. The star positions are determined by the current date and time.</p> |
| <p><i>Date/Time Valid</i></p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Invalid 1 Valid</p> | <p>This parameter specifies whether the <i>Hour</i>, <i>Minute</i>, and <i>Date</i> parameters are valid. If <i>Date/Time Valid</i> is set to Valid (1), these values will override the IG's current date and time.</p> |
| <p><i>Date</i></p> <p>Type: unsigned int32</p> <p>Units: N/A</p> <p>Values: See description at right</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the current date within the simulation. The date is represented as a seven- or eight-digit decimal integer formatted as follows:</p> $\text{MMDDYYYY} = (\text{month} \times 1000000) + (\text{day} \times 10000) + \text{year}$ |
| <p><i>Star Field Intensity</i></p> <p>Type: single float</p> <p>Units: percent</p> <p>Values: 0 – 100</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the intensity of the star field within the sky model. This parameter is ignored if <i>Star Field Enable</i> is set to Disable (0).</p> |

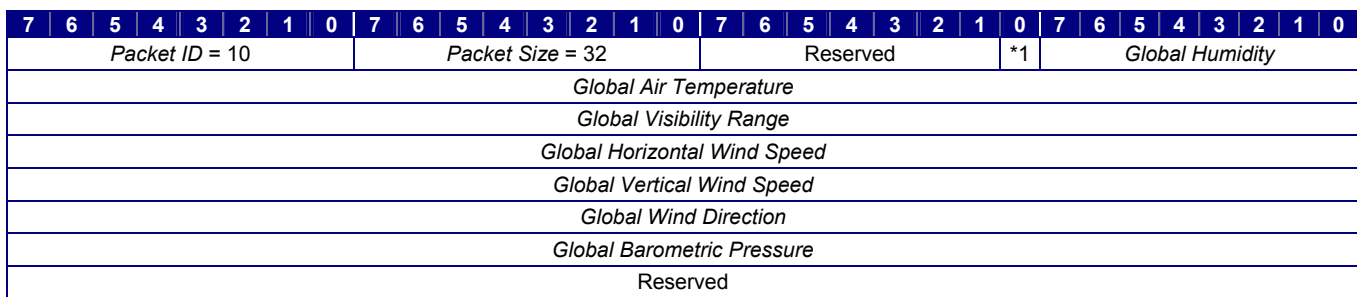
4.1.10 Atmosphere Control

The **Atmosphere Control** data packet allows the Host to control global atmospheric properties within the simulation.

Weather layers and weather entities always take precedence over the global atmospheric conditions. Once the atmospheric properties of a layer or entity are set, global atmospheric changes will not affect the weather inside the layer or entity unless that layer or entity is disabled. The global atmospheric changes will, however, affect the weather within a transition band or transition perimeter.

CIGI supports the use of FASCODE, MODTRAN, SEDRIS, or other atmospheric models for determining radiance and transmittance within a heterogeneous atmosphere for sensor simulations. The *Atmospheric Model Enable* parameter determines whether an atmospheric model is used. The particular model is not specified and is determined by the IG.

The contents of the **Atmosphere Control** packet are as follows:



*1 Atmospheric Model Enable

Figure 39 – Atmosphere Control Packet Structure

Table 15 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 15 – Atmosphere Control Parameter Definitions

| Parameter | Description |
|---|--|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 10</p> | <p>This parameter identifies this data packet as the Atmosphere Control packet. The value of this parameter must be 10.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 32</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 32.</p> |

| Parameter | Description |
|---|---|
| <p>Atmospheric Model Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: 0</p> | <p>This parameter specifies whether the IG should use an atmospheric model to determine spectral radiances for sensor applications. If this parameter is set to Disable (0), source radiances will be calculated. If this parameter is set to Enable (1), apparent radiances will be calculated using the appropriate models.</p> |
| <p>Global Humidity</p> <p>Type: unsigned int8</p> <p>Units: percent</p> <p>Values: 0 – 100</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the global humidity of the environment.</p> |
| <p>Global Air Temperature</p> <p>Type: single float</p> <p>Units: degrees Celsius (°C)</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the global air temperature of the environment.</p> |
| <p>Global Visibility Range</p> <p>Type: single float</p> <p>Units: meters</p> <p>Values: ≥ 0</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the global visibility range through the atmosphere.</p> |
| <p>Global Horizontal Wind Speed</p> <p>Type: single float</p> <p>Units: m/s</p> <p>Values: ≥ 0</p> <p>Default: 0</p> | <p>This parameter specifies the global wind speed parallel to the ellipsoid-tangential reference plane.</p> |
| <p>Global Vertical Wind Speed</p> <p>Type: single float</p> <p>Units: m/s</p> <p>Default: 0</p> | <p>This parameter specifies the global vertical wind speed.</p> <p>Note: A positive value produces an updraft, while a negative value produces a downdraft.</p> |

| Parameter | Description |
|---|---|
| <p><i>Global Wind Direction</i></p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: 0.0 – 360.0</p> <p>Default: 0</p> <p>Datum: True North</p> | <p>This parameter specifies the global wind direction.</p> <p>Note: This is the direction from which the wind is blowing.</p> |
| <p><i>Global Barometric Pressure</i></p> <p>Type: single float</p> <p>Units: millibars (mb) or hectopascals (hPa)</p> <p>Values: ≥ 0</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the global atmospheric pressure. The units are interchangeable.</p> |

4.1.11 Environmental Region Control

The **Environmental Region Control** packet is used to define an area over which the atmospheric conditions and maritime and terrestrial surface conditions can be specified. The shape of the region is a rounded rectangle, as shown below:

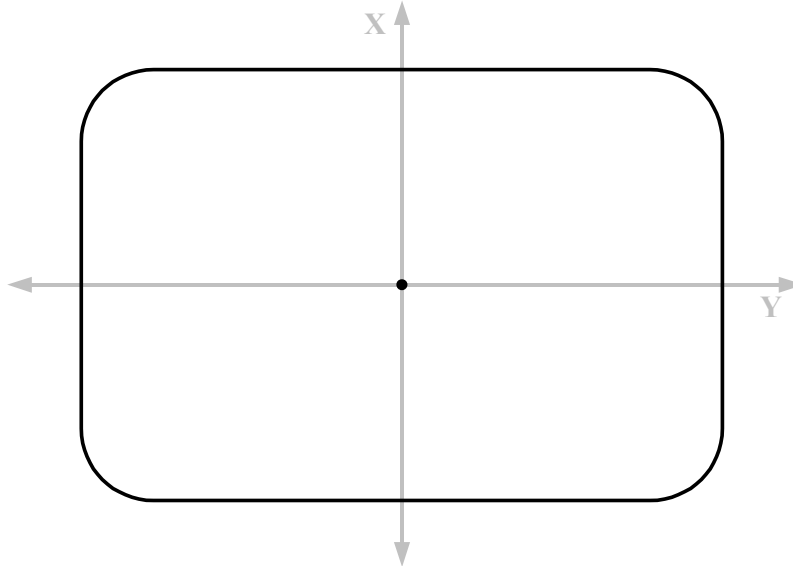


Figure 40 – Example of a Rounded Rectangle on NED Cartesian XY Plane

Up to 256 weather layers may be defined within a region. Weather layers can be created and manipulated with the **Weather Control** packet (Section 4.1.12). Up to one set of maritime and/or terrestrial surface condition parameters may be defined per region.

The Host is responsible for updating the position and shape of each region. The IG does not automatically manipulate regions because of wind activity or any other internal or external forces.

The center of the region is defined by the *Latitude* and *Longitude* parameters. The origin of the region's local coordinate system is at this point. The *Size X* and *Size Y* parameters determine the length of the rounded rectangle along its X and Y axes (represented by X' and Y' in Figure 43), respectively.

The “roundness” of the corners is determined by the *Corner Radius* parameter. Setting this radius to zero (0) will create a rectangle. Setting the value equal to one-half that of *Size X* and *Size Y* when both are equal will create a circle. The corner radius must be less than or equal to one half of the smaller of *Size X* or *Size Y*.

The *Rotation* parameter specifies an angle of rotation (clockwise) about the **Z** axis of the local NED coordinate system. Figure 41 shows a rounded rectangle on the NED reference plane rotated by a positive angle ψ .

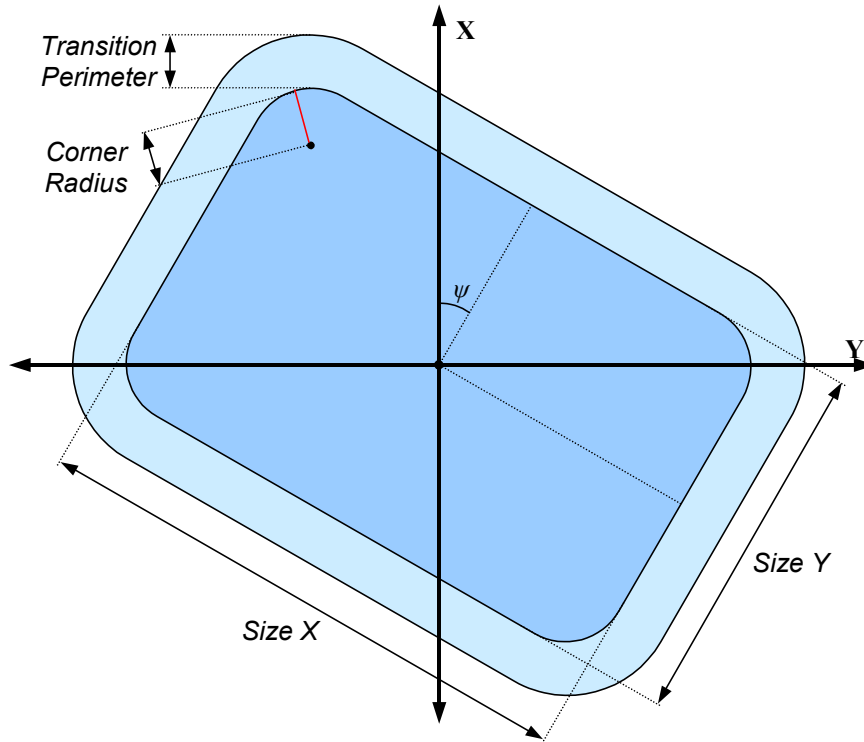


Figure 41 – Rotated Rounded rectangle with Transition Perimeter

The *Transition Perimeter* parameter specifies the width of a corridor around the outside of the rounded rectangle, as illustrated in Figure 41. Within this corridor, the weather conditions will change gradually from those inside the rounded rectangle to those immediately outside the corridor. This is analogous to the *Transition Band* parameter within the **Weather Control** packet (Section 4.1.12).

To determine the instantaneous value of a weather attribute at a point within the transition perimeter, the IG must interpolate between the value inside the rounded rectangle and immediately outside the perimeter. For example, assume the temperature within the region, T_{region} , is defined to be 20°C and the global air temperature, T_{global} , is 40°C. The region has a transition perimeter width, p , of 1000m. The IG could perform linear interpolation to determine the temperature $T_{x,y}$ at some point (x, y) within the transition perimeter.

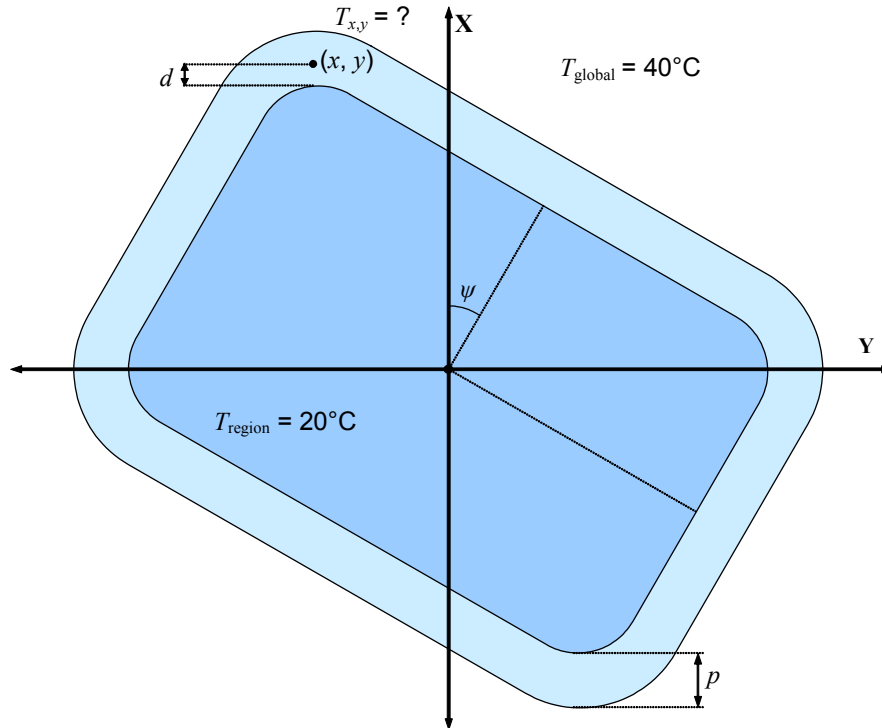


Figure 42 – Interpolation of Temperature within Transition Perimeter

In Figure 42, point (x, y) is some distance d from the edge of the rounded rectangle. This distance is measured along a line normal to the rounded rectangle. To determine whether this line emanates from one of the flat sides or one of the round corners, a coordinate transformation can be applied to (x, y) to determine the coordinates (x', y') of the point with respect to a coordinate system whose axes are parallel to the sides of the rectangle (see Figure 43). The values of x' and y' can be calculated from the following equations:

$$x' = y \sin \psi + x \cos \psi \quad (1)$$

$$y' = y \cos \psi - x \sin \psi \quad (2)$$

Figure 43 shows the rounded rectangle relative to the new coordinate system:

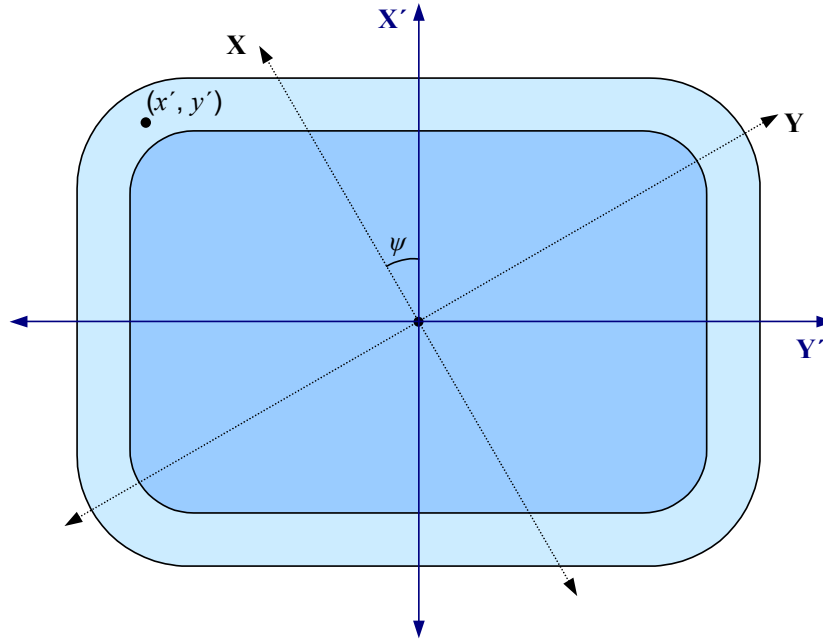


Figure 43 – Rounded Rectangle after Coordinate System Transformation

Determining whether the point is at a corner or along a straight side is now trivial.

Because point (x', y') in this example is at one of the corners, the distance d should be measured along a line emanating from the corner's focal point (x_f, y_f) . A circle with radius r centered at this focal point can be drawn through point (x', y') as shown in Figure 44:

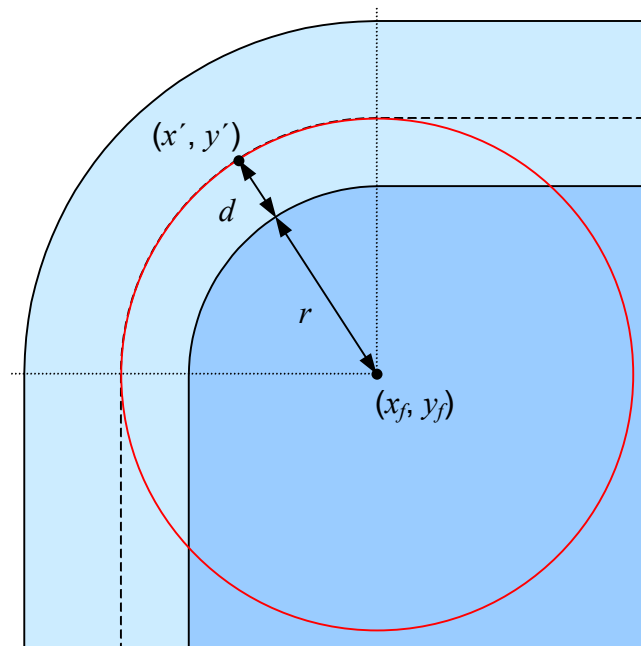


Figure 44 – Circle Drawn though Point (x', y')

Equations (3) and (4) give the coordinates of the focal point in the second quadrant:

$$x_f = r - \frac{(\text{Size } X)}{2} \quad (3)$$

$$y_f = \frac{(\text{Size } Y)}{2} - r \quad (4)$$

The value of d can be found from the equation for the circle:

$$d = \sqrt{(x' - x_f)^2 + (y' - y_f)^2} - r \quad (5)$$

The value of each attribute at point (x, y) can now be linearly interpolated. Continuing the example, the temperature at point (x, y) is given by the following equation:

$$T_{x,y} = \frac{d (T_{\text{global}} - T_{\text{region}})}{p} + T_{\text{region}} \quad (6)$$

If (x, y) is found to be 400 meters from the edge of the region, for instance, then the air temperature at that point would be calculated as follows:

$$T_{x,y} = \frac{400\text{m} \cdot (40^\circ\text{C} - 20^\circ\text{C})}{1000\text{m}} + 20^\circ\text{C} = 28^\circ\text{C} \quad (7)$$

Note that once d is found, the IG may use other functions for interpolating the values of weather attributes across a transition perimeter. The linear interpolation function shown by Equations (6) and (7) in the preceding example is used merely for illustration purposes.

Weather layers in one region may overlap layers in other regions. Similarly, any global weather layers will overlap layers in other regions. Figure 45 shows two overlapping environmental regions, each containing a cloud layer. The cross-hatched areas indicate the region of overlap.

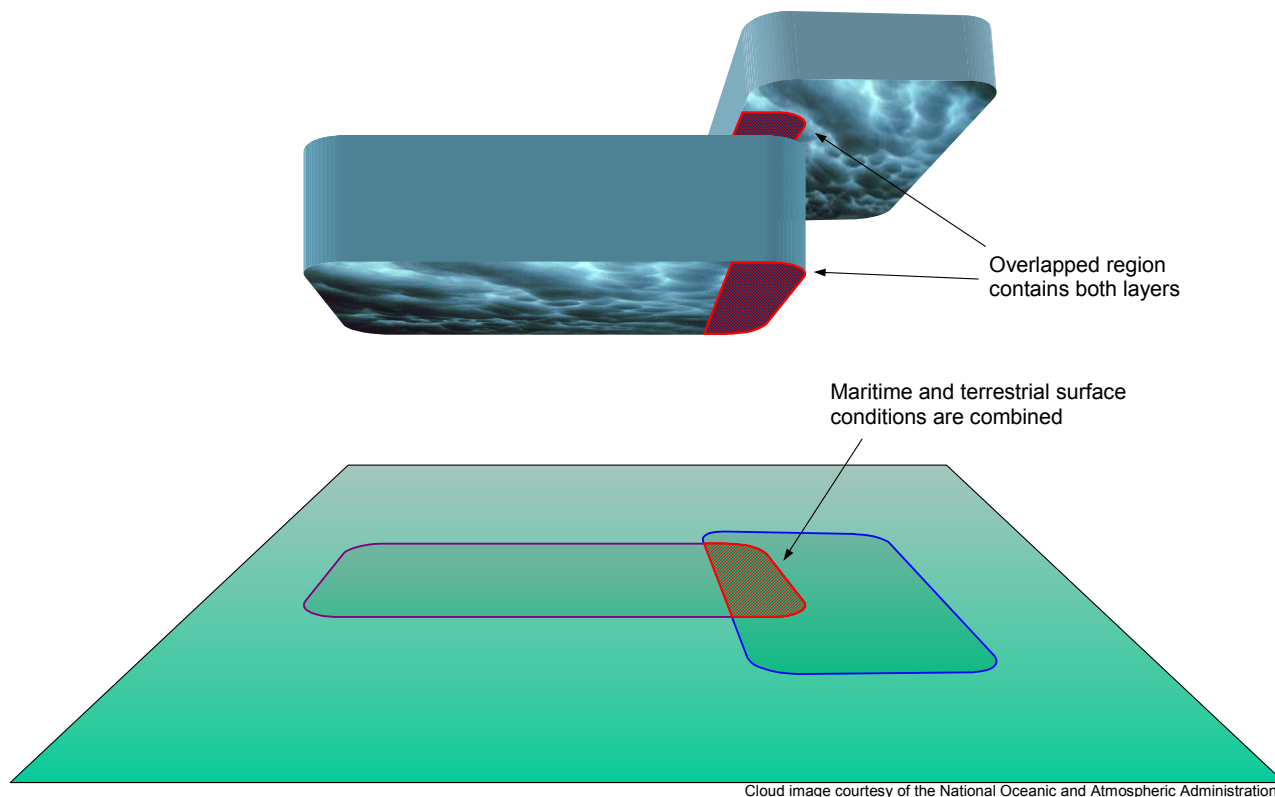


Figure 45 – Example of Overlapping Environmental Regions

If two overlapping regions contain layers that intersect, the values of each atmospheric property within the intersecting volumes may be combined. The *Merge Weather Properties* and *Merge Aerosol Concentrations* parameters determine whether the atmospheric properties and/or aerosol concentrations are combined for a given point within the volume or the last **Weather Control** packet describing the point is used. If these two parameters differ for two intersecting regions, priority is given to the region whose *Merge Weather Properties* or *Merge Aerosol Concentrations* parameter is set to Merge (1). Table 16 lists the recommended method of combining each property:

Table 16 – Recommended Methods of Combining Atmospheric Properties

| Atmospheric Property | Recommended Function |
|------------------------------|---|
| <i>Aerosol Concentration</i> | weighted average (if same <i>Layer ID</i>) or blend (if different <i>Layer IDs</i>) |
| <i>Air Temperature</i> | weighted average |
| <i>Barometric Pressure</i> | maximum |
| <i>Humidity</i> | maximum |
| <i>Visibility Range</i> | minimum |
| <i>Wind Velocity</i> | sum of velocity vectors |

Note that Table 16 lists two different methods for combining the *Aerosol Concentration* attribute of intersecting volumes. If the *Layer ID* of each layer is the same, the resulting aerosol concentration should be the average of the concentrations (taking into account interpolation through transition bands). This allows for complex regional shapes formed by combining two or more regions. If the *Layer ID* values assigned to the intersecting weather

layers are different, then the aerosols are assumed to be different and are each present in their specified concentrations. Any visual or spectral effects caused by the aerosols should be calculated independently for each aerosol.

Maritime and terrestrial surface conditions may also be combined within areas where regions overlap. The recommended method is to average the value of each attribute.

Multiple environmental regions may be arranged to form a weather grid. Figure 46 illustrates a portion of a grid created by adjacent rectangles, each with a narrow transition perimeter and a corner radius of zero. The color of each cell indicates the severity of some atmospheric phenomenon within, such as visibility range or wind speed. As an entity moves from one cell to another, it passes through two or more transition perimeters. The effect is a continuous intensity gradient rather than an abrupt change at cell boundaries.

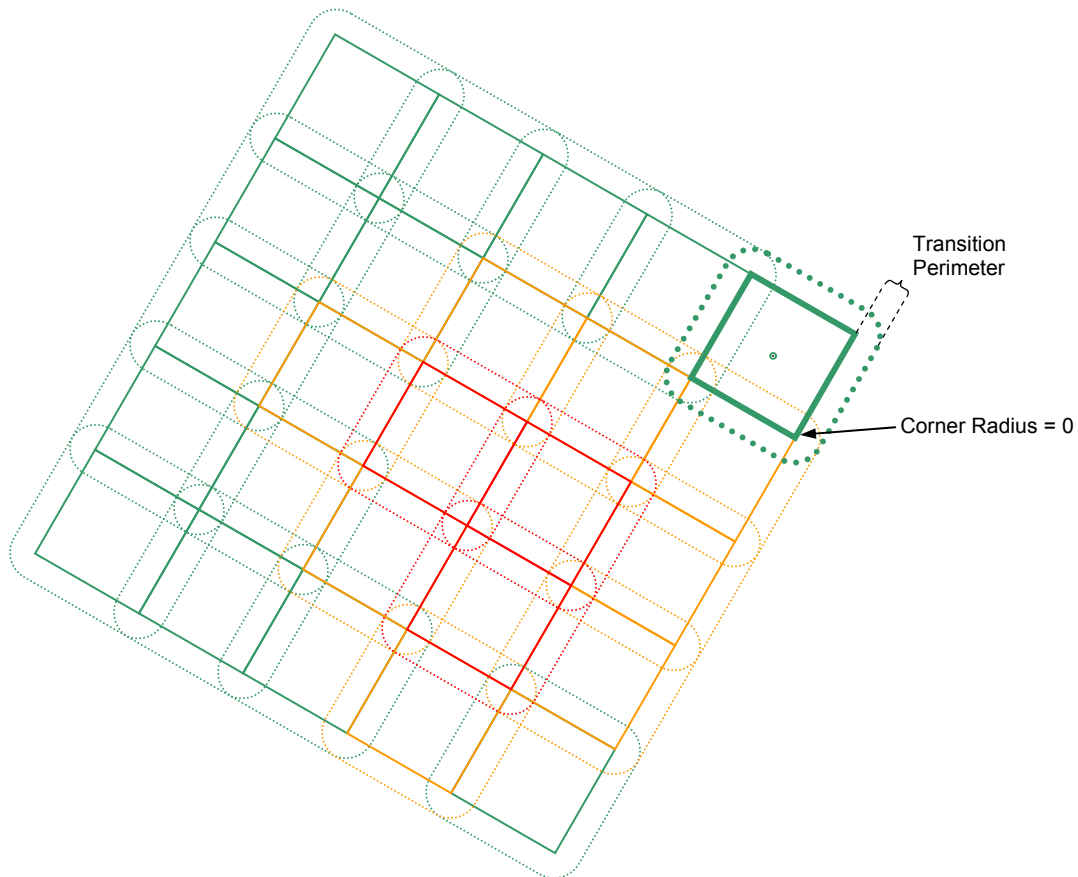


Figure 46 – Example of Gridded Weather System

Circular environmental regions can be used to approximate non-rectangular weather cells. These regions would have lengths and heights of zero and corner radii equal to the radius of each circle. A transition perimeter would ensure that an entity would experience a continuous, gradual transition at cell boundaries rather than a sudden change. Figure 47 illustrates a group of environmental regions approximating a system of hexagonal weather cells..

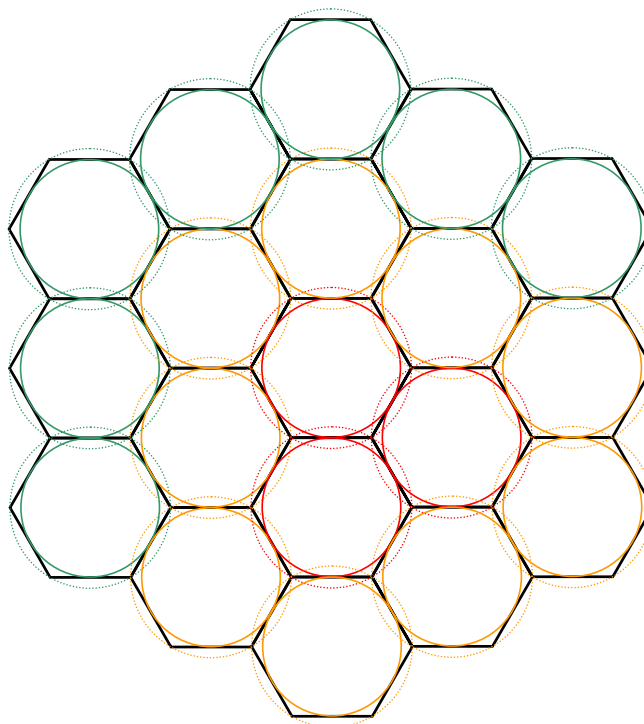


Figure 47 – Example of Approximation of Hexagonal Weather Cells

The *Region State* parameter specifies whether the region should be active, inactive, or destroyed. If the region is inactive, the surface conditions and all weather layers defined within the region are also inactive.

The contents of the **Environmental Region Control** packet are as follows:

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|-----------------------------|----|----|----|----|----|---|---|-------------------------|---|---|---|---|---|---|---|------------------|---|---|---|---|---|---|---|
| <i>Packet ID = 11</i> | | | | | | | | <i>Packet Size = 48</i> | | | | | | | | <i>Region ID</i> | | | | | | | |
| *6 | *5 | *4 | *3 | *2 | *1 | | | Reserved | | | | | | | | | | | | | | | |
| <i>Latitude</i> | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Longitude</i> | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Size X</i> | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Size Y</i> | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Corner Radius</i> | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Rotation</i> | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Transition Perimeter</i> | | | | | | | | | | | | | | | | | | | | | | | |
| Reserved | | | | | | | | | | | | | | | | | | | | | | | |

- *1 *Region State*
- *2 *Merge Weather Properties*
- *3 *Merge Aerosol Concentrations*
- *4 *Merge Maritime Surface Conditions*
- *5 *Merge Terrestrial Surface Conditions*
- *6 *Reserved*

Figure 48 – Environmental Region Control Packet Structure

Table 17 defines each parameter's data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 17 – Environmental Region Control Parameter Definitions

| Parameter | Description |
|--|---|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 11</p> | <p>This parameter identifies this data packet as the Environmental Region Control packet. The value of this parameter must be 11.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 48</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 48.</p> |
| <p>Region ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the environmental region to which the data in this packet will be applied.</p> |
| <p>Region State</p> <p>Type: unsigned 2-bit field</p> <p>Units: N/A</p> <p>Values: 0 Inactive 1 Active 2 Destroyed</p> | <p>This parameter specifies whether the region should be active or destroyed. This parameter may be set to one of the following values:</p> <p>Inactive – Any weather layers and surface conditions defined within the region are disabled regardless of their individual enable states.</p> <p>Active – Any weather layers and surface conditions defined within the region are enabled according to their individual enable states.</p> <p>Destroyed – The environmental region is permanently deleted, as are all weather layers and surface conditions assigned to the region.</p> |

| Parameter | Description |
|--|--|
| <p>Merge Weather Properties</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Use Last 1 Merge</p> | <p>This parameter specifies whether atmospheric conditions within this region should be merged with those of other regions within areas of overlap.</p> <p>If this parameter is set to Use Last (0), the last Weather Control packet (Section 4.1.12) describing a layer containing a given point will be used to determine the weather conditions at that point.</p> <p>If this parameter is set to Merge (1), the atmospheric properties of all weather layers containing a given point are combined (see Table 16).</p> <p>Note: Weather layers within the same region will always be combined. Regional weather conditions always take priority over global weather conditions.</p> |
| <p>Merge Aerosol Concentrations</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Use Last 1 Merge</p> | <p>This parameter specifies whether the concentrations of aerosols found within this region should be merged with those of other regions within areas of overlap.</p> <p>If this parameter is set to Use Last (0), the last Weather Control packet (Section 4.1.12) describing a layer containing a given point will be used to determine the concentration of the specified aerosol at that point.</p> <p>If this parameter is set to Merge (1), the aerosol concentrations within all weather layers containing a given point are combined (see Table 16).</p> <p>Note: Weather layers within the same region will always be combined. Regional weather conditions always take priority over global weather conditions.</p> |
| <p>Merge Maritime Surface Conditions</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Use Last 1 Merge</p> | <p>This parameter specifies whether the maritime surface conditions found within this region should be merged with those of other regions within areas of overlap.</p> <p>If this parameter is set to Use Last (0), the last Maritime Surface Conditions Control packet (Section 4.1.13) describing a region containing a given point will be used to determine the surface conditions at that point.</p> <p>If this parameter is set to Merge (1), the surface conditions at any given point within the region are averaged with those of any other regions also containing that point.</p> <p>Note: Regional surface conditions always take priority over global surface conditions.</p> |

| Parameter | Description |
|--|---|
| <p>Merge Terrestrial Surface Conditions</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Use Last 1 Merge</p> | <p>This parameter specifies whether the terrestrial surface conditions found within this region should be merged with those of other regions within areas of overlap.</p> <p>If this parameter is set to Use Last (0), the last Terrestrial Surface Conditions Control packet (Section 4.1.15) describing a region containing a given point will be used to determine the surface conditions at that point.</p> <p>If this parameter is set to Merge (1), the surface conditions at any given point within the region are averaged with those of any other regions also containing that point.</p> <p>Note: Regional surface conditions always take priority over global surface conditions.</p> |
| <p>Latitude</p> <p>Type: double float</p> <p>Units: degrees</p> <p>Values: -90.0 – 90.0</p> <p>Default: IG-configurable</p> <p>Datum: Equator</p> | <p>This parameter specifies the geodetic latitude of the center of the rounded rectangle.</p> |
| <p>Longitude</p> <p>Type: double float</p> <p>Units: degrees</p> <p>Values: -180.0 – 180.0</p> <p>Default: IG-configurable</p> <p>Datum: Prime Meridian</p> | <p>This parameter specifies the geodetic longitude of the center of the rounded rectangle.</p> |
| <p>Size X</p> <p>Type: single float</p> <p>Units: meters</p> <p>Values: > 0</p> <p>Default: IG-configurable</p> <p>Datum: Ellipsoid-tangential reference plane</p> | <p>This parameter specifies the length of the environmental region along its X axis at the geoid surface. This length does not include the width of the transition perimeter.</p> |

| Parameter | Description |
|---|--|
| <p>Size Y</p> <p>Type: single float</p> <p>Units: meters</p> <p>Values: > 0</p> <p>Default: IG-configurable</p> <p>Datum: Ellipsoid-tangential reference plane</p> | <p>This parameter specifies the length of the environmental region along its Y axis at the geoid surface. This length does not include the width of the transition perimeter.</p> |
| <p>Corner Radius</p> <p>Type: single float</p> <p>Units: meters</p> <p>Values: 0 to lesser of $(\frac{1}{2} \times \text{Size X})$ or $(\frac{1}{2} \times \text{Size Y})$</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the radius of the corner of the rounded rectangle. The smaller the radius, the “tighter” the corner. A value of 0.0 produces a rectangle.</p> |
| <p>Rotation</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: -180.0 – 180.0</p> <p>Default: IG-configurable</p> <p>Datum: True North</p> | <p>This parameter specifies the yaw angle of the rounded rectangle.</p> |
| <p>Transition Perimeter</p> <p>Type: single float</p> <p>Units: meters</p> <p>Values: ≥ 0</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the width of the transition perimeter around the environmental region. This perimeter is a region through which the weather conditions are interpolated between those inside the environmental region and those immediately outside the perimeter.</p> |

4.1.12 Weather Control

The **Weather Control** packet is used to control weather layers and weather entities. Global weather layers have no distinct horizontal boundaries. Atmospheric affects can be observed anywhere within the vertical range of the layer. Regional weather layers occur only in areas defined by the **Environmental Region Control** packet (Section 4.1.11). Weather entities are entities that represent meteorological phenomena.

The *Layer ID* parameter specifies the global or regional weather layer whose attributes are being set. If the *Scope* parameter is set to Global (0), the weather layer exists everywhere over the database. If this parameter is set to Region (1), the weather layer is bound to the region specified by the *Region ID* parameter. Up to 256 weather layers may be defined globally, and up to 256 layers may be defined within each region. The *Layer ID* parameter is ignored for weather entities.

The *Cloud Type* parameter specifies the type of cloud found within a cloud layer or entity. Each value may correspond to a specific cloud texture or model. Values one through 10 are reserved for the most common general cloud types as listed in Table 18. The remaining values can be used for mammatus clouds, Kelvin-Helmholtz cloud effects, and other specific cloud phenomena.

The vertical range of a weather layer is specified by the *Base Elevation*, *Thickness*, and *Transition Band* parameters. *Base Elevation* specifies the distance from Mean Sea Level to the bottom of the layer. *Thickness* is the vertical height of the layer. *Transition Band* specifies the vertical height of both the region above and below the layer through which visibility gradually changes from that of the layer to that immediately outside the region. Figure 49 illustrates the use of these parameters:

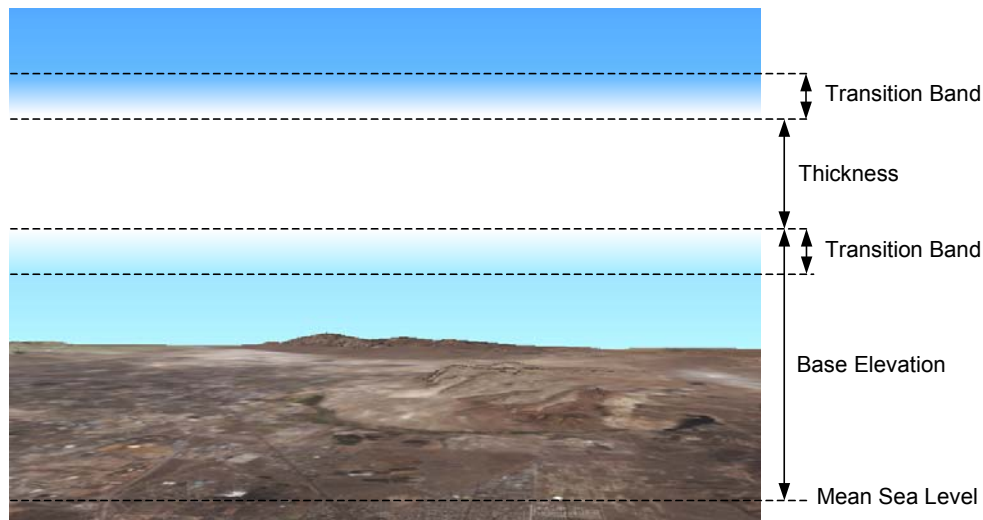


Figure 49 – Weather Layer Base Elevation and Thickness

For weather entities, the *Transition Band* parameter can be used to specify a threshold radius for partial penetration into a cloud model. The *Base Elevation* and *Thickness* parameters are ignored for weather entities.

The *Scud Enable* parameter specifies whether the layer produces scud effects within the transition band. The *Scud Frequency* parameter defines how often scud occurs. The placement of scud (i.e., above versus below the layer) depends upon the IG implementation. Some systems allow this to be controlled via a **Component Control** packet.

The *Horizontal Wind Speed*, *Vertical Wind Speed*, and *Wind Direction* parameters define the wind velocity within the weather layer or entity. These can be used to specify surface winds or winds aloft, depending upon the base elevation and thickness of the layer or the altitude of the weather entity. The *Random Winds Enable* parameter causes the IG to create gusts of random duration and frequency.

A typical effect of weather layers is the suspension of liquid or solid particles in the air. The density of this particulate matter is specified by the *Aerosol Concentration* parameter. The most common aerosol is liquid water, but ice crystals, sand, and dust are also common. Weather layers may also be used to create smoke, combat haze, and other man-made airborne contaminants. Each layer can contain zero or one type of mutable aerosol; multiple aerosols in a given space must be implemented as separate weather layers.

The contents of the **Weather Control** packet are as follows:

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|------------------------------|---|---|---|---|---|---|---|-------------------------|---|---|---|---|---|---|---|----------------------------|---|-----------|-----------|-----------|-----------|-----------------|---|---|---|-----------|---|-----------|---|---|---|
| <i>Packet ID = 12</i> | | | | | | | | <i>Packet Size = 56</i> | | | | | | | | <i>Entity ID/Region ID</i> | | | | | | | | | | | | | | | |
| <i>Layer ID</i> | | | | | | | | <i>Humidity</i> | | | | | | | | <i>*5</i> | | <i>*4</i> | <i>*3</i> | <i>*2</i> | <i>*1</i> | <i>Reserved</i> | | | | <i>*7</i> | | <i>*6</i> | | | |
| <i>Air Temperature</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Visibility Range</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Scud Frequency</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Coverage</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Base Elevation</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Thickness</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Transition Band</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Horizontal Wind Speed</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Vertical Wind Speed</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Wind Direction</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Barometric Pressure</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Aerosol Concentration</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

- *1 *Weather Enable*
- *2 *Scud Enable*
- *3 *Random Winds Enable*
- *4 *Random Lightning Enable*
- *5 *Cloud Type*
- *6 *Scope*
- *7 *Severity*

Figure 50 – Weather Control Packet Structure

Table 18 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 18 – Weather Control Parameter Definitions

| Parameter | Description |
|---------------------|--|
| Packet ID | This parameter identifies this data packet as the Weather Control packet. The value of this parameter must be 12. |
| Type: unsigned int8 | |
| Units: N/A | |
| Value: 12 | |

| Parameter | Description |
|---|--|
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 56</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 56.</p> |
| <p>Entity ID (Weather Entities)</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the entity to which the weather attributes in this packet are applied.</p> |
| <p>Region ID (Regional Layers)</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the region to which the weather layer is confined.</p> <p>Note: <i>Entity ID/Region ID</i> is ignored if <i>Scope</i> is set to Global (0).</p> |
| <p>Layer ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Values: 0 Ground Fog 1 Cloud Layer 1 2 Cloud Layer 2 3 Cloud Layer 3 4 Rain 5 Snow 6 Sleet 7 Hail 8 Sand 9 Dust 10 – 255 Defined by IG</p> | <p>This parameter specifies the weather layer to which the data in this packet are applied. This parameter also determines the type of aerosol contained within the layer.</p> <p>Values 0 through 9 are defined as standard weather layer types. Values beyond this range are defined in the IG configuration.</p> <p>Note: This parameter is ignored if <i>Scope</i> is set to Entity (2).</p> |
| <p>Humidity</p> <p>Type: unsigned int8</p> <p>Units: percent</p> <p>Values: 0 – 100</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the humidity within the weather layer.</p> |

| Parameter | Description |
|---|---|
| <p><i>Weather Enable</i></p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: IG-configurable</p> | <p>This parameter specifies whether a weather layer and its atmospheric effects are enabled.</p> |
| <p><i>Scud Enable</i></p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: IG-configurable</p> | <p>This parameter specifies whether weather layer produces scud effects within its transition bands.</p> |
| <p><i>Random Winds Enable</i></p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: IG-configurable</p> | <p>This parameter specifies whether a random frequency and duration should be applied to the local wind effects.</p> |
| <p><i>Random Lightning Enable</i></p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: IG-configurable</p> | <p>This parameter specifies whether the weather layer exhibits random lightning effects. The frequency and severity of the lightning varies according to the <i>Severity</i> parameter.</p> |

| Parameter | Description | | | | | | | | | | | | | | | | | | | | | | | | |
|--|---|--------|---|--------------|---|--------------|---|---------------|---|---------------|---|--------|---|--------------|---|---------|---|--------------|---|----------------|----|---------|---------|-------|---|
| <p>Cloud Type</p> <p>Type: unsigned 4-bit field</p> <p>Units: N/A</p> <p>Values:</p> <table data-bbox="256 407 586 772"> <tr><td>0</td><td>None</td></tr> <tr><td>1</td><td>Alto cumulus</td></tr> <tr><td>2</td><td>Alto stratus</td></tr> <tr><td>3</td><td>Cirro cumulus</td></tr> <tr><td>4</td><td>Cirro stratus</td></tr> <tr><td>5</td><td>Cirrus</td></tr> <tr><td>6</td><td>Cumulonimbus</td></tr> <tr><td>7</td><td>Cumulus</td></tr> <tr><td>8</td><td>Nimbostratus</td></tr> <tr><td>9</td><td>Strato cumulus</td></tr> <tr><td>10</td><td>Stratus</td></tr> <tr><td>11 – 15</td><td>Other</td></tr> </table> <p>Default: IG-configurable</p> | 0 | None | 1 | Alto cumulus | 2 | Alto stratus | 3 | Cirro cumulus | 4 | Cirro stratus | 5 | Cirrus | 6 | Cumulonimbus | 7 | Cumulus | 8 | Nimbostratus | 9 | Strato cumulus | 10 | Stratus | 11 – 15 | Other | <p>This parameter specifies the type of clouds contained within the weather layer. If the value of <i>Layer ID</i> does not correspond to a cloud layer, <i>Cloud Type</i> should be set to None (0).</p> |
| 0 | None | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | Alto cumulus | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | Alto stratus | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | Cirro cumulus | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | Cirro stratus | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | Cirrus | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | Cumulonimbus | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | Cumulus | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | Nimbostratus | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | Strato cumulus | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | Stratus | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 – 15 | Other | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>Scope</p> <p>Type: unsigned 2-bit field</p> <p>Units: N/A</p> <p>Values:</p> <table data-bbox="256 1031 488 1121"> <tr><td>0</td><td>Global</td></tr> <tr><td>1</td><td>Regional</td></tr> <tr><td>2</td><td>Entity</td></tr> </table> <p>Default: IG-configurable</p> | 0 | Global | 1 | Regional | 2 | Entity | <p>This parameter specifies whether the weather is global, regional, or assigned to an entity. If this value is set to Regional (1), the layer is confined to the region specified by <i>Region ID</i>. If this value is set to Entity (2), the weather attributes are applied to the volume within the moving model specified by <i>Entity ID</i>.</p> | | | | | | | | | | | | | | | | | | |
| 0 | Global | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | Regional | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | Entity | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>Severity</p> <p>Type: unsigned 3-bit field</p> <p>Units: N/A</p> <p>Values: 0 – 5 (Least to most severe)</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the severity of the weather layer.</p> | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>Air Temperature</p> <p>Type: single float</p> <p>Units: degrees Celsius (°C)</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the temperature within the weather layer.</p> | | | | | | | | | | | | | | | | | | | | | | | | |

| Parameter | Description |
|--|---|
| <p>Visibility Range</p> <p>Type: single float</p> <p>Units: meters</p> <p>Values: See description at right</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the visibility range through the weather layer. This would correspond to Runway Visibility Range through ground fog, for example.</p> <p>The range specified by this parameter takes precedence over that specified by the <i>Global Visibility Range</i> parameter of the Atmosphere Control packet (see Section 4.1.10).</p> |
| <p>Scud Frequency</p> <p>Type: single float</p> <p>Units: percent</p> <p>Values: 0 – 100</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the frequency of scud within the transition bands above and/or below a cloud or fog layer. A value of 0% produces no scud effect; 100% produces a solid effect.</p> |
| <p>Coverage</p> <p>Type: single float</p> <p>Units: percent</p> <p>Values: 0 – 100</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the amount of area coverage for the weather layer.</p> |
| <p>Base Elevation</p> <p>Type: single float</p> <p>Units: meters</p> <p>Default: IG-configurable</p> <p>Datum: Mean Sea Level</p> | <p>This parameter specifies the altitude of the base (bottom) of the weather layer. This parameter is ignored if <i>Scope</i> is set to Entity (2).</p> |
| <p>Thickness</p> <p>Type: single float</p> <p>Units: meters</p> <p>Default: IG-configurable</p> <p>Datum: Base (specified by <i>Base Elevation</i>)</p> | <p>This parameter specifies the vertical thickness of the weather layer. The altitude of the top of the layer is equal to this value plus that specified by <i>Base Elevation</i>. This parameter is ignored if <i>Scope</i> is set to Entity (2).</p> |
| <p>Transition Band</p> <p>Type: single float</p> <p>Units: meters</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the height of a vertical transition band both above and below the weather layer. This band produces a visibility gradient from the layer's visibility to that immediately outside the transition band.</p> |

| Parameter | Description |
|--|--|
| <p><i>Horizontal Wind Speed</i></p> <p>Type: single float</p> <p>Units: m/s</p> <p>Values: ≥ 0</p> <p>Default: 0</p> | <p>This parameter specifies the local wind speed parallel to the ellipsoid-tangential reference plane.</p> |
| <p><i>Vertical Wind Speed</i></p> <p>Type: single float</p> <p>Units: m/s</p> <p>Default: 0</p> | <p>This parameter specifies the local vertical wind speed.</p> <p>Note: A positive value produces an updraft, while a negative value produces a downdraft.</p> |
| <p><i>Wind Direction</i></p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: 0.0 – 360.0</p> <p>Default: 0</p> <p>Datum: True North</p> | <p>This parameter specifies the local wind direction.</p> <p>Note: This is the direction from which the wind is blowing.</p> |
| <p><i>Barometric Pressure</i></p> <p>Type: single float</p> <p>Units: millibars (mb) or hectopascals (hPa)</p> <p>Values: ≥ 0</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the atmospheric pressure within the weather layer. The units are interchangeable.</p> |
| <p><i>Aerosol Concentration</i></p> <p>Type: single float</p> <p>Units: g/m^3</p> <p>Values: ≥ 0</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the concentration of water, smoke, dust, or other particles suspended in the air. This parameter is provided primarily for sensor applications; any visual effect is secondary and is IG- and layer-dependent.</p> <p>Note: The type of aerosol depends upon the layer ID of a weather layer, or the entity type of a weather phenomenon entity.</p> |

4.1.13 Maritime Surface Conditions Control

The **Maritime Surface Conditions Control** packet is used to specify the surface behavior for seas and other bodies of water. This packet is used in conjunction with the **Weather Control** and **Wave Control** packets to define sea states.

Regional maritime surface conditions always take precedence over the global surface conditions. Once the surface conditions of a region are set, global changes will not affect the surface conditions within that region unless it is disabled. Global changes will, however, contribute to the conditions within a region’s transition perimeter.

If two or more regions overlap, the value of each surface condition attribute defining the sea state within the area of overlap should be the average of the values determined by overlapping the regions.

To determine the maritime surface conditions within areas of overlap or through a transition perimeter, the Host can request the conditions at a specific latitude and longitude by issuing an **Environmental Conditions Request** packet (Section 4.1.28). The Host can request the instantaneous height of the water surface at a specific latitude and longitude by sending a **HAT/HOT Request** packet (Section 4.1.24).

The contents of the **Maritime Surface Conditions Control** packet are as follows:

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|----------------------------------|---|---|----|---|----|----|---|-------------------------|---|---|---|---|---|---|---|----------------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| <i>Packet ID = 13</i> | | | | | | | | <i>Packet Size = 24</i> | | | | | | | | <i>Entity ID/Region ID</i> | | | | | | | | | | | | | | | |
| Reserved | | | *3 | | *2 | *1 | | Reserved | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Sea Surface Height</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Surface Water Temperature</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Surface Clarity</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Reserved | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

- *1 *Surface Conditions Enable*
- *2 *Whitecap Enable*
- *3 *Scope*

Figure 51 – Maritime Surface Conditions Control Packet Structure

Table 19 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 19 – Maritime Surface Conditions Control Parameter Definitions

| Parameter | Description |
|---------------------|--|
| Packet ID | This parameter identifies this data packet as the Maritime Surface Conditions Control packet. The value of this parameter must be 13. |
| Type: unsigned int8 | |
| Units: N/A | |
| Value: 13 | |

| Parameter | Description |
|--|--|
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 24</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 24.</p> |
| <p>Entity ID (Entity-based Surface Conditions)</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the entity to which the surface attributes in this packet are applied.</p> |
| <p>Region ID (Regional Surface Conditions)</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the region to which the surface attributes are confined.</p> <p>Note: <i>Entity ID/Region ID</i> is ignored if <i>Scope</i> is set to Global (0).</p> |
| <p>Surface Conditions Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: IG-configurable</p> | <p>This parameter determines the state of the specified surface conditions. If this parameter is set to Disable (0), the surface conditions within the region or entity are the same as the global maritime surface conditions. If the parameter is set to Enable (1), the surface conditions are defined by this packet.</p> <p>This parameter is ignored if <i>Scope</i> is set to Global (0).</p> |
| <p>Whitecap Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: IG-configurable</p> | <p>This parameter determines whether whitecaps are enabled.</p> |
| <p>Scope</p> <p>Type: unsigned 2-bit field</p> <p>Units: N/A</p> <p>Values: 0 Global 1 Regional 2 Entity</p> <p>Default: IG-configurable</p> | <p>This parameter specifies whether this packet is applied globally, applied to a region, or assigned to an entity. If this value is set to Regional (1), the surface condition properties are applied only within the region specified by <i>Region ID</i>. If this value is set to Entity (2), the properties are applied to the area defined by the moving model specified by <i>Entity ID</i>.</p> |

| Parameter | Description |
|---|--|
| <p><i>Sea Surface Height</i></p> <p>Type: single float</p> <p>Units: meters</p> <p>Datum: Mean Sea Level</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the height of the water above MSL at equilibrium. This parameter can also be used to specify the tide level within the surf zone.</p> |
| <p><i>Surface Water Temperature</i></p> <p>Type: single float</p> <p>Units: degrees Celsius (°C)</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the water temperature at the surface.</p> |
| <p><i>Surface Clarity</i></p> <p>Type: single float</p> <p>Units: percent</p> <p>Values: 0 – 100</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the clarity of the water at its surface. This is used to control the visual effect of the water's turbidity and sediment type. A value of 100% indicates pristine water. A value of 0% indicates extremely turbid water.</p> |

4.1.14 Wave Control

The **Wave Control** packet is used to specify the behavior of waves propagating across the surface of a body of water. Examples include simulated swells and wind chop.

The basic waveform is defined by a wave height, wavelength, period, and direction of propagation. Wave height refers to the vertical distance between the wave’s crest and trough. The wavelength is the distance from one crest to the next or from one trough to the next. These wave properties are illustrated below:

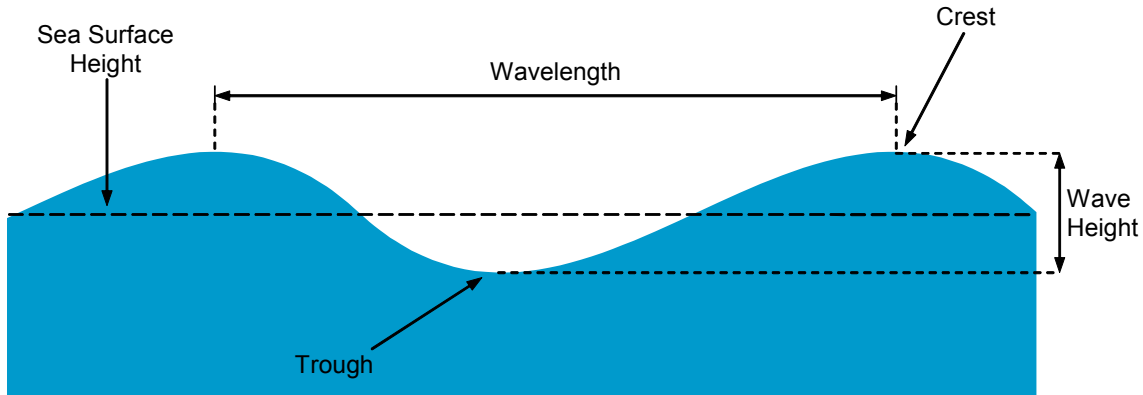


Figure 52 – Basic Wave Properties

The *Phase Offset* parameter specifies a phase angle to be added to the IG’s reference phase. This is useful for modeling the interference patterns produced within a multiple-wave system.

The *Leading* parameter determines the cross-sectional shape of the wave. This value is the phase angle at which the crest of the wave occurs. For a sinusoidal wave, this angle is zero (0) degrees. As the value increases, the trough flattens and the crest moves toward the front of the wave as shown below:

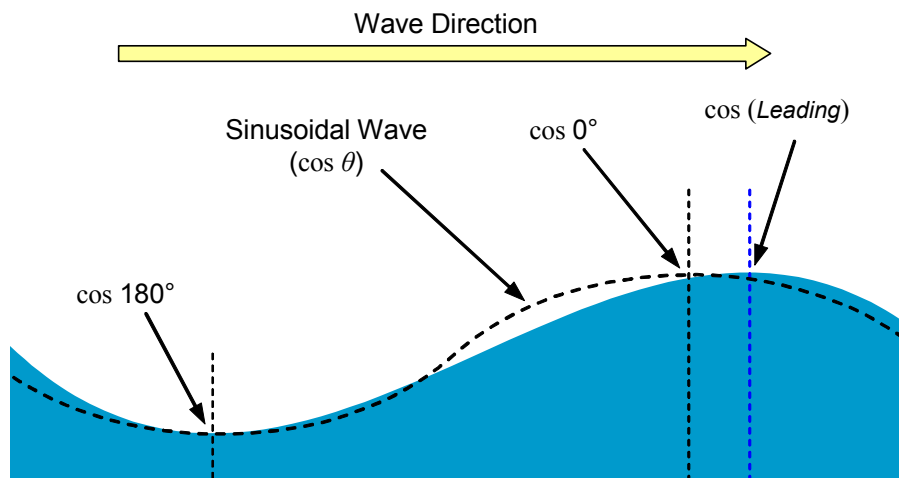
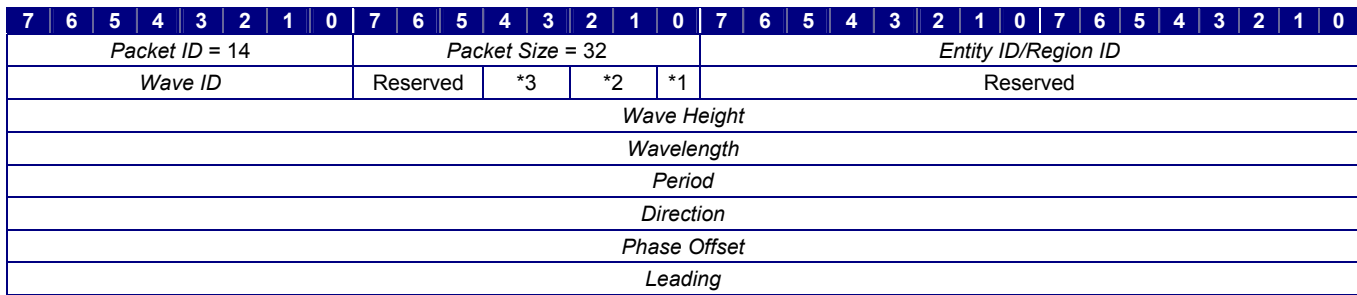


Figure 53 – Example of Wave Leading

Note that the trough of the wave remains at 180° regardless of the value of the *Leading* parameter.

The contents of the **Wave Control** packet are as follows:



- *1 Wave Enable
- *2 Scope
- *3 Breaker Type

Figure 54 – Wave Control Packet Structure

Table 20 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 20 – Wave Control Parameter Definitions

| Parameter | Description |
|--|--|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 14</p> | <p>This parameter identifies this data packet as the Wave Control packet. The value of this parameter must be 14.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 32</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 32.</p> |
| <p>Wave Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: IG-configurable</p> | <p>This parameter determines whether the wave is enabled or disabled. A disabled wave does not contribute to the shape of the water’s surface.</p> |

| Parameter | Description |
|---|---|
| <p>Scope</p> <p>Type: unsigned 2-bit field</p> <p>Units: N/A</p> <p>Values: 0 Global 1 Regional 2 Entity</p> <p>Default: IG-configurable</p> | <p>This parameter specifies whether the wave is defined for global, regional, or entity-controlled maritime surface conditions. If this value is set to Regional (1), the wave properties are applied only within the region specified by <i>Region ID</i>. If this value is set to Entity (2), the properties are applied to the area defined by the moving model specified by <i>Entity ID</i>.</p> |
| <p>Breaker Type</p> <p>Type: unsigned 2-bit field</p> <p>Units: N/A</p> <p>Values: 0 Plunging 1 Spilling 2 Surging</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the type of breaker within the surf zone. This may be one of the following values:</p> <p>Plunging – Plunging waves peak until the wave forms a vertical wall, at which point the crest moves faster than the base of the breaker. The wave will then break violently into the wave trough.</p> <p>Spilling – Spilling breakers break gradually over a great distance. White water forms over the crest, which spills down the face of the breaker.</p> <p>Surging – Surging breakers advance toward the beach as vertical walls of water. Unlike with plunging and spilling breakers, the crest does not fall over the front of the wave.</p> |
| <p>Entity ID (Entity-based Surface Conditions)</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the surface entity for which the wave is defined.</p> |
| <p>Region ID (Regional Surface Conditions)</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the environmental region for which the wave is defined.</p> <p>Note: <i>Entity ID/Region ID</i> is ignored if <i>Scope</i> is set to Global (0).</p> |
| <p>Wave ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter specifies the wave to which the attributes in this packet are applied.</p> |
| <p>Wave Height</p> <p>Type: single float</p> <p>Units: meters</p> <p>Values: ≥ 0</p> <p>Datum: <i>Sea Surface Height</i></p> | <p>This parameter specifies the average vertical distance from trough to crest produced by the wave.</p> |

| Parameter | Description |
|--|---|
| <p><i>Wavelength</i></p> <p>Type: single float</p> <p>Units: meters</p> <p>Values: > 0</p> | <p>This parameter specifies the distance from a particular phase on a wave to the same phase on an adjacent wave.</p> |
| <p><i>Period</i></p> <p>Type: single float</p> <p>Units: seconds</p> <p>Values: > 0</p> | <p>This parameter specifies the time required for one complete oscillation of the wave.</p> |
| <p><i>Direction</i></p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: 0 – 360</p> <p>Datum: True North</p> | <p>This parameter specifies the direction in which the wave propagates.</p> |
| <p><i>Phase Offset</i></p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: -360.0 – 360.0</p> | <p>This parameter specifies a phase offset for the wave.</p> |
| <p><i>Leading</i></p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: -180.0 – 180.0</p> | <p>This parameter specifies the phase angle at which the crest occurs (see Figure 53).</p> |

4.1.15 Terrestrial Surface Conditions Control

The **Terrestrial Surface Conditions Control** packet is used to specify the conditions of the terrain surface. These typically describe driving conditions, runway contaminants, or conditions that would otherwise impede or add risk to the movement of vehicles on the ground.

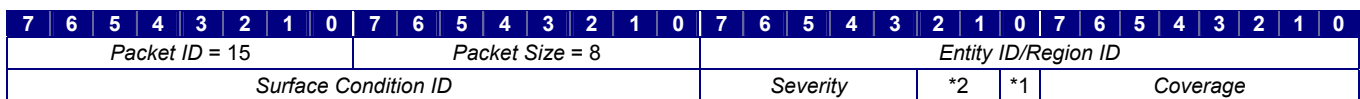
The possible surface conditions are IG-dependent. Examples might range from weather-related conditions such as dry, wet, icy, or slushy, to hazards such as sand, dirt, and gravel.

Regional terrestrial surface conditions always take precedence over the global surface conditions. Once the surface conditions of a region are set, global changes will not affect the surface conditions within that region unless it is disabled. Global changes will, however, change the conditions within a region’s transition perimeter.

If two or more regions overlap, the value of each surface condition attribute within the area of overlap should be the average of the values determined by the overlapping regions.

To determine the terrestrial surface conditions within areas of overlap or through a transition perimeter, the Host can request the conditions at a specific latitude and longitude by issuing an **Environmental Conditions Request** packet (Section 4.1.28).

The contents of the **Terrestrial Surface Conditions Control** packet are as follows:



*1 *Surface Condition Enable*

*2 *Scope*

Figure 55 – Terrestrial Surface Conditions Control Packet Structure

Table 21 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 21 – Terrestrial Surface Conditions Control Parameter Definitions

| Parameter | Description |
|--|--|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 15</p> | <p>This parameter identifies this data packet as the Terrestrial Surface Conditions Control packet. The value of this parameter must be 15.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 8</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 8.</p> |

| Parameter | Description |
|--|--|
| <p>Entity ID (Environmental Entities)</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the environmental entity to which the surface condition attributes in this packet are applied.</p> |
| <p>Region ID (Regional Conditions)</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the region to which the surface conditions are confined.</p> <p>Note: <i>Entity ID/Region ID</i> is ignored if <i>Scope</i> is set to Global (0).</p> |
| <p>Surface Condition ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> <p>Values: 0 Dry (reset) > 0 Defined by IG</p> <p>Default: IG-configurable</p> | <p>This parameter identifies a surface condition or contaminant. Multiple conditions can be specified by sending multiple Terrestrial Surface Conditions Control packets.</p> <p>When this parameter is set to Dry (0), all existing surface conditions will be removed within the specified scope. All other surface condition codes are IG-dependent.</p> |
| <p>Surface Condition Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: IG-configurable</p> | <p>This parameter specifies whether the surface condition attribute identified by the <i>Surface Condition ID</i> parameter should be enabled.</p> |
| <p>Scope</p> <p>Type: unsigned 2-bit field</p> <p>Units: N/A</p> <p>Values: 0 Global 1 Regional 2 Entity</p> <p>Default: IG-configurable</p> | <p>This parameter determines whether the specified surface conditions are applied globally, regionally, or to an environmental entity. If this value is set to Regional (1), the conditions are confined to the region specified by <i>Region ID</i>. If this value is set to Entity (2), the conditions are applied to the model specified by <i>Entity ID</i>.</p> <p>Note: Regional and entity surface conditions override global surface conditions.</p> |
| <p>Severity</p> <p>Type: unsigned 5-bit field</p> <p>Units: N/A</p> <p>Values: 0 – 31 (least to most severe)</p> <p>Default: IG-configurable</p> | <p>This parameter determines the degree of severity for the specified surface contaminant(s). A value of zero (0) indicates that any effects of the contaminant are negligible. A value of 31 indicates that the surface is not navigable.</p> |

| Parameter | Description |
|---|--|
| Coverage Type: unsigned int8 Units: percent Values: 0 – 100 Default: IG-configurable | This parameter determines the degree of coverage of the specified surface contaminant. |

4.1.16 View Control

The **View Control** packet is used to attach a view or view group to an entity and to define the position and rotation of the view relative to the entity's reference point. Views can be positioned to correspond to the pilot eye, weapon/sensor viewpoints, and stealth view cameras.

Multiple views may be combined to form one or more view groups. This allows more than one view to be moved in unison with a single **View Control** packet. A view group is identified by the *Group ID* parameter. Operations performed upon a view group affect all views in that group. If *Group ID* is set to zero (0), the packet is applied to an individual view, identified by the *View ID* parameter.

The order of operation for views and view groups is the same as that for entities. A view is first translated along the entity's **X**, **Y**, and **Z** axes. After it is translated, the view is rotated about the eyepoint. The order of rotation is first about **Z** axis (yaw), then the **Y** axis (pitch), and finally the **X** axis (roll). Figure 56 illustrates the degrees of freedom for positioning and rotating a view:

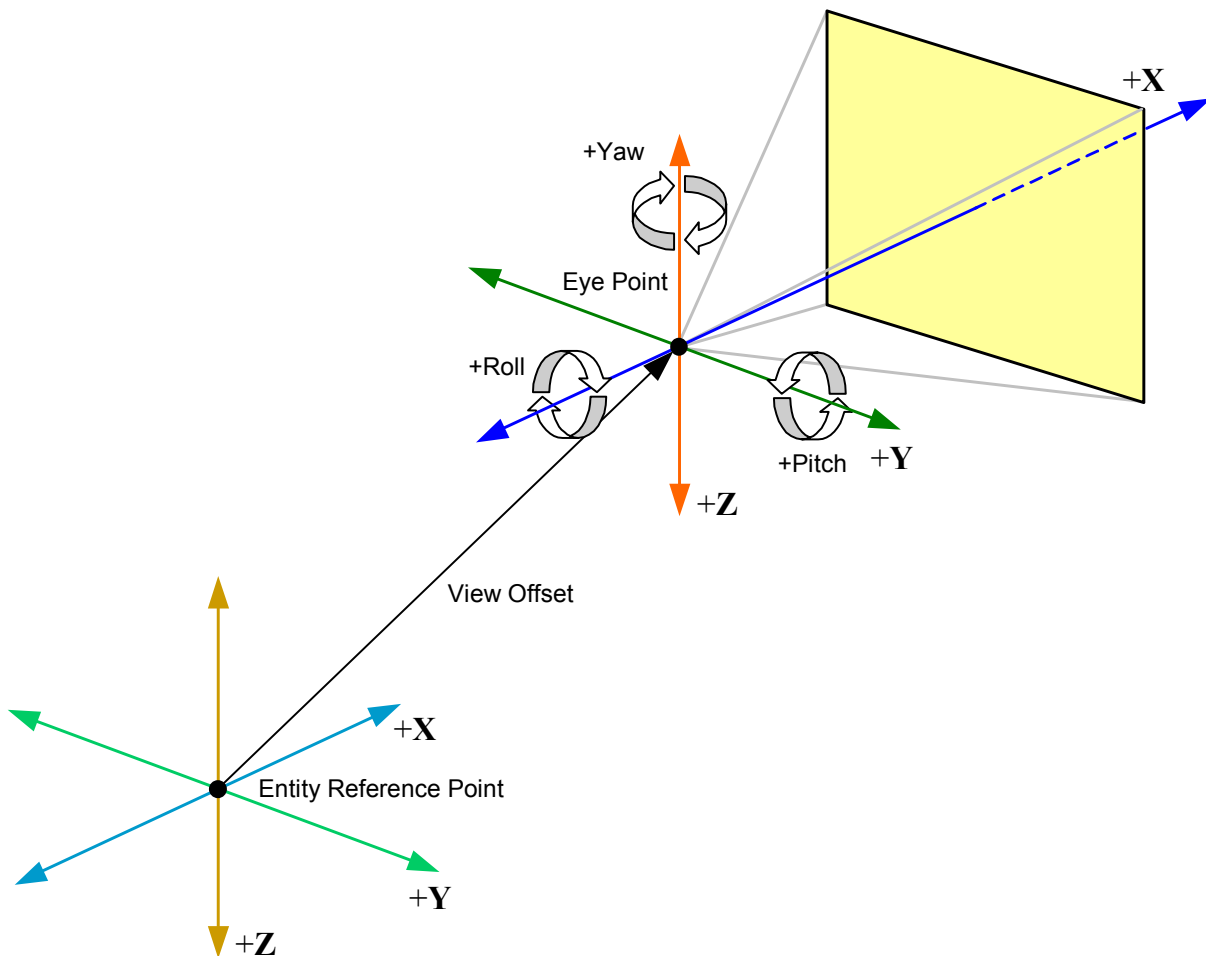


Figure 56 – View Point Position and Rotation

The contents of the **View Control** packet are as follows:

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-----------------------|---|---|---|---|---|---|---|-------------------------|----|----|----|----|----|----|------------------|----------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| <i>Packet ID = 16</i> | | | | | | | | <i>Packet Size = 32</i> | | | | | | | | <i>View ID</i> | | | | | | | | | | | | | | | |
| <i>Group ID</i> | | | | | | | | *7 | *6 | *5 | *4 | *3 | *2 | *1 | <i>Entity ID</i> | | | | | | | | | | | | | | | | |
| <i>X Offset</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Y Offset</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Z Offset</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Roll</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Pitch</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Yaw</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

- *1 *X Offset Enable*
- *2 *Y Offset Enable*
- *3 *Z Offset Enable*
- *4 *Roll Enable*
- *5 *Pitch Enable*
- *6 *Yaw Enable*
- *7 *Reserved*

Figure 57 – View Control Packet Structure

Table 22 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 22 – View Control Parameter Definitions

| Parameter | Description |
|--|--|
| <p><i>Packet ID</i></p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 16</p> | <p>This parameter identifies this data packet as the View Control packet. The value of this parameter must be 16.</p> |
| <p><i>Packet Size</i></p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 32</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 32.</p> |
| <p><i>View ID</i></p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the view to which the contents of this packet should be applied. This value is ignored if the <i>Group ID</i> parameter contains a non-zero value.</p> |

| Parameter | Description |
|--|---|
| <p>Group ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Values: 0 None 1 – 255 Specifies view group</p> | <p>This parameter specifies the view group to which the contents of this packet are applied. If this value is zero (0), the packet is applied to the individual view specified by the <i>View ID</i> parameter. If this value is non-zero, the packet is applied to the specified view group and the <i>View ID</i> parameter is ignored.</p> |
| <p>X Offset Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> | <p>This parameter determines whether the <i>X Offset</i> parameter should be applied to the specified view or view group. If this flag is set to Disable (0), the <i>X Offset</i> parameter is ignored.</p> |
| <p>Y Offset Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> | <p>This parameter determines whether the <i>Y Offset</i> parameter should be applied to the specified view or view group. If this flag is set to Disable (0), the <i>Y Offset</i> parameter is ignored.</p> |
| <p>Z Offset Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> | <p>This parameter determines whether the <i>Z Offset</i> parameter should be applied to the specified view or view group. If this flag is set to Disable (0), the <i>Z Offset</i> parameter is ignored.</p> |
| <p>Roll Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> | <p>This parameter determines whether the <i>Roll</i> parameter should be applied to the specified view or view group. If this flag is set to Disable (0), the <i>Roll</i> parameter is ignored.</p> |
| <p>Pitch Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> | <p>This parameter determines whether the <i>Pitch</i> parameter should be applied to the specified view or view group. If this flag is set to Disable (0), the <i>Pitch</i> parameter is ignored.</p> |

| Parameter | Description |
|---|---|
| <p>Yaw Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> | <p>This parameter determines whether the Yaw parameter should be applied to the specified view or view group. If this flag is set to Disable (0), the Yaw parameter is ignored.</p> |
| <p>Entity ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the entity to which the view or view group should be attached.</p> |
| <p>X Offset</p> <p>Type: single float</p> <p>Units: meters</p> <p>Default: IG-configurable</p> <p>Datum: Entity reference point</p> | <p>This parameter specifies the position of the view eyepoint along the X axis of the entity specified by the <i>Entity ID</i> parameter.</p> |
| <p>Y Offset</p> <p>Type: single float</p> <p>Units: meters</p> <p>Default: IG-configurable</p> <p>Datum: Entity reference point</p> | <p>This parameter specifies the position of the view eyepoint along the Y axis of the entity specified by the <i>Entity ID</i> parameter.</p> |
| <p>Z Offset</p> <p>Type: single float</p> <p>Units: meters</p> <p>Default: IG-configurable</p> <p>Datum: Entity reference point</p> | <p>This parameter specifies the position of the view eyepoint along the Z axis of the entity specified by the <i>Entity ID</i> parameter.</p> |
| <p>Roll</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: -180 – 180</p> <p>Default: IG-configurable</p> <p>Datum: View coordinate system</p> | <p>This parameter specifies the angle of rotation of the view or view group about its X axis after yaw and pitch have been applied.</p> |

| Parameter | Description |
|---|---|
| <p>Pitch</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: -90 – 90</p> <p>Default: IG-configurable</p> <p>Datum: View XY plane</p> | <p>This parameter specifies the angle of rotation of the view or view group about its Y axis after yaw has been applied.</p> |
| <p>Yaw</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: 0 – 360</p> <p>Default: IG-configurable</p> <p>Datum: View reference coordinate system</p> | <p>This parameter specifies the angle of rotation of the view or view group about its Z axis.</p> |

4.1.17 Sensor Control

The **Sensor Control** packet is used to control sensor modes and display behavior for sensor-based weapons systems and other sensor applications. It is typically used in conjunction the **View Control** packet (Section 4.1.16), which moves the sensor camera eyepoint. The **View Definition** and **Component Control** packets (Sections 4.1.21 and 4.1.4, respectively) can also be used to control various aspects of camera and sensor behavior.

Each sensor is associated with exactly one view, specified by the *View ID* parameter. The view eyepoint represents the sensor camera.

In a typical scenario, the sensor will be inactive until the user turns the sensor on. The Host will send a **Sensor Control** packet with the *Sensor On/Off* parameter set to On (1). Because the sensor is not yet tracking a target, the *Track Mode* parameter of this packet should be set to Off (0). The Host might also send a **View Control** packet to make sure the initial sensor camera position is set. Additional **View Control** packets will be sent as the user slews the sensor view. This sequence of events is illustrated in Figure 58:

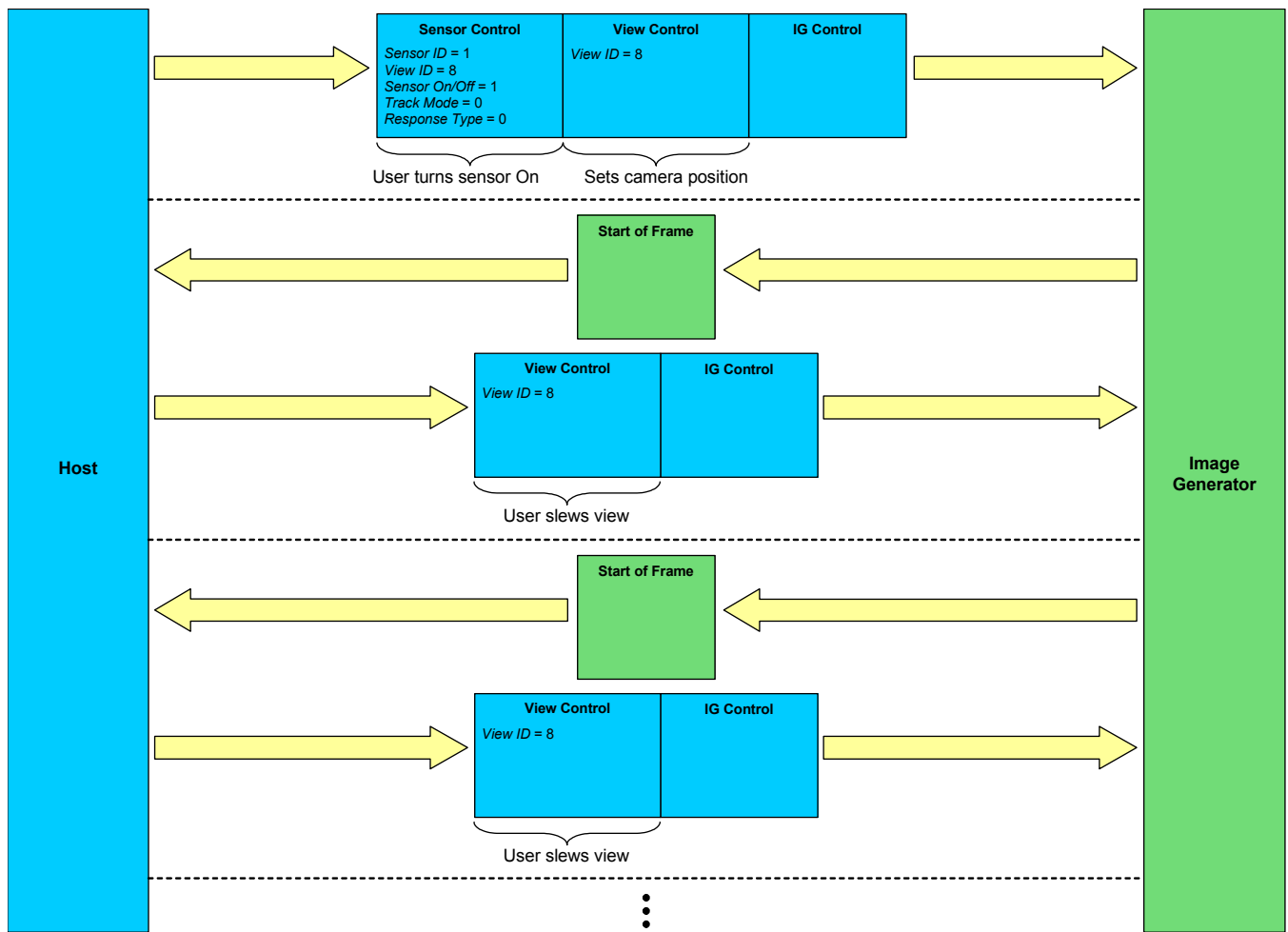


Figure 58 – Data Exchange for Sensor Control (1 of 3)

When the user attempts to lock onto a target, the Host will send a **Sensor Control** packet, setting the *Track Mode* parameter to the appropriate value. Because the Host will need the position of the track point to determine which entity is the target, it sets the *Response Type* parameter to Gate and Target Position (1).

The IG will immediately begin sending response packets (in this case, **Sensor Extended Response** packets) that contain the gate symbol position and, if appropriate, the sensor target position. A response packet will be sent every frame until the IG is directed to do otherwise by the Host.

The *Sensor Status* parameter of the response packets will indicate whether the sensor was able to establish a lock. If the sensor was unable to do so, the *Sensor Status* parameter will be set to zero (0). The Host then should reset the *Track Mode* parameter to Off (0) before the user again tries to lock onto the target. If, on the other hand, the lock was successful, then the *Sensor Status* parameter will be set to one (1).

Figure 59 continues the example illustrated above. Here, the user attempts to acquire a sensor lock, prompting the Host to send a **Sensor Control** packet. The *Track Mode* parameter is set to Target (3) and the *Response Type* parameter to Gate and Target Position (1). The IG responds with **Sensor Extended Response** packets that indicate the lock was successful and that provide gate and target positions.

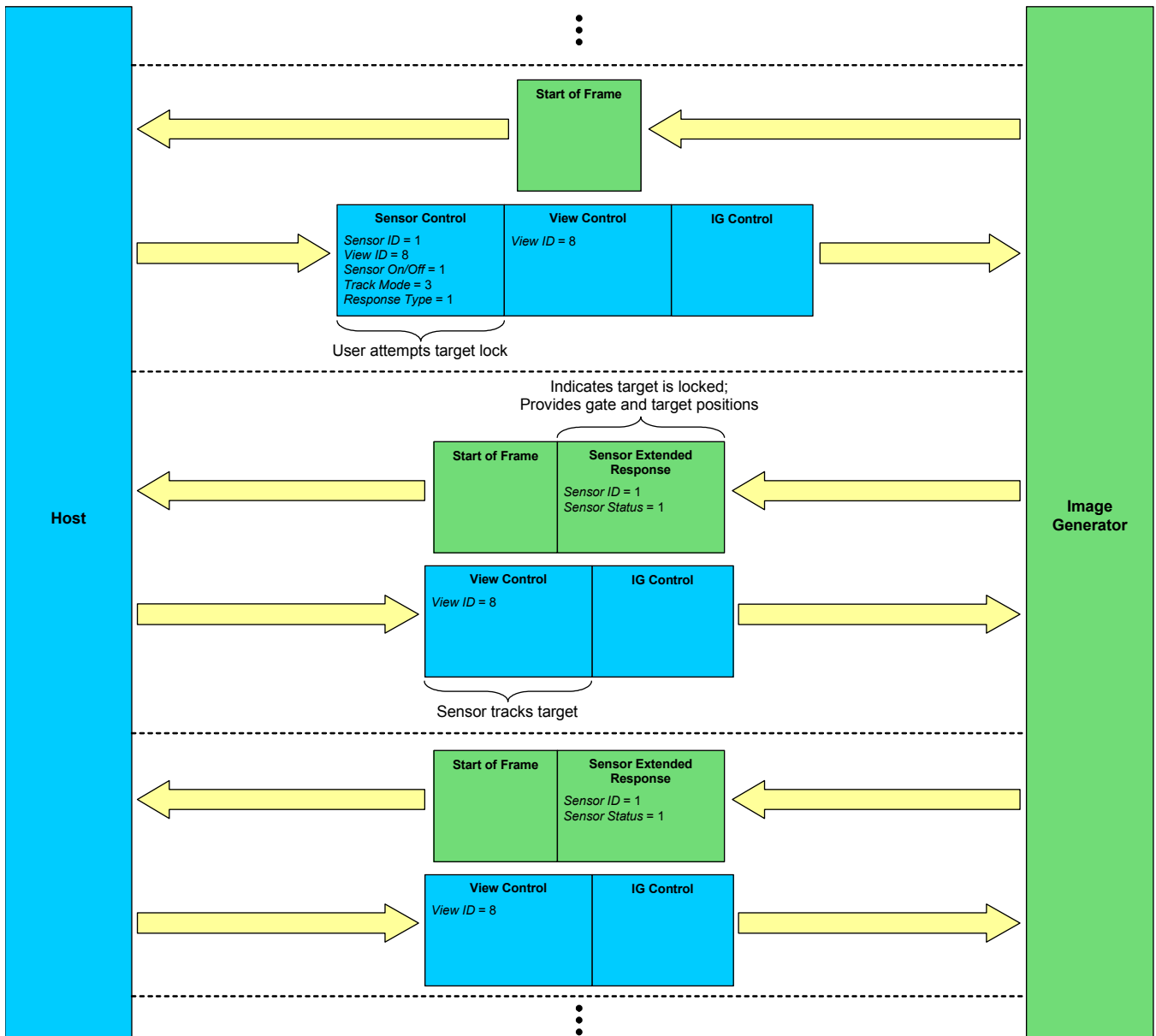


Figure 59 – Data Exchange for Sensor Control (2 of 3)

The *Entity ID* parameter of the **Sensor Extended Response** packet contains the ID of the target entity. If the IG cannot determine the target, or if the sensor is tracking non-entity geometry, then the *Entity ID Valid* parameter of the response packet will be set to Invalid (0). The Host must then use the target position returned by the IG to determine which entity or object is being tracked by the sensor. This may occur immediately or over several frames, depending upon the number and proximity of entities along the sensor viewing vector.

Once the Host has determined the target, it can send a **Sensor Control** packet with its *Response Type* parameter set to Gate Position (1), directing the IG to send **Sensor Response** packets instead of **Sensor Extended Response** packets. This exchange of data is illustrated in Figure 60:

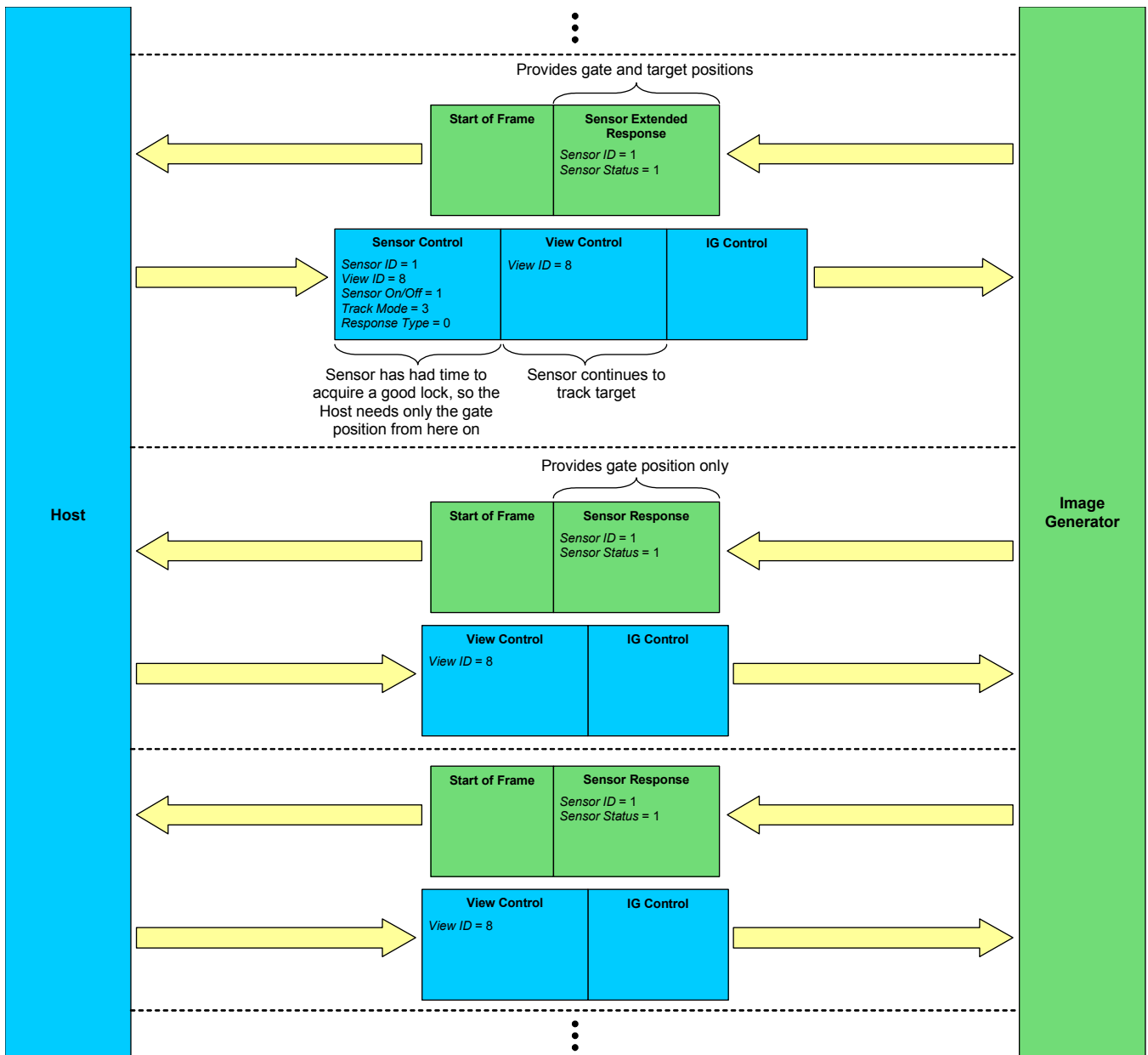
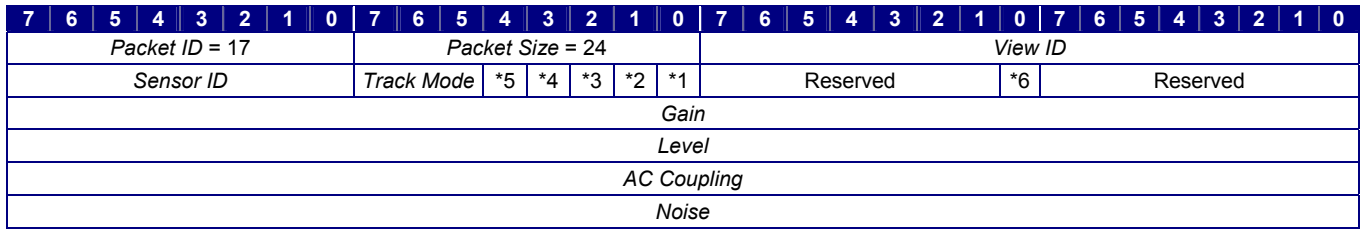


Figure 60 – Data Exchange for Sensor Control (3 of 3)

The contents of the **Sensor Control** packet are as follows:



- *1 Sensor On/Off
- *2 Polarity
- *3 Line-by-Line Dropout Enable
- *4 Automatic Gain
- *5 Track White/Black
- *6 Response Type

Figure 61 – Sensor Control Packet Structure

Table 23 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 23 – Sensor Control Parameter Definitions

| Parameter | Description |
|--|---|
| Packet ID Type: unsigned int8 Units: N/A Value: 17 | This parameter identifies this data packet as the Sensor Control packet. The value of this parameter must be 17. |
| Packet Size Type: unsigned int8 Units: Bytes Value: 24 | This parameter indicates the number of bytes in this data packet. The value of this parameter must be 24. |
| View ID Type: unsigned int16 Units: N/A | This parameter identifies the view to which the specified sensor is assigned. Note that a sensor cannot be assigned to a view group. |
| Sensor ID Type: unsigned int8 Units: N/A | This parameter specifies the sensor to which the data in this packet are applied. |

| Parameter | Description |
|---|---|
| <p>Track Mode</p> <p>Type: unsigned 3-bit field</p> <p>Units: N/A</p> <p>Values: 0 Off 1 Force Correlate 2 Scene 3 Target 4 Ship 5 – 7 Defined by IG</p> <p>Default: 0</p> | <p>This parameter specifies which track mode the sensor should use:</p> <p>Off – No tracking will occur.</p> <p>Force Correlate – The sensor processes a portion of the view image, establishes an image pattern, and attempts to keep the seeker pointed at the center of that image pattern. This mode is typically used for Maverick sensors.</p> <p>Scene – The sensor processes a portion of the view image, establishes an image pattern, and attempts to keep the seeker pointed at the center of that image pattern. This mode is typically used for FLIR sensors.</p> <p>Target – The sensor uses contrast tracking to lock to a specific target area.</p> <p>Ship – The sensor uses contrast tracking and adjusts the tracking point so that the weapon strikes close to the water line.</p> |
| <p>Sensor On/Off</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Off 1 On</p> <p>Default: 0</p> | <p>This parameter specifies whether the sensor is turned on or off.</p> |
| <p>Polarity</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 White hot 1 Black hot</p> <p>Default: 0</p> | <p>This parameter specifies whether the sensor shows white hot or black hot.</p> |
| <p>Line-by-Line Dropout Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: 0</p> | <p>This parameter specifies whether line-by-line dropout is enabled.</p> |

| Parameter | Description |
|---|---|
| <p>Automatic Gain</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: 0</p> | <p>This parameter specifies whether the sensor automatically adjusts the gain value to optimize the brightness and contrast of the sensor display</p> |
| <p>Track White/Black</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 White 1 Black</p> <p>Default: 0</p> | <p>This parameter specifies whether the sensor tracks white or black. This, along with the <i>Polarity</i> parameter, controls whether the sensor tracks hot or cold spots.</p> |
| <p>Response Type</p> <p>Type: unsigned 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Normal (gate position) 1 Extended (gate and target position)</p> <p>Default: 0</p> | <p>This parameter specifies whether the IG should return a Sensor Response (Section 4.2.6) packet or a Sensor Extended Response packet (Section 4.2.7).</p> <p>The IG should return one of the two sensor response packets every frame as long as the following two criteria are met:</p> <ol style="list-style-type: none"> 1. <i>Sensor On/Off</i> is set to On (1). 2. <i>Track Mode</i> is not set to Off (0). |
| <p>Gain</p> <p>Type: single float</p> <p>Units: N/A</p> <p>Values: 0.0 – 1.0</p> <p>Default: 0.0</p> | <p>This parameter specifies the contrast for the sensor display.</p> |
| <p>Level</p> <p>Type: single float</p> <p>Units: N/A</p> <p>Values: 0.0 – 1.0</p> <p>Default: 0.0</p> | <p>This parameter specifies the brightness for the sensor display.</p> |

| Parameter | Description |
|--|---|
| AC Coupling Type: single float Units: μ s Values: ≥ 0.0 Default: 0.0 | This parameter specifies the AC coupling decay constant for the sensor display. |
| Noise Type: single float Units: N/A Values: 0.0 – 1.0 Default: 0.0 | This parameter specifies the amount of detector noise for the sensor. |

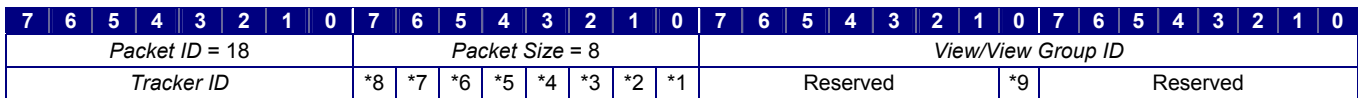
4.1.18 Motion Tracker Control

The **Motion Tracker Control** packet is used to initialize and change properties of tracked input devices connected to the IG. These devices may include head trackers, eye trackers, wands, trackballs, etc.

The Host may request the instantaneous position and orientation of a tracker device by sending a **Position Request** packet (Section 4.1.27) with its *Object Class* parameter set to Motion Tracker (4).

Note that if tracked input devices are connected to the Host, the Host should interpret the tracked input data and send the appropriate CIGI packets to achieve the desired effect on the IG. For example, the Host would interpret input from a connected head tracker and send **View Control** packets to the IG to move the eyepoint of the appropriate view or view group.

The contents of the **Motion Tracker Control** packet are as follows:



- *1 Tracker Enable
- *2 Boresight Enable
- *3 X Enable
- *4 Y Enable
- *5 Z Enable
- *6 Roll Enable
- *7 Pitch Enable
- *8 Yaw Enable
- *9 View/View Group Select

Figure 62 – Motion Tracker Control Packet Structure

Table 24 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 24 – Motion Tracker Control Parameter Definitions

| Parameter | Description |
|--|--|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 18</p> | <p>This parameter identifies this data packet as the Motion Tracker Control packet. The value of this parameter must be 18.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 8</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 8.</p> |

| Parameter | Description |
|---|---|
| <p>View/View Group ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> <p>Default: 0</p> | <p>This parameter specifies the view or view group to which the tracking device is attached.</p> |
| <p>Tracker ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter specifies the tracker whose state the data in this packet represents.</p> |
| <p>Tracker Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: IG-configurable</p> | <p>This parameter specifies whether the tracking device is enabled.</p> |
| <p>Boresight Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: 0</p> | <p>This parameter is used to set the boresight state of the external tracking device. This mode is used to reestablish the tracker's "center" position at the current position and orientation.</p> <p>Note: If boresighting is enabled, the Host must send a Motion Tracker Control packet with <i>Boresight Enable</i> set to Disable (0) to return the tracker to normal operation. The IG will continue to update the boresight position each frame until that occurs.</p> |
| <p>X Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: 1</p> | <p>This parameter is used to enable or disable the X-axis position of the motion tracker.</p> |

| Parameter | Description |
|---|--|
| <p>Y Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: 1</p> | <p>This parameter is used to enable or disable the Y-axis position of the motion tracker.</p> |
| <p>Z Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: 1</p> | <p>This parameter is used to enable or disable the Z-axis position of the motion tracker.</p> |
| <p>Roll Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: 1</p> | <p>This parameter is used to enable or disable the roll (X-axis rotation) of the motion tracker.</p> |
| <p>Pitch Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: 1</p> | <p>This parameter is used to enable or disable the pitch (Y-axis rotation) of the motion tracker.</p> |
| <p>Yaw Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: 1</p> | <p>This parameter is used to enable or disable the yaw (Z-axis rotation) of the motion tracker.</p> |

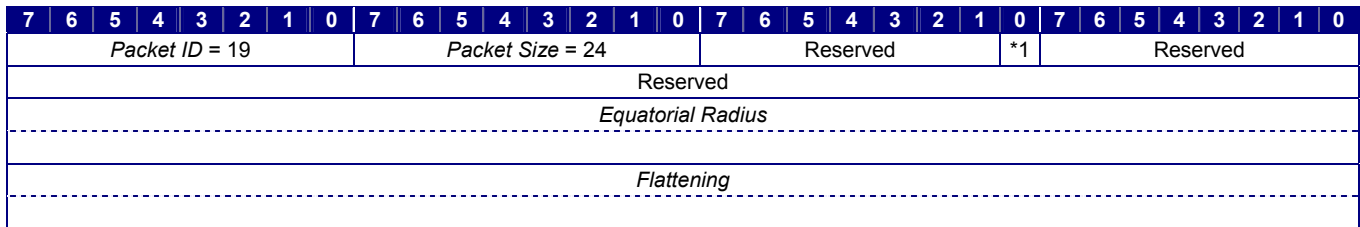
| Parameter | Description |
|---|--|
| <i>View/View Group Select</i> Type: 1-bit field Units: N/A Values: 0 View 1 View Group Default: IG-configurable | This parameter specifies whether the tracking device is attached to a single view or a view group. If set to View (0), the <i>View/View Group ID</i> parameter identifies a single view. If set to View Group (1), that parameter identifies a view group. |

4.1.19 Earth Reference Model Definition

The default Earth Reference Model (ERM) used for geodetic positioning is WGS 84. The Host may define another ERM by sending an **Earth Reference Model Definition** packet to the IG. This packet defines the equatorial radius and the flattening of the new reference ellipsoid.

When the IG receives an **Earth Reference Model Definition** packet, it should set the *Earth Reference Model* parameter of the **Start of Frame** packet to Host-Defined (1). If, for some reason, the IG cannot support the ERM defined by the Host, the parameter should be set to WGS 84 (0).

The contents of the **Earth Reference Model Definition** packet are as follows:



*1 Custom ERM Enable

Figure 63 – Earth Reference Model Definition Packet Structure

Table 25 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 25 – Earth Reference Model Definition Parameter Definitions

| Parameter | Description |
|---|--|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 19</p> | <p>This parameter identifies this data packet as the Earth Reference Model Definition packet. The value of this parameter must be 19.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 24</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 24.</p> |

| Parameter | Description |
|---|---|
| <p>Custom ERM Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable (use WGS 84) 1 Enable</p> <p>Default: 0</p> | <p>This parameter specifies whether the IG should use the Earth Reference Model (ERM) defined by this packet.</p> <p>If this parameter is set to Disable (0), the IG will use the WGS 84 reference model and all other parameters in this packet will be ignored.</p> |
| <p>Equatorial Radius</p> <p>Type: double float</p> <p>Units: meters</p> <p>Default: 6,378,137.0</p> | <p>This parameter specifies the semi-major axis of the ellipsoid.</p> |
| <p>Flattening</p> <p>Type: double float</p> <p>Units: meters</p> <p>Default: $\frac{1}{298.257223563}$</p> | <p>This parameter specifies the flattening of the ellipsoid. This value is calculated as follows:</p> $f = \frac{(a - b)}{a}$ <p>where f is the flattening, a is the semi-major axis (equatorial radius), and b is the semi-minor axis (polar radius).</p> <p>A flattening value of 0.0 defines a spherical Earth.</p> |

4.1.20 Trajectory Definition

The **Trajectory Definition** packet enables the Host to describe a trajectory along which an IG-driven entity, such as a tracer round or particulate debris, travels. This is useful for simulating gravity and other static forces acting upon the entity. This packet is commonly used in conjunction with the **Rate Control** packet (Section 4.1.8).

The contents of the **Trajectory Definition** packet are as follows:

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|--------------------------|---|---|---|---|---|---|---|------------------|---|---|---|---|---|---|---|-----------|---|---|---|---|---|---|---|
| Packet ID = 20 | | | | | | | | Packet Size = 24 | | | | | | | | Entity ID | | | | | | | |
| <i>Acceleration X</i> | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Acceleration Y</i> | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Acceleration Z</i> | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Retardation Rate</i> | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Terminal Velocity</i> | | | | | | | | | | | | | | | | | | | | | | | |

Figure 64 – Trajectory Definition Packet Structure

Table 26 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 26 – Trajectory Definition Parameter Definitions

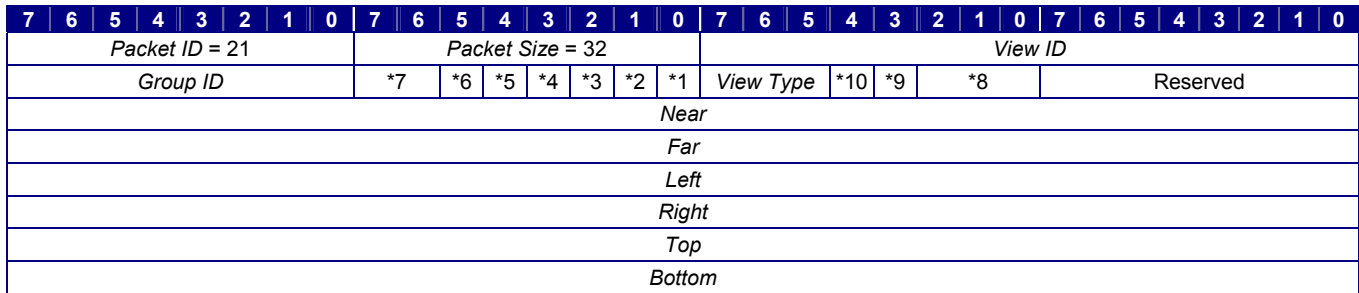
| Parameter | Description |
|---|---|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 20</p> | <p>This parameter identifies this data packet as the Trajectory Definition packet. The value of this parameter must be 20.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 24</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 24.</p> |
| <p>Entity ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter identifies the entity for which the trajectory is defined.</p> |

| Parameter | Description |
|--|---|
| <p><i>Acceleration X</i></p> <p>Type: single float</p> <p>Units: m/s²</p> <p>Default: 0</p> <p>Datum: Ellipsoid-tangential NED reference coordinate system</p> | <p>This parameter specifies the X component of the acceleration vector.</p> |
| <p><i>Acceleration Y</i></p> <p>Type: single float</p> <p>Units: m/s²</p> <p>Default: 0</p> <p>Datum: Ellipsoid-tangential NED reference coordinate system</p> | <p>This parameter specifies the X component of the acceleration vector.</p> |
| <p><i>Acceleration Z</i></p> <p>Type: single float</p> <p>Units: m/s²</p> <p>Default: 0</p> <p>Datum: Ellipsoid-tangential NED reference coordinate system</p> | <p>This parameter specifies the X component of the acceleration vector.</p> |
| <p><i>Retardation Rate</i></p> <p>Type: single float</p> <p>Units: m/s²</p> <p>Default: 0</p> | <p>This parameter specifies the magnitude of an acceleration applied against the entity's instantaneous linear velocity vector. This is used to simulate drag and other frictional forces acting upon the entity.</p> |
| <p><i>Terminal Velocity</i></p> <p>Type: single float</p> <p>Units: m/s</p> <p>Default: 0</p> | <p>This parameter specifies the maximum velocity the entity can sustain.</p> |

4.1.21 View Definition

The **View Definition** packet allows the Host to override the IG's default configuration for a view. This packet is used to specify the projection type, to define the size of the viewing volume, and to assign the view to a view group. Refer to Section 3.2 for details on these view characteristics.

The contents of the **View Definition** packet are as follows:



- *1 *Near Enable*
- *2 *Far Enable*
- *3 *Left Enable*
- *4 *Right Enable*
- *5 *Top Enable*
- *6 *Bottom Enable*
- *7 *Mirror Mode*
- *8 *Pixel Replication Mode*
- *9 *Projection Type*
- *10 *Reorder*

Figure 65 – View Definition Packet Structure

Table 27 defines each parameter's data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 27 – View Definition Parameter Definitions

| Parameter | Description |
|---|---|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 21</p> | <p>This parameter identifies this data packet as the View Definition packet. The value of this parameter must be 21.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 32</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 32.</p> |

| Parameter | Description |
|--|--|
| <p>View ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the view to which the data in this packet will be applied.</p> |
| <p>Group ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Values: 0 None 1 – 255 Specifies view group</p> | <p>This parameter specifies the group to which the view is to be assigned. If this value is zero (0), the view is not assigned to a group.</p> |
| <p>Near Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> | <p>This parameter specifies whether the near clipping plane will be set to the value of the <i>Near</i> parameter within this packet. If this parameter is set to Disable (0), the <i>Near</i> parameter will be ignored.</p> |
| <p>Far Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> | <p>This parameter specifies whether the far clipping plane will be set to the value of the <i>Far</i> parameter within this packet. If this parameter is set to Disable (0), the <i>Far</i> parameter will be ignored.</p> |
| <p>Left Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> | <p>This parameter specifies whether the left half-angle of the view frustum will be set according to the value of the <i>Left</i> parameter within this packet. If this parameter is set to Disable (0), the <i>Left</i> parameter will be ignored.</p> |
| <p>Right Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> | <p>This parameter specifies whether the right half-angle of the view frustum will be set according to the value of the <i>Right</i> parameter within this packet. If this parameter is set to Disable (0), the <i>Right</i> parameter will be ignored.</p> |

| Parameter | Description |
|---|---|
| <p>Top Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> | <p>This parameter specifies whether the top half-angle of the view frustum will be set according to the value of the <i>Top</i> parameter within this packet. If this parameter is set to Disable (0), the <i>Top</i> parameter will be ignored.</p> |
| <p>Bottom Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> | <p>This parameter specifies whether the bottom half-angle of the view frustum will be set according to the value of the <i>Bottom</i> parameter within this packet. If this parameter is set to Disable (0), the <i>Bottom</i> parameter will be ignored.</p> |
| <p>Mirror Mode</p> <p>Type: unsigned 2-bit field</p> <p>Units: N/A</p> <p>Values: 0 None 1 Horizontal 2 Vertical 3 Horizontal and Vertical</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the mirroring function to be performed on the view. This feature is typically used to replicate the view of a mirrored surface such as a rear view mirror.</p> |
| <p>Pixel Replication Mode</p> <p>Type: unsigned 3-bit field</p> <p>Units: N/A</p> <p>Values: 0 None 1 1 × 2 2 2 × 1 3 2 × 2 4 – 7 Defined by IG</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the pixel replication function to be performed on the view. This feature is typically used in sensor applications to perform electronic zooming (i.e., pixel and line doubling).</p> |
| <p>Projection Type</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Perspective 1 Orthographic Parallel</p> <p>Default: IG-configurable</p> | <p>This parameter specifies whether the view projection should be perspective (Section 3.2.1.1) or orthographic parallel (Section 3.2.1.2).</p> |

| Parameter | Description |
|---|---|
| <p>Reorder</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 No Reorder 1 Bring to Top</p> <p>Default: IG-configurable</p> | <p>This parameter specifies whether the view should be moved to the top of any overlapping views. In cases where multiple overlapping views are moved to the top, the last view specified gets priority.</p> |
| <p>View Type</p> <p>Type: unsigned 3-bit field</p> <p>Units: N/A</p> <p>Values: 0 – 7</p> <p>Default: IG-configurable</p> | <p>This parameter specifies an IG-defined type for the indicated view. For example, a Host might switch a view type from out-the-window to IR for a given channel.</p> |
| <p>Near</p> <p>Type: single float</p> <p>Units: meters</p> <p>Values: > 0 to < <i>Far</i></p> <p>Default: IG-configurable</p> | <p>This parameter specifies the position of the view's near clipping plane. This distance is measured along the viewing vector from the eyepoint to the plane.</p> |
| <p>Far</p> <p>Type: single float</p> <p>Units: meters</p> <p>Values: > <i>Near</i></p> <p>Default: IG-configurable</p> | <p>This parameter specifies the position of the view's far clipping plane. This distance is measured along the viewing vector from the eyepoint to the plane.</p> |
| <p>Left</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: > -90.0 to < <i>Right</i></p> <p>Default: IG-configurable</p> | <p>This parameter specifies the left half-angle of the view frustum. This value is the measure of the angle formed at the view eyepoint between the viewing vector and the frustum side (see Figure 12, page 18).</p> |

| Parameter | Description |
|--|---|
| <p><i>Right</i></p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: > <i>Left</i> to < 90.0</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the right half-angle of the view frustum. This value is the measure of the angle formed at the view eyepoint between the viewing vector and the frustum side (see Figure 12, page 18).</p> |
| <p><i>Top</i></p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: > <i>Bottom</i> to < 90.0</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the top half-angle of the view frustum. This value is the measure of the angle formed at the view eyepoint between the viewing vector and the frustum side (see Figure 12, page 18).</p> |
| <p><i>Bottom</i></p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: > -90.0 to < <i>Top</i></p> <p>Default: IG-configurable</p> | <p>This parameter specifies the bottom half-angle of the view frustum. This value is the measure of the angle formed at the view eyepoint between the viewing vector and the frustum side (see Figure 12, page 18).</p> |

4.1.22 Collision Detection Segment Definition

The **Collision Detection Segment Definition** packet enables the Host to define one or more collision detection segments for an entity. A collision detection segment is a line segment along which collision testing is performed by the IG. When a collision detection segment intersects a polygon, the IG registers a collision by sending a **Collision Detection Segment Notification** (Section 4.2.13) packet to the Host identifying the segment and the object with which it collided.

The segment is defined by specifying the locations of its endpoints with respect to the associated entity's body coordinate system. Figure 66 illustrates five segments defined for an aircraft:

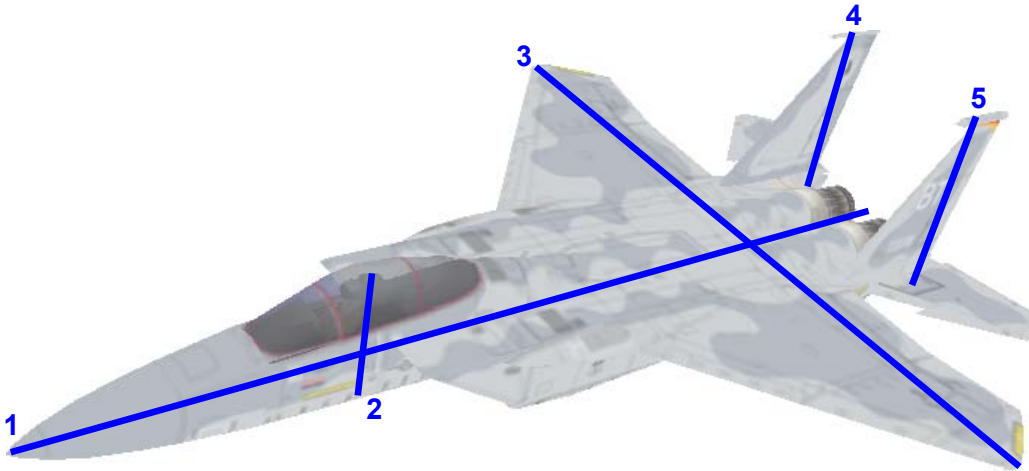


Figure 66 – Examples of Collision Detection Segments

Collision detection volumes are tested segment-to-polygon. An entity will not perform collision detection segment testing against its own geometry.

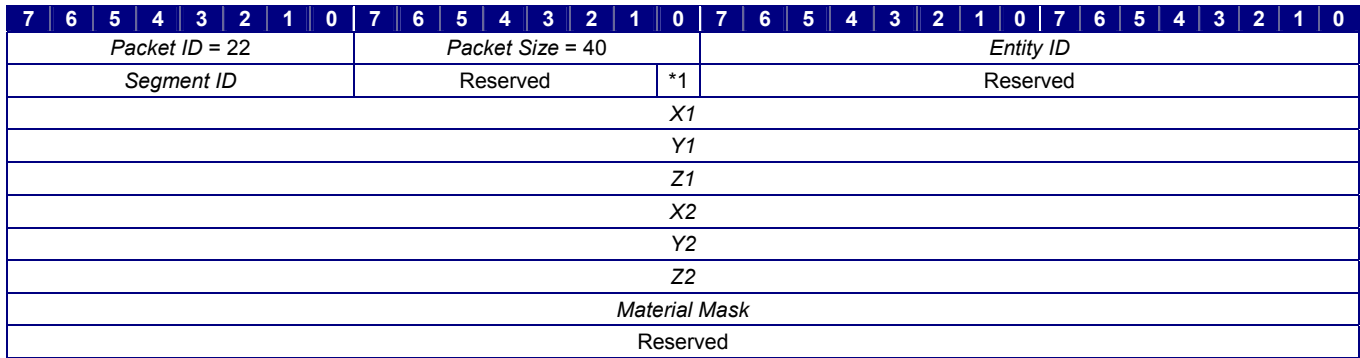
If the *Collision Detection Request* parameter of an **Entity Control** packet is set to No Request (0), the referenced entity's segments will not be used for collision detection segment testing. If the state of an entity is set to Inactive/Standby (0) via the *Entity State* parameter of an **Entity Control** packet, neither that entity's segments nor its geometry will be included in collision detection segment testing.

If an entity is destroyed, any collision detection segments defined for that entity will also be destroyed.

Although non-entity collision detection segments may be defined by the IG configuration, the Host can only create collision detection segments by referencing an entity. If a segment must be defined along a non-entity object, the Host must first create an entity with no geometry (entity type zero) to represent that object.

Since collision tests are conducted at discrete moments in time, it is possible that a segment could pass completely through a polygon between successive tests, causing a missed collision. It may therefore be necessary for the IG to use segment sweeping or some other mechanism to avoid this situation.

The contents of the **Collision Detection Segment Definition** packet are as follows:



*1 Segment Enable

Figure 67 – Collision Detection Segment Definition Packet Structure

Table 28 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 28 – Collision Detection Segment Definition Parameter Definitions

| Parameter | Description |
|---|--|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 22</p> | <p>This parameter identifies this data packet as the Collision Detection Segment Definition packet. The value of this parameter must be 22.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 40</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 40.</p> |
| <p>Entity ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the entity for which the segment is defined.</p> |
| <p>Segment ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter specifies the ID of the segment. If an ID is specified for which a segment is already defined, that segment will be overwritten.</p> |

| Parameter | Description |
|---|---|
| <p>Segment Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: IG-configurable</p> | <p>This parameter specifies whether the segment is enabled or disabled. If it is set to Disable (0), the specified segment is ignored during collision testing.</p> |
| <p>X1</p> <p>Type: single float</p> <p>Units: meters</p> <p>Default: IG-configurable</p> <p>Datum: Entity reference point</p> | <p>This parameter specifies the X offset of one endpoint of the collision segment. This offset is measured with respect to the coordinate system of the entity specified by the <i>Entity ID</i> parameter.</p> <p>The X offset of the other endpoint is defined by the X2 parameter.</p> |
| <p>Y1</p> <p>Type: single float</p> <p>Units: meters</p> <p>Default: IG-configurable</p> <p>Datum: Entity reference point</p> | <p>This parameter specifies the Y offset of one endpoint of the collision segment. This offset is measured with respect to the coordinate system of the entity specified by the <i>Entity ID</i> parameter.</p> <p>The Y offset of the other endpoint is defined by the Y2 parameter.</p> |
| <p>Z1</p> <p>Type: single float</p> <p>Units: meters</p> <p>Default: IG-configurable</p> <p>Datum: Entity reference point</p> | <p>This parameter specifies the Z offset of one endpoint of the collision segment. This offset is measured with respect to the coordinate system of the entity specified by the <i>Entity ID</i> parameter.</p> <p>The Z offset of the other endpoint is defined by the Z2 parameter.</p> |
| <p>X2</p> <p>Type: single float</p> <p>Units: meters</p> <p>Default: IG-configurable</p> <p>Datum: Entity reference point</p> | <p>This parameter specifies the X offset of one endpoint of the collision segment. This offset is measured with respect to the coordinate system of the entity specified by the <i>Entity ID</i> parameter.</p> <p>The X offset of the other endpoint is defined by the X1 parameter.</p> |

| Parameter | Description |
|--|--|
| <p>Y2</p> <p>Type: single float</p> <p>Units: meters</p> <p>Default: IG-configurable</p> <p>Datum: Entity reference point</p> | <p>This parameter specifies the Y offset of one endpoint of the collision segment. This offset is measured with respect to the coordinate system of the entity specified by the <i>Entity ID</i> parameter.</p> <p>The Y offset of the other endpoint is defined by the <i>Y1</i> parameter.</p> |
| <p>Z2</p> <p>Type: single float</p> <p>Units: meters</p> <p>Default: IG-configurable</p> <p>Datum: Entity reference point</p> | <p>This parameter specifies the Z offset of one endpoint of the collision segment. This offset is measured with respect to the coordinate system of the entity specified by the <i>Entity ID</i> parameter.</p> <p>The Z offset of the other endpoint is defined by the <i>Z1</i> parameter.</p> |
| <p>Material Mask</p> <p>Type: unsigned int32</p> <p>Units: N/A</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the environmental and cultural features to be included in or excluded from consideration for collision testing. Each bit represents a range of material code values. Setting that bit to one (1) will cause the IG to register hits with materials within the corresponding range.</p> <p>Refer to the appropriate IG documentation for material code assignments.</p> |

4.1.23 Collision Detection Volume Definition

The **Collision Detection Volume Definition** packet enables the Host to define one or more collision detection volumes for an entity. A collision detection volume is a sphere or a cuboid through which collision testing is performed by the IG. When a collision detection volume passes through another collision detection volume, the IG registers a collision by sending a **Collision Detection Volume Notification** (Section 4.2.14) packet to the Host identifying the collided volumes.

A volume is defined by specifying its location, size, and orientation with respect to the associated entity's body coordinate system. A sphere's size is specified as a radius; a cuboid's size is specified by its width, height, and depth. Figure 68 illustrates two cuboid volumes defined for an aircraft:

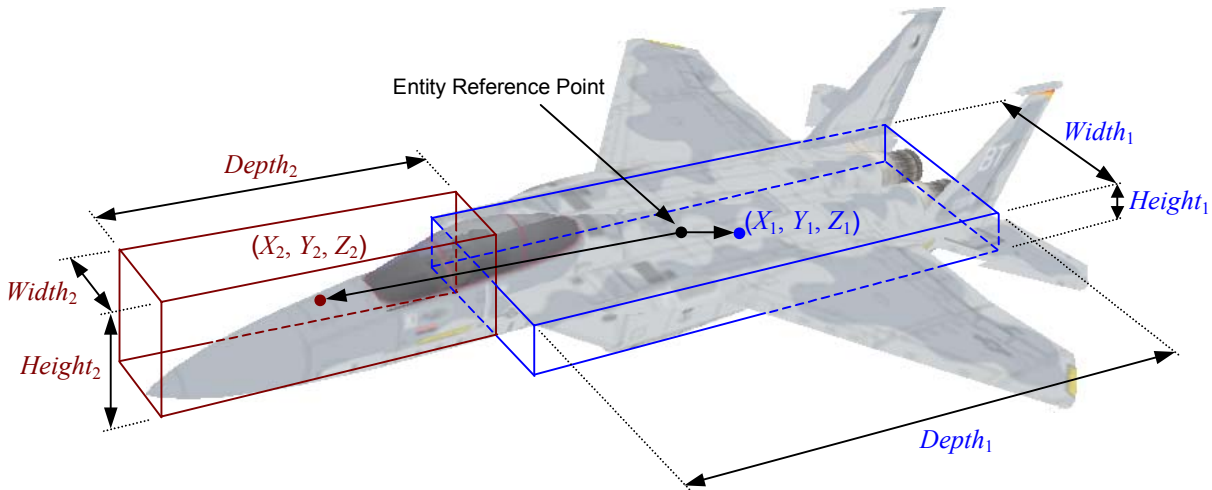


Figure 68 – Examples of Collision Detection Volumes

Unlike collision detection segments, which are tested segment-to-polygon, collision detection volumes are tested volume-to-volume. Volumes associated with the same entity are not tested against each other.

Since collision tests are conducted at discrete moments in time, it is possible that two volumes could pass completely through one another between successive tests, causing a missed collision. It may therefore be necessary for the IG to use volume sweeping or some other mechanism to avoid this situation.

If the state of an entity is set to Inactive/Standby (0) via the *Entity State* parameter of an **Entity Control** packet, no collision detection volume testing will be performed for that entity.

If the *Collision Detection Enable* parameter of the **Entity Control** packet is set to Disable (0), no volumes defined for the entity will be used as “source” volumes for collision testing. Figure 69 below illustrates the individual tests that would occur each frame between a hypothetical group of entities:

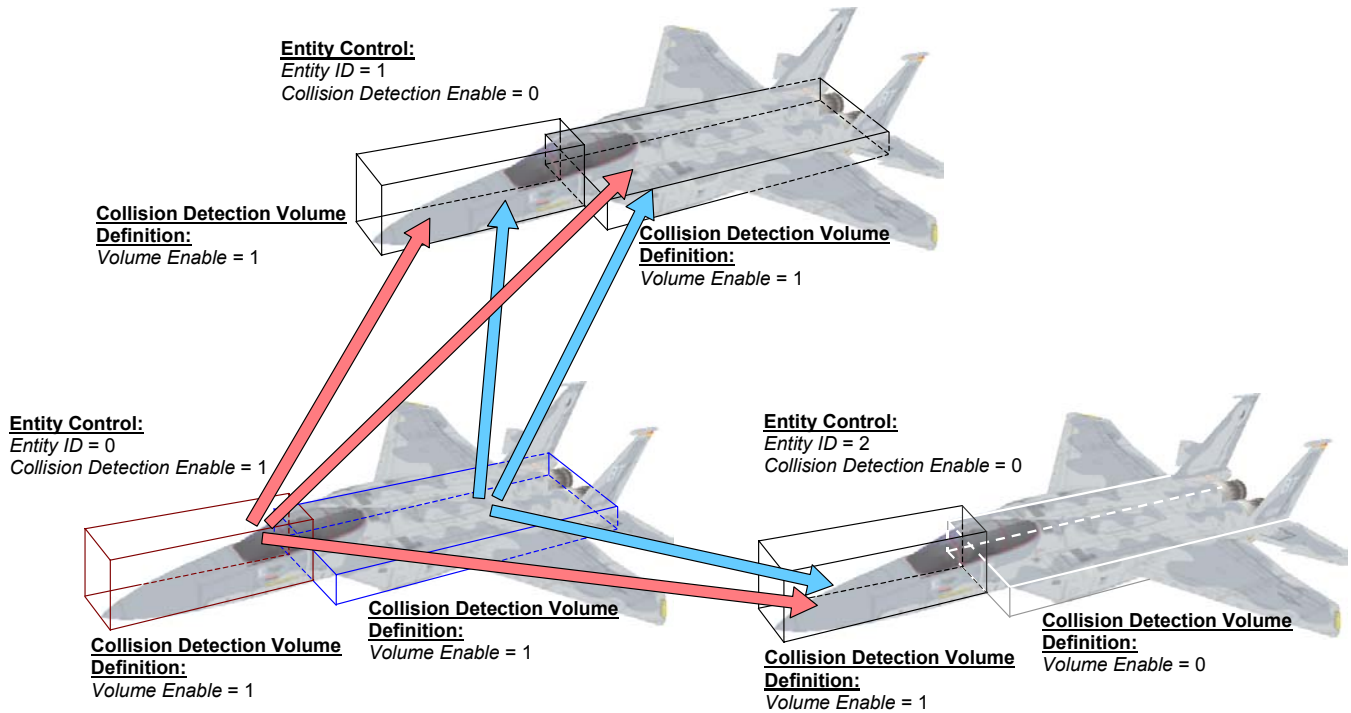


Figure 69 – Collision Volume Testing Between Multiple Entities

The illustration shows three aircraft with two collision detection volumes defined for each. The *Collision Detection Enable* parameter has been set to one (1) for the Ownship (Entity 0) and to zero (0) for Entities 1 and 2. This means that only the volumes associated with the Ownship will be used as the sources of collision testing. The two source volumes are tested with every other enabled volume not associated with the Ownship. Note that one of the volumes defined for Entity 2 is disabled; that volume is not included in *any* collision testing.

If collision detection is enabled for two entities, two tests will be performed between each pair of volumes. This is because each volume will be used as both source and destination in each pair-wise test.

If an entity is destroyed, any collision detection volumes defined for that entity will also be destroyed.

Although non-entity collision detection volumes may be defined by the IG configuration, the Host can only create collision detection volumes by referencing an entity. If a volume must be defined about a non-entity object, the Host must first create an entity with no geometry (entity type zero) to represent that object.

The contents of the **Collision Detection Volume Definition** packet are as follows:

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | | |
|----------------|---|---|---|---|---|---|---|------------------|---|---|---|---|---|----|---|---------------|---|----------|---|---|---|---|---|---|---|---|---|---|---|---|---|--|--|
| Packet ID = 23 | | | | | | | | Packet Size = 48 | | | | | | | | Entity ID | | | | | | | | | | | | | | | | | |
| Volume ID | | | | | | | | Reserved | | | | | | *2 | | *1 | | Reserved | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | Y | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | Z | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | Height/Radius | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | Width | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | Depth | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | Roll | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | Pitch | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | Yaw | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | Reserved | | | | | | | | | | | | | | | | | |

*1 Volume Enable

*2 Volume Type

Figure 70 – Collision Detection Volume Definition Packet Structure

Table 29 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 29 – Collision Detection Volume Definition Parameter Definitions

| Parameter | Description |
|---|---|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 23</p> | <p>This parameter identifies this data packet as the Collision Detection Volume Definition packet. The value of this parameter must be 23.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 48</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 48.</p> |
| <p>Entity ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the entity for which the volume is defined.</p> |
| <p>Volume ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter specifies the ID of the volume. If an ID is specified for which a volume is already defined, that volume will be overwritten.</p> |

| Parameter | Description |
|--|--|
| <p>Volume Enable</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Disable 1 Enable</p> <p>Default: IG-configurable</p> | <p>This parameter specifies whether the volume is enabled or disabled. If it is set to Disable (0), the specified volume is ignored during collision testing.</p> |
| <p>Volume Type</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Sphere 1 Cuboid</p> <p>Default: IG-configurable</p> | <p>This parameter specified whether the volume is spherical or cuboid.</p> |
| <p>X</p> <p>Type: single float</p> <p>Units: meters</p> <p>Default: IG-configurable</p> <p>Datum: Entity reference point</p> | <p>This parameter specifies the X offset of the center of the volume. This offset is measured with respect to the coordinate system of the entity specified by the <i>Entity ID</i> parameter.</p> |
| <p>Y</p> <p>Type: single float</p> <p>Units: meters</p> <p>Default: IG-configurable</p> <p>Datum: Entity reference point</p> | <p>This parameter specifies the Y offset of the center of the volume. This offset is measured with respect to the coordinate system of the entity specified by the <i>Entity ID</i> parameter.</p> |
| <p>Z</p> <p>Type: single float</p> <p>Units: meters</p> <p>Default: IG-configurable</p> <p>Datum: Entity reference point</p> | <p>This parameter specifies the Z offset of the center of the volume. This offset is measured with respect to the coordinate system of the entity specified by the <i>Entity ID</i> parameter.</p> |

| Parameter | Description |
|---|--|
| <p>Radius (Spherical Volumes)</p> <p>Type: single float</p> <p>Units: meters</p> <p>Values: > 0</p> <p>Default: IG-configurable</p> | <p>For spherical collision detection volumes, this parameter specifies the radius of the sphere.</p> |
| <p>Height (Cuboid Volumes)</p> <p>Type: single float</p> <p>Units: meters</p> <p>Values: > 0</p> <p>Default: IG-configurable</p> | <p>For cuboid collision detection volumes, this parameter specifies the length of the cuboid along its Z axis.</p> |
| <p>Width</p> <p>Type: single float</p> <p>Units: meters</p> <p>Values: > 0</p> <p>Default: IG-configurable</p> | <p>For cuboid collision detection volumes, this parameter specifies the length of the cuboid along its Y axis. This parameter is ignored if <i>Volume Type</i> is set to Sphere (0).</p> |
| <p>Depth</p> <p>Type: single float</p> <p>Units: meters</p> <p>Values: > 0</p> <p>Default: IG-configurable</p> | <p>For cuboid collision detection volumes, this parameter specifies the length of the cuboid along its X axis. This parameter is ignored if <i>Volume Type</i> is set to Sphere (0).</p> |
| <p>Roll</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: -180 – 180</p> <p>Default: IG-configurable</p> <p>Datum: Entity reference plane</p> | <p>For cuboid collision detection volumes, this parameter specifies the roll of the cuboid with respect to the entity's coordinate system. This parameter is ignored if <i>Volume Type</i> is set to Sphere (0).</p> |

| Parameter | Description |
|---|---|
| <p>Pitch</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: -90 – 90</p> <p>Default: IG-configurable</p> <p>Datum: Entity reference plane</p> | <p>For cuboid collision detection volumes, this parameter specifies the pitch of the cuboid with respect to the entity's coordinate system. This parameter is ignored if <i>Volume Type</i> is set to Sphere (0).</p> |
| <p>Yaw</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: 0 – 360</p> <p>Default: IG-configurable</p> <p>Datum: Entity reference coordinate system</p> | <p>For cuboid collision detection volumes, this parameter specifies the yaw of the cuboid with respect to the entity's coordinate system. This parameter is ignored if <i>Volume Type</i> is set to Sphere (0).</p> |

4.1.24 HAT/HOT Request

The **HAT/HOT Request** packet is used by the Host to request the Height Above Terrain (HAT) of a specified point and/or the Height Of Terrain (HOT) below a specified point. The point may be defined with respect to either the Geodetic coordinate system or an entity’s body coordinate system.

Each request is identified by the *HAT/HOT ID* parameter. When the IG responds to the request, it will set the *HAT/HOT ID* parameter of the response packet to match that in the request. The Host should manipulate the value of *HAT/HOT ID* so that an ID is not reused before the IG has sufficient time to process and respond to the request.

If the *Request Type* parameter is set to HAT (0) or HOT (1), the IG will respond with a **HAT/HOT Response** packet (Section 4.2.2) containing the requested datum. If the parameter is set to Extended HAT/HOT (2), the IG will respond with a **HAT/HOT Extended Response** packet (Section 4.2.3) containing *both* data, along with the surface material code and normal vector.

The IG can only return valid HAT and/or HOT data if the test point is located within the bounds of the current database. If the HAT or HOT cannot be calculated, the *Valid* parameter of the response packet will be set to Invalid (0).

Besides the range of the *HAT/HOT ID* parameter, there is no restriction on the number of HAT and/or HOT requests that can be sent in a single frame; however, the response time of the IG might be degraded as the number of requests increases.

The contents of the **HAT/HOT Request** packet are as follows:

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--------------------|---|---|---|----|---|----|---|------------------|---|---|---|---|---|---|---|------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Packet ID = 24 | | | | | | | | Packet Size = 32 | | | | | | | | HAT/HOT ID | | | | | | | | | | | | | | | |
| Reserved | | | | *2 | | *1 | | Reserved | | | | | | | | Entity ID | | | | | | | | | | | | | | | |
| Latitude/X Offset | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ----- | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Longitude/Y Offset | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ----- | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Altitude/Z Offset | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ----- | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

*1 Request Type
 *2 Coordinate System

Figure 71 – HAT/HOT Request Packet Structure

Table 30 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 30 – HAT/HOT Request Parameter Definitions

| Parameter | Description |
|---|--|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 24</p> | <p>This parameter identifies this data packet as the HAT/HOT Request packet. The value of this parameter must be 24.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 32</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 32.</p> |
| <p>HAT/HOT ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter identifies the HAT/HOT request. When the IG returns a HAT/HOT Response or HAT/HOT Extended Response packet in response to this request, the <i>HAT/HOT ID</i> parameter of that packet will contain this value to correlate the response with this request.</p> |
| <p>Request Type</p> <p>Type: unsigned 2-bit field</p> <p>Units: N/A</p> <p>Values: 0 HAT 1 HOT 2 Extended</p> | <p>This parameter determines what type of response packet the IG should return for this request.</p> <p>If this parameter is set to HAT (0), the IG will respond with a HAT/HOT Response packet containing the Height Above Terrain. If this parameter is set to HOT (1), the IG will respond with a HAT/HOT Response packet containing the Height Of Terrain. If this parameter is set to Extended (2), the IG will respond with a HAT/HOT Extended Response packet, which contains both the Height Above Terrain and the Height Of Terrain.</p> |
| <p>Coordinate System</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Geodetic 1 Entity</p> | <p>This parameter specifies the coordinate system within which the test point is defined.</p> <p>If this parameter is set to Geodetic (0), the test point is defined as a Latitude, Longitude, and Altitude. If this parameter is set to Entity (1), the test point is defined as X, Y, and Z offsets from the reference point of the entity specified by <i>Entity ID</i>.</p> |
| <p>Entity ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the entity relative to which the test point is defined. This parameter is ignored if Coordinate System is set to Geodetic (0).</p> |

| Parameter | Description |
|---|---|
| <p>Latitude (Geodetic Coordinate System)</p> <p>Type: double float</p> <p>Units: degrees</p> <p>Values: -90.0 – 90.0</p> <p>Datum: Equator</p> | <p>This parameter specifies the latitude from which the HAT/HOT request is being made.</p> |
| <p>X Offset (Entity Coordinate System)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Entity Reference Point</p> | <p>This parameter specifies the X offset of the point from which the HAT/HOT request is being made. This value is given relative to the entity's reference point.</p> |
| <p>Longitude (Geodetic Coordinate System)</p> <p>Type: double float</p> <p>Units: degrees</p> <p>Values: -180.0 – 180.0</p> <p>Datum: Prime Meridian</p> | <p>This parameter specifies the longitude from which the HAT/HOT request is being made.</p> |
| <p>Y Offset (Entity Coordinate System)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Entity Reference Point</p> | <p>This parameter specifies the Y offset of the point from which the HAT/HOT request is being made. This value is given relative to the entity's reference point.</p> |
| <p>Altitude (Geodetic Coordinate System)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Mean Sea Level</p> | <p>This parameter specifies the altitude from which the HAT/HOT request is being made.</p> <p>This parameter is ignored if <i>Request Type</i> is set to HOT (1).</p> |
| <p>Z Offset (Entity Coordinate System)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Entity Reference Point</p> | <p>This parameter specifies the Z offset of the point from which the HAT/HOT request is being made. This value is given relative to the entity's reference point.</p> |

4.1.25 Line of Sight Segment Request

Line-of-Sight (LOS) Segment testing is used to determine whether an object lies along a test segment. This type of test is typically used to determine whether one point is visible from another, or whether the point is occluded by some object. The Line of Sight test segment is defined in the **Line of Sight Segment Request** packet by a source point and a destination point.

The *LOS ID* parameter is used to correlate requests from the Host with responses from the IG. When the IG responds to a LOS request, it will copy the *LOS ID* value contained within the request to the *LOS ID* parameter of the corresponding response packet. The Host should manipulate the value of *LOS ID* so that the ID is not reused before the IG has sufficient time to respond to the LOS request. This will prevent similarly identified requests from being lost by the IG.

Note that **Line of Sight Segment Request** packets and **Line of Sight Vector Request** packets share the *LOS ID* parameter. Duplicating the *LOS ID* value between both request types can also cause data loss.

If the *Request Type* parameter is set to Basic (0), the IG will respond with a **Line of Sight Response** packet (Section 4.2.4). If the parameter is set to Extended (1), the IG will respond with a **Line of Sight Extended Response** packet (Section 4.2.5).

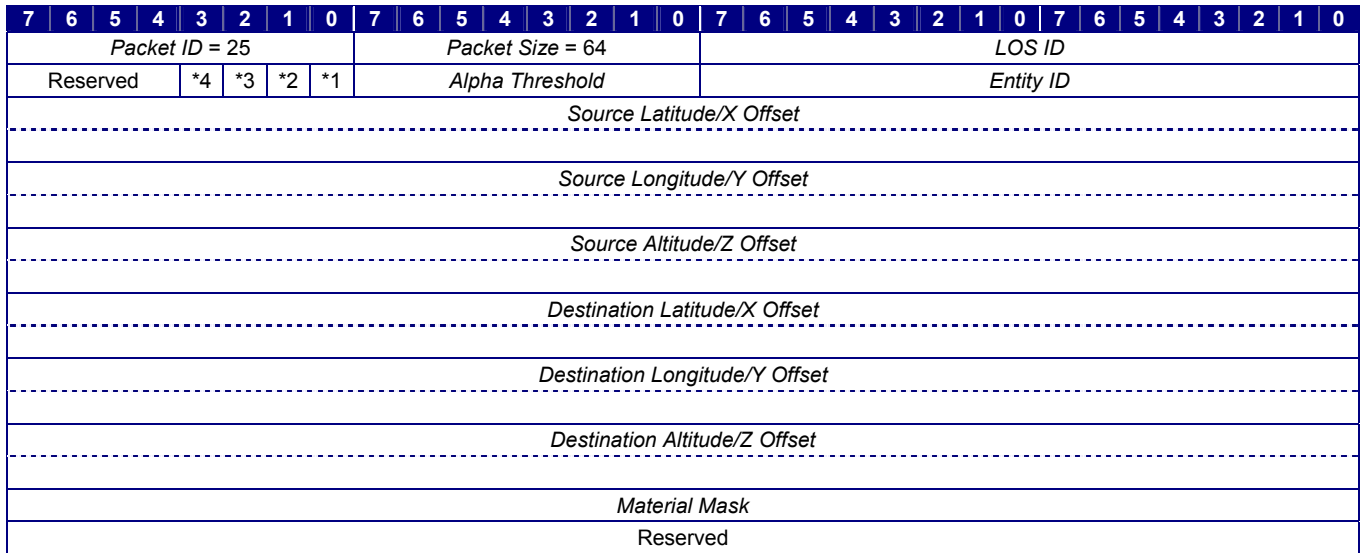
The *Alpha Threshold* parameter specifies the minimum alpha value with which an intersection should register. If an LOS test segment intersects with a surface whose alpha at the intersection point is lower than this value, no **Line of Sight Response** or **Line of Sight Extended Response** packet will be generated.

The IG can only return valid LOS data if an intersection is detected along the LOS segment. If the LOS data cannot be calculated, the *Valid* parameter of the response packet will be set to zero (0).

The IG will generate a response for each intersection along the LOS segment.

Besides the range of the *LOS ID* parameter, there is no restriction on the number of LOS requests that can be sent in a single frame; however, the response time of the IG might be degraded as the number of LOS requests increases.

The contents of the **Line of Sight Segment Request** packet are as follows:



- *1 Request Type
- *2 Source Point Coordinate System
- *3 Destination Point Coordinate System
- *4 Response Coordinate System

Figure 72 – Line of Sight Segment Request Packet Structure

Table 31 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 31 – Line of Sight Segment Request Parameter Definitions

| Parameter | Description |
|---|---|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 25</p> | <p>This parameter identifies this data packet as the Line of Sight Segment Request packet. The value of this parameter must be 25.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 64</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 64.</p> |

| Parameter | Description |
|---|--|
| <p>LOS ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter identifies the LOS request. When the IG returns a Line of Sight Response packet in response to this request, the <i>LOS ID</i> parameter of that packet will contain this value to correlate the response with this request.</p> <p>Note: Because the Line of Sight Response data packet is used for responding to both the LOS segment and LOS vector requests, the <i>LOS ID</i> value used for one request type should not be duplicated for the other request type before the IG has sufficient time to generate a response.</p> |
| <p>Request Type</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Basic 1 Extended</p> | <p>This parameter determines what type of response the IG should return for this request.</p> <p>If this parameter is set to Basic (0), the IG will respond with a Line of Sight Response packet. If this parameter is set to Extended (1), the IG will respond with a Line of Sight Extended Response packet.</p> |
| <p>Source Point Coordinate System</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Geodetic 1 Entity</p> | <p>This parameter indicates the coordinate system relative to which the test segment source endpoint is specified. If this parameter is set to Geodetic (0), then the endpoint is given by latitude, longitude, and altitude.</p> <p>If this parameter is set to Entity (1), then the endpoint is defined relative to the reference point of the entity specified by <i>Entity ID</i>.</p> |
| <p>Destination Point Coordinate System</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Geodetic 1 Entity</p> | <p>This parameter indicates the coordinate system relative to which the test segment destination endpoint is specified. If this parameter is set to Geodetic (0), then the endpoint is given by latitude, longitude, and altitude.</p> <p>If this parameter is set to Entity (1), then the endpoint is defined relative to the reference point of the entity specified by <i>Entity ID</i>.</p> |
| <p>Response Coordinate System</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Geodetic 1 Entity</p> | <p>This parameter specifies the coordinate system to be used in the response. If this parameter is set to Geodetic (0), then the intersection point will be specified by latitude, longitude, and altitude.</p> <p>If this parameter is set to Entity (1), then the intersection point will be specified relative to the reference point of the intersected entity.</p> |
| <p>Alpha Threshold</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter specifies the minimum alpha value (i.e., minimum opacity) a surface may have for an LOS response to be generated.</p> |

| Parameter | Description |
|--|--|
| <p>Entity ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the entity relative to which the test segment endpoints are defined. This parameter is ignored if <i>Source Point Coordinate System</i> and <i>Destination Point Coordinate System</i> are both set to Geodetic (0).</p> |
| <p>Source Latitude (Geodetic Coordinate System)</p> <p>Type: double float</p> <p>Units: degrees</p> <p>Values: -90.0 – 90.0</p> <p>Datum: Equator</p> | <p>If <i>Source Point Coordinate System</i> is set to Geodetic (0), this parameter specifies the latitude of the source endpoint of the LOS test segment.</p> |
| <p>Source X Offset (Entity Coordinate System)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Entity reference point</p> | <p>If <i>Source Point Coordinate System</i> is set to Entity (1), this parameter specifies the X offset of the source endpoint of the LOS test segment.</p> |
| <p>Source Longitude (Geodetic Coordinate System)</p> <p>Type: double float</p> <p>Units: degrees</p> <p>Values: -180.0 – 180.0</p> <p>Datum: Prime Meridian</p> | <p>If <i>Source Point Coordinate System</i> is set to Geodetic (0), this parameter specifies the longitude of the source endpoint of the LOS test segment.</p> |
| <p>Source Y Offset (Entity Coordinate System)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Entity reference point</p> | <p>If <i>Source Point Coordinate System</i> is set to Entity (1), this parameter specifies the Y offset of the source endpoint of the LOS test segment.</p> |

| Parameter | Description |
|---|--|
| <p>Source Altitude (Geodetic Coordinate System)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Mean Sea Level</p> | <p>If <i>Source Point Coordinate System</i> is set to Geodetic (0), this parameter specifies the altitude of the source endpoint of the LOS test segment.</p> |
| <p>Source Z Offset (Entity Coordinate System)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Entity reference point</p> | <p>If <i>Source Point Coordinate System</i> is set to Entity (1), this parameter specifies the Z offset of the source endpoint of the LOS test segment.</p> |
| <p>Destination Latitude (Geodetic Coordinate System)</p> <p>Type: double float</p> <p>Units: degrees</p> <p>Values: -90.0 – 90.0</p> <p>Datum: Equator</p> | <p>If <i>Destination Point Coordinate System</i> is set to Geodetic (0), this parameter specifies the latitude of the destination endpoint of the LOS test segment.</p> |
| <p>Destination X Offset (Entity Coordinate System)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Entity reference point</p> | <p>If <i>Destination Point Coordinate System</i> is set to Entity (1), this parameter specifies the X offset of the destination endpoint of the LOS test segment.</p> |
| <p>Destination Longitude (Geodetic Coordinate System)</p> <p>Type: double float</p> <p>Units: degrees</p> <p>Values: -180.0 – 180.0</p> <p>Datum: Prime Meridian</p> | <p>If <i>Destination Point Coordinate System</i> is set to Geodetic (0), this parameter specifies the longitude of the destination endpoint of the LOS test segment.</p> |
| <p>Destination Y Offset (Entity Coordinate System)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Entity reference point</p> | <p>If <i>Destination Point Coordinate System</i> is set to Entity (1), this parameter specifies the Y offset of the destination endpoint of the LOS test segment.</p> |

| Parameter | Description |
|---|---|
| <p>Destination Altitude (Geodetic Coordinate System)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Mean Sea Level</p> | <p>If <i>Destination Point Coordinate System</i> is set to Geodetic (0), this parameter specifies the altitude of the destination endpoint of the LOS test segment.</p> |
| <p>Destination Z Offset (Entity Coordinate System)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Entity reference point</p> | <p>If <i>Destination Point Coordinate System</i> is set to Entity (1), this parameter specifies the Z offset of the destination endpoint of the LOS test segment.</p> |
| <p>Material Mask</p> <p>Type: unsigned int32</p> <p>Units: N/A</p> <p>Default: IG-configurable</p> | <p>This parameter specifies the environmental and cultural features to be included in or excluded from consideration for LOS segment testing. Each bit represents a material code range; setting that bit to one (1) will cause the IG to register intersections with polygons whose material codes are within that range.</p> <p>Material code ranges are IG-dependent. Refer to the appropriate IG documentation for material code assignments.</p> |

4.1.26 Line of Sight Vector Request

Line-of-Sight (LOS) Vector testing is used to determine the range from a source point to an object along a test vector. Applications may include but are not limited to laser range finding, determining range to target, and testing for weight on wheels. The Line of Sight test vector emanates from the source position specified in the **Line of Sight Vector Request** packet. A minimum and a maximum range are specified in order to constrain the search.

The *LOS ID* parameter is used to correlate requests from the Host with responses from the IG. When the IG responds to a LOS request, it will copy the *LOS ID* value contained within the request to the *LOS ID* parameter of the corresponding response packet. The Host should manipulate the value of *LOS ID* so that the ID is not reused before the IG has sufficient time to respond to the LOS request. This will prevent similarly identified requests from being lost by the IG.

Note that **Line of Sight Segment Request** packets and **Line of Sight Vector Request** packets share the *LOS ID* parameter. Duplicating the *LOS ID* value between both request types can also cause data loss.

If the *Request Type* parameter is set to Basic (0), the IG will respond with a **Line of Sight Response** packet (Section 4.2.4). If the parameter is set to Extended (1), the IG will respond with a **Line of Sight Extended Response** packet (Section 4.2.5).

The *Alpha Threshold* parameter specifies the minimum alpha value with which an intersection should register. If an LOS test vector intersects with a surface whose alpha at the intersection point is lower than this value, no **Line of Sight Response** or **Line of Sight Extended Response** packet will be generated.

The IG can only return valid LOS data if an intersection is detected along the LOS segment, that is, between the minimum and maximum ranges specified. If the LOS data cannot be calculated, the *Valid* parameter of the response packet will be set to zero (0).

The IG will generate a response for each intersection along the LOS vector.

Besides the range of the *LOS ID* parameter, there is no restriction on the number of LOS requests that can be sent in a single frame; however, the response time of the IG might be degraded as the number of LOS requests increases.

The contents of the **Line of Sight Vector Request** packet are as follows:

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---------------------------|---|---|---|----|---|----|---|------------------|---|-----------------|---|---|---|---|---|--------|---|-----------|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Packet ID = 26 | | | | | | | | Packet Size = 56 | | | | | | | | LOS ID | | | | | | | | | | | | | | | |
| Reserved | | | | *3 | | *2 | | *1 | | Alpha Threshold | | | | | | | | Entity ID | | | | | | | | | | | | | |
| Azimuth | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Elevation | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Minimum Range | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Maximum Range | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Source Latitude/X Offset | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ----- | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Source Longitude/Y Offset | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ----- | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Source Altitude/Z Offset | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ----- | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Material Mask | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Reserved | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

- *1 Request Type
- *2 Source Point Coordinate System
- *3 Response Coordinate System

Figure 73 – Line of Sight Vector Request Packet Structure

Table 32 defines each parameter's data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 32 – Line of Sight Vector Request Parameter Definitions

| Parameter | Description |
|---|--|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 26</p> | <p>This parameter identifies this data packet as the Line of Sight Vector Request packet. The value of this parameter must be 26.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 56</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 56.</p> |
| <p>LOS ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter identifies the LOS request. When the IG returns a Line of Sight Response packet in response to this request, the <i>LOS ID</i> parameter of that packet will contain this value to correlate the response with this request.</p> <p>Note: Because the Line of Sight Response data packet is used for responding to both the LOS segment and LOS vector requests, the <i>LOS ID</i> value used for one request type should not be duplicated for the other request type before the IG has sufficient time to generate a response.</p> |
| <p>Request Type</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Basic 1 Extended</p> | <p>This parameter determines what type of response the IG should return for this request.</p> <p>If this parameter is set to Basic (0), the IG will respond with a Line of Sight Response packet. If this parameter is set to Extended (1), the IG will respond with a Line of Sight Extended Response packet.</p> |

| Parameter | Description |
|---|---|
| <p>Source Point Coordinate System</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Geodetic 1 Entity</p> | <p>This parameter indicates the coordinate system relative to which the test vector source point is specified. If this parameter is set to Geodetic (0), then the point is given by latitude, longitude, and altitude. The vector, specified by <i>Azimuth</i> and <i>Elevation</i>, is defined relative to the Geodetic coordinate system.</p> <p>If this parameter is set to Entity (1), then the point is defined relative to the reference point of the entity specified by <i>Entity ID</i>. The vector is also specified relative to the entity's coordinate system.</p> <p>Note: The value of this parameter also determines the coordinate system in which the response data are given.</p> |
| <p>Response Coordinate System</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Geodetic 1 Entity</p> | <p>This parameter specifies the coordinate system to be used in the response. If this parameter is set to Geodetic (0), then the intersection point will be specified by latitude, longitude, and altitude.</p> <p>If this parameter is set to Entity (1), then the intersection point will be specified relative to the reference point of the intersected entity.</p> |
| <p>Alpha Threshold</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter specifies the minimum alpha value (i.e., minimum opacity) a surface may have for an LOS response to be generated.</p> |
| <p>Entity ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the entity relative to which the test segment endpoints are defined. This parameter is ignored if <i>Source Point Coordinate System</i> is set to Geodetic (0).</p> |
| <p>Azimuth</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: -180.0 – 180.0</p> <p>Datum: If <i>Source Point Coordinate System</i> = 0: True North If <i>Source Point Coordinate System</i> = 1: Submodel's +X axis</p> | <p>This parameter specifies the horizontal angle of the LOS test vector.</p> |

| Parameter | Description |
|---|---|
| <p>Elevation</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: -90.0 – 90.0</p> <p>Datum: If <i>Source Point Coordinate System</i> = 0: Geodetic reference plane If <i>Source Point Coordinate System</i> = 1: Submodel reference plane</p> | <p>This parameter specifies the vertical angle of the LOS test vector.</p> |
| <p>Minimum Range</p> <p>Type: single float</p> <p>Units: meters</p> <p>Values: ≥ 0</p> <p>Datum: LOS test vector source point</p> | <p>This parameter specifies the minimum range along the LOS test vector at which intersection testing should occur.</p> |
| <p>Maximum Range</p> <p>Type: single float</p> <p>Units: meters</p> <p>Values: $> \text{Minimum Range}$</p> <p>Datum: LOS test vector source point</p> | <p>This parameter specifies the maximum range along the LOS test vector at which intersection testing should occur.</p> |
| <p>Source Latitude (Geodetic Coordinate System)</p> <p>Type: double float</p> <p>Units: degrees</p> <p>Values: -90 – 90</p> <p>Datum: Equator</p> | <p>If Source point Coordinate System is set to Geodetic (0), this parameter specifies the latitude of the source point of the LOS test vector.</p> |
| <p>Source X Offset (Entity Coordinate System)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Entity reference point</p> | <p>If <i>Source Point Coordinate System</i> is set to Entity (1), this parameter specifies the X offset of the source point of the LOS test vector.</p> |

| Parameter | Description |
|--|--|
| <p>Source Longitude (Geodetic Coordinate System)</p> <p>Type: double float</p> <p>Units: degrees</p> <p>Values: -180 – 180</p> <p>Datum: Prime Meridian</p> | <p>If Source point Coordinate System is set to Geodetic (0), this parameter specifies the longitude of the source point of the LOS test vector.</p> |
| <p>Source Y Offset (Entity Coordinate System)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Entity reference point</p> | <p>If <i>Source Point Coordinate System</i> is set to Entity (1), this parameter specifies the Y offset of the source point of the LOS test vector.</p> |
| <p>Source Altitude (Geodetic Coordinate System)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Mean Sea Level</p> | <p>If <i>Source Point Coordinate System</i> is set to Geodetic (0), this parameter specifies the altitude of the source point of the LOS test vector.</p> |
| <p>Source Z Offset (Entity Coordinate System)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Entity reference point</p> | <p>If <i>Source Point Coordinate System</i> is set to Entity (1), this parameter specifies the Z offset of the source point of the LOS test vector.</p> |
| <p>Material Mask</p> <p>Type: unsigned int32</p> <p>Units: N/A</p> | <p>This parameter specifies the environmental and cultural features to be included in LOS segment testing. Each bit represents a material code range; setting that bit to one (1) will cause the IG to register intersections with polygons whose material codes are within that range.</p> <p>Material code ranges are IG-dependent. Refer to the appropriate IG documentation for material code assignments.</p> |

4.1.27 Position Request

The **Position Request** packet is used to query the IG for the current position of an entity, articulated part, view, view group, or motion tracker. This feature is useful for determining the locations of autonomous IG-driven entities, child entities and articulated parts, and view eyepoints. It can also be used for determining the instantaneous position and orientation of head trackers and other tracked input devices.

The contents of the **Position Request** packet are as follows:

| | | | |
|---------------------|-----------------|-----------------|-----------------|
| 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |
| Packet ID = 27 | Packet Size = 8 | Object ID | |
| Articulated Part ID | *4 | *3 | *2 *1 |
| | | Reserved | |

- *1 Update Mode
- *2 Object Class
- *3 Coordinate System
- *4 Reserved

Figure 74 – Position Request Packet Structure

Table 33 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 33 – Position Request Parameter Definitions

| Parameter | Description |
|---|---|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 27</p> | <p>This parameter identifies this data packet as the Position Request packet. The value of this parameter must be 27.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 8</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 8.</p> |
| <p>Object ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> <p>Values: If <i>Object Class</i> = 0: 0 – 65,535 If <i>Object Class</i> = 1: 0 – 65,535 If <i>Object Class</i> = 2: 0 – 65,535 If <i>Object Class</i> = 3: 1 – 255 If <i>Object Class</i> = 4: 0 – 255</p> | <p>This parameter identifies the entity, view, view group, or motion tracking device whose position is being requested.</p> <p>If <i>Object Class</i> is set to Articulated Part (1), this parameter specifies the entity whose part is identified by the <i>Articulated Part ID</i> parameter.</p> |

| Parameter | Description |
|---|--|
| <p>Articulated Part ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter identifies the articulated part whose position is being requested. The entity to which the part belongs is specified by the <i>Object ID</i> parameter.</p> <p>This parameter is valid only when <i>Object Class</i> is set to Articulated Part (1).</p> |
| <p>Update Mode</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 One-Shot 1 Continuous</p> | <p>This parameter specifies whether the IG should report the position of the requested object each frame. If this parameter is set to One-Shot (0), the IG should report the position only one time.</p> |
| <p>Object Class</p> <p>Type: unsigned 3-bit field</p> <p>Units: N/A</p> <p>Values: 0 Entity 1 Articulated Part 2 View 3 View Group 4 Motion Tracker</p> | <p>This parameter specifies the type of object whose position is being requested.</p> |
| <p>Coordinate System</p> <p>Type: unsigned 2-bit field</p> <p>Units: N/A</p> <p>Values: 0 Geodetic 1 Parent Entity 2 Submodel</p> | <p>This parameter specifies the desired coordinate system relative to which the position and orientation should be given.</p> <p>Geodetic – Position will be specified as a geodetic latitude, longitude, and altitude. Orientation is given with respect to the reference plane shown in Figure 17, page 22.</p> <p>Parent Entity – Position and orientation are with respect to the entity to which the specified entity or view is attached. This value is invalid for top-level entities.</p> <p>Submodel – Position and orientation will be specified with respect to the articulated part's reference coordinate system as described in Section 3.3.3. This value is valid only when <i>Object Class</i> is set to Articulated Part (1).</p> <p>Note: If <i>Object Class</i> is set to Motion Tracker (3), The coordinate system is defined by the tracking device and this parameter is ignored.</p> |

4.1.28 Environmental Conditions Request

At any given location, it may be impossible for the Host to determine exactly the visibility range, air temperature, or other atmospheric or surface conditions. One factor is that various IG implementations may differ in how they calculate values across transition bands and within overlapping regions. Random phenomena such as winds aloft, scud, and wave activity may also make determining instantaneous conditions at a specific point impossible.

The **Environmental Conditions Request** packet is used by the Host to request the state of the environment at a specific location. The *Request Type* parameter determines what data are returned by the IG. Each request type is represented by a power of two (i.e., a unique bit), so request types may be combined by adding or bit-wise ORing the values together.

For a given test point, the IG may respond with no more than one of each of the **Maritime Surface Conditions Response** and **Weather Conditions Response** packets. For terrestrial surface conditions requests, the IG should respond with one **Terrestrial Surface Conditions Response** packet for each surface condition type or attribute present at the test point. If the *Request Type* parameter specifies that aerosol concentrations should be returned, the IG must send a **Weather Conditions Aerosol Response** packet for each weather layer that encompasses the test point.

For example, assume that two overlapping environmental regions have been defined, each containing a weather layer. The vertical ranges of the weather layers overlap, and both layers have the same layer ID. A test point is contained within both layers as illustrated in Figure 75:

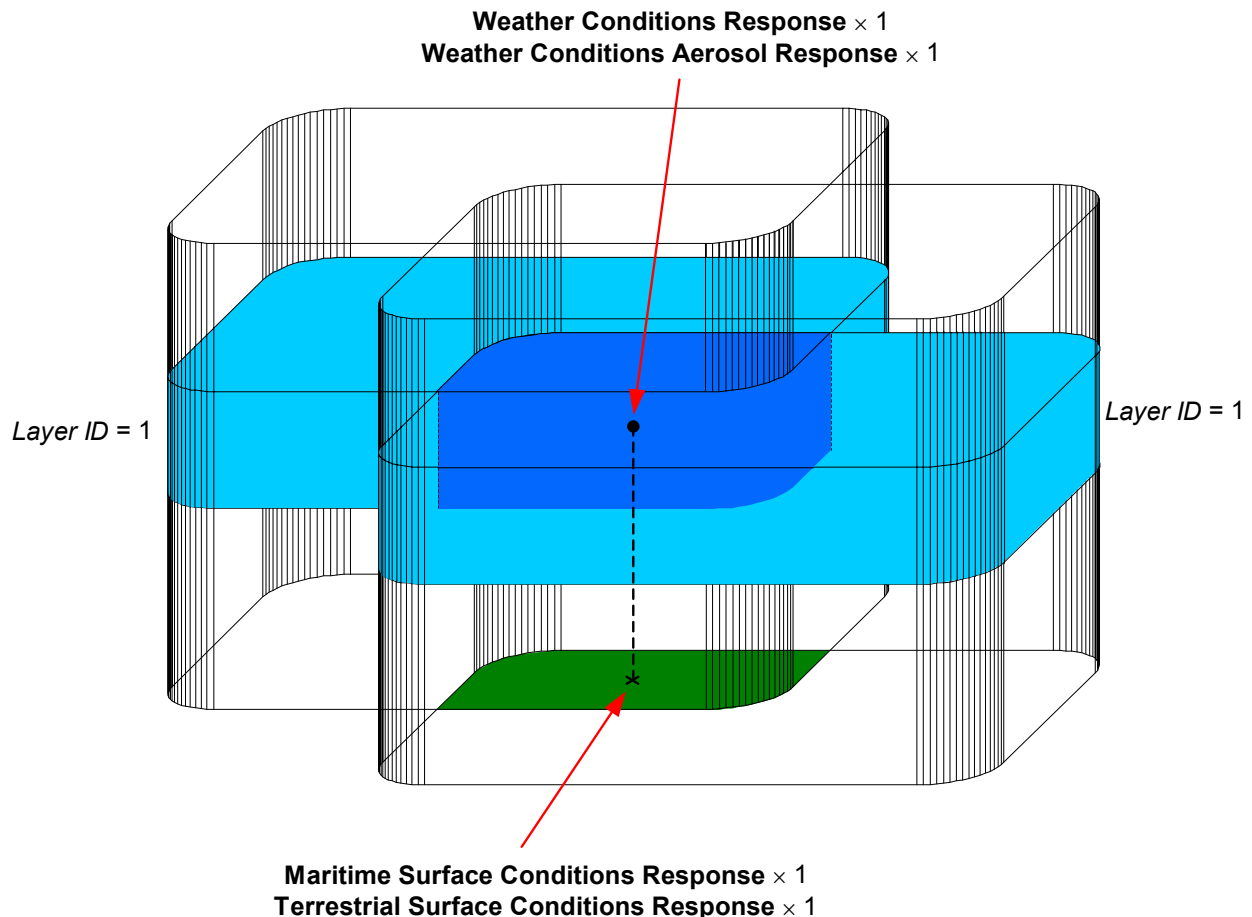


Figure 75 – Environmental Conditions Request (Weather Layers with Same ID)

The Host would send an **Environmental Conditions Request** packet to the IG, specifying the geodetic position of the test point. For this example, assume that the Host requires the weather conditions and aerosol concentrations at that point plus the terrestrial and maritime surface conditions on the terrain directly below that point. The value of the *Request Type* parameter of this packet would therefore be 15, which is the sum of the values corresponding to each request type. This is shown in Figure 76.

The IG would answer the request with each of the required response packets. Note that the IG would populate the *Request ID* parameter of each response packet with the value of the *Request ID* parameter in the **Environmental Conditions Request** packet. The following diagram illustrates this exchange of data between the Host and IG:

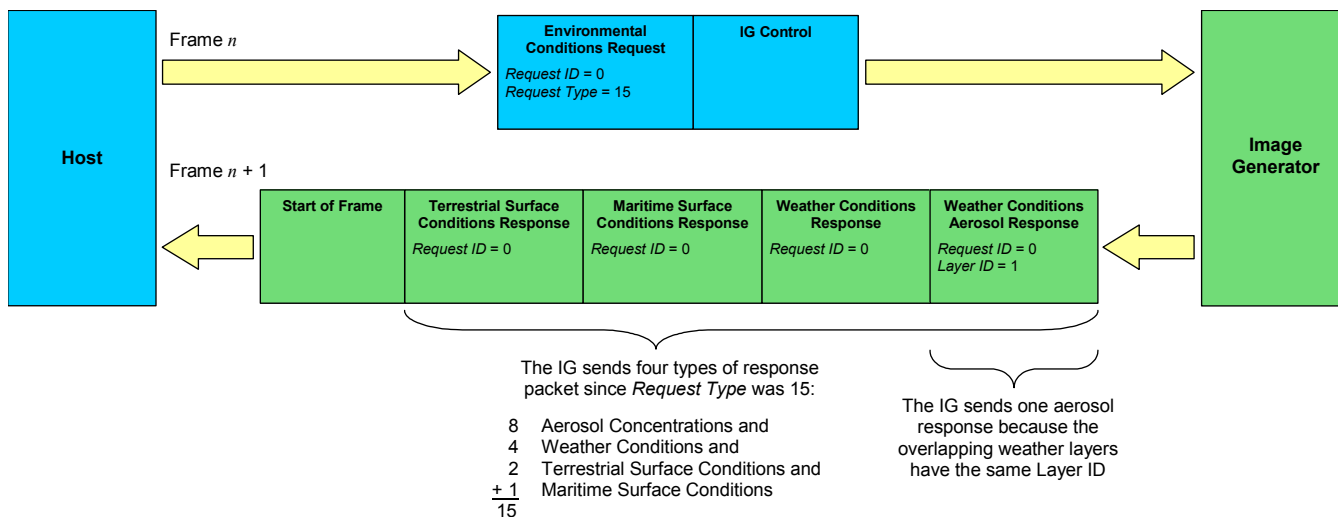


Figure 76 – Data Exchange for Environmental Conditions Request (One Aerosol)

Because the *Layer ID* of both weather layers is the same, the IG would send only one **Weather Conditions Aerosol Response** packet. This packet would contain the average (or the result of some other appropriate combining function) of the concentrations of the aerosol contained within Layer 1 of each of the two regions. In this case, the layer ID corresponds to a cloud layer, so the aerosol is liquid water. This allows for the creation of a composite weather volume in which the aerosol is more or less continuous through regions of intersection.

On the other hand, the overlapping weather layers might have different layer IDs as shown below:

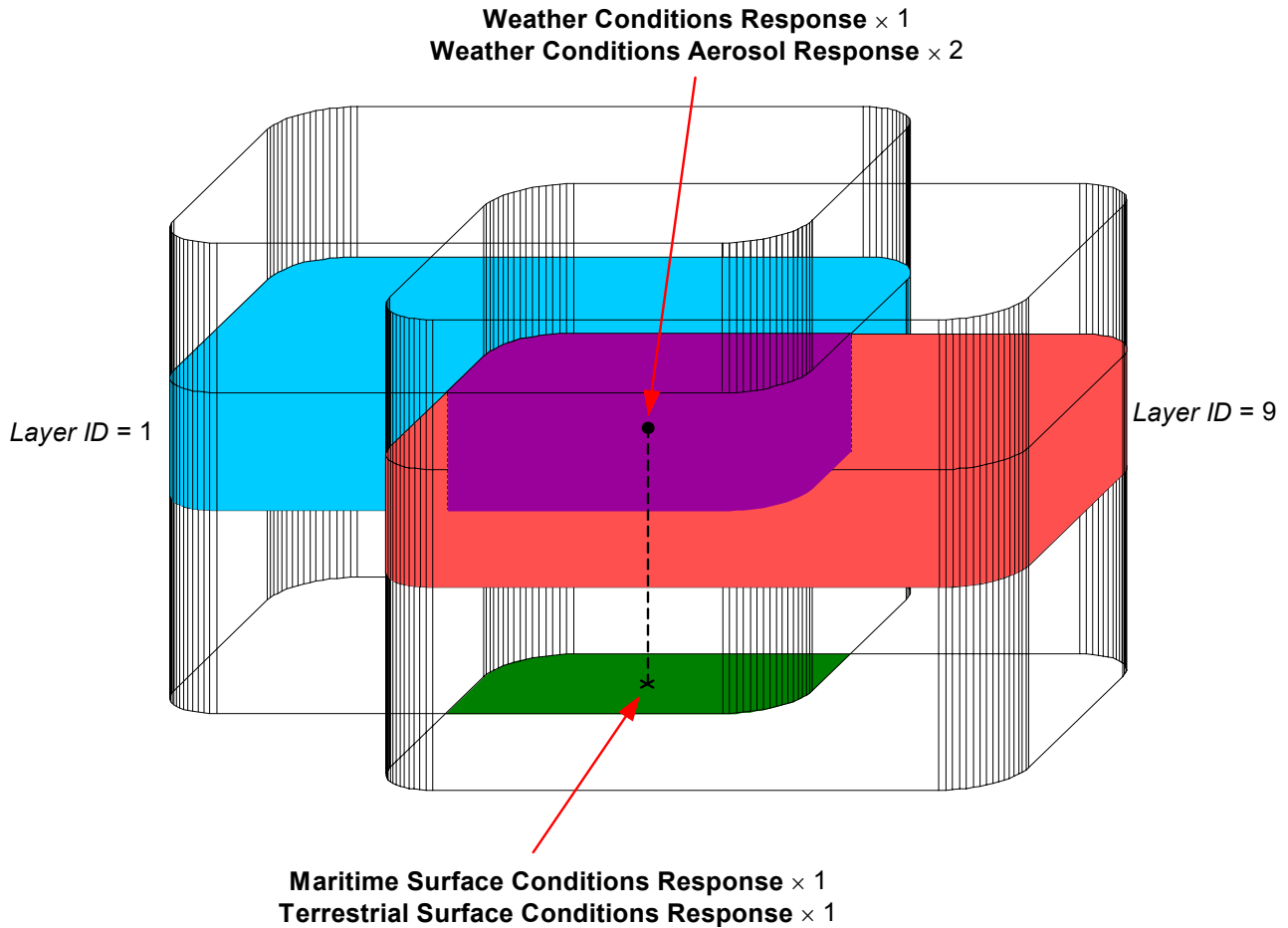


Figure 77 – Environmental Conditions Request (Weather Layers with Different IDs)

The figure above shows a cloud layer (Layer 1) overlapping with a dust layer (Layer 9). Given the same environmental conditions request, the IG would now send two **Weather Conditions Aerosol Response** packets:

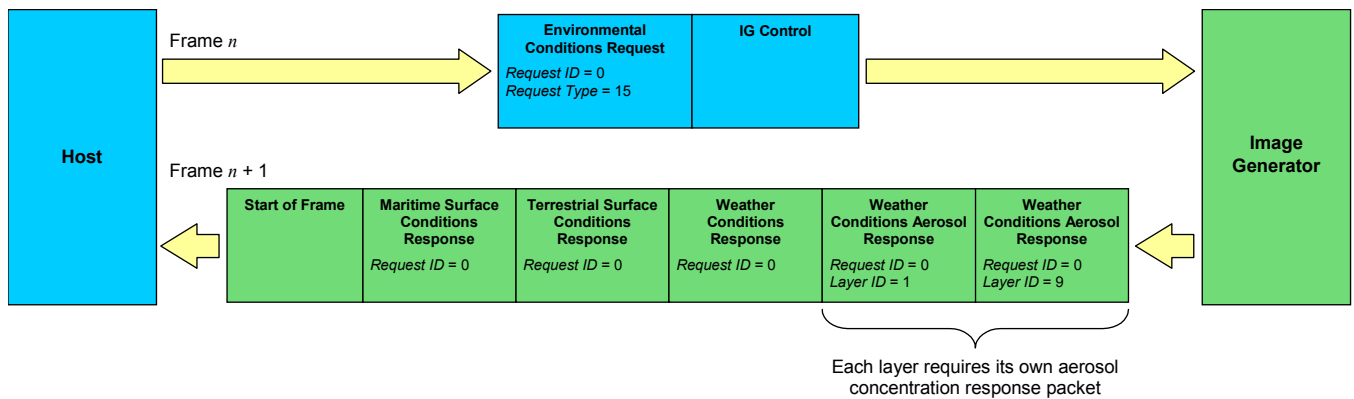
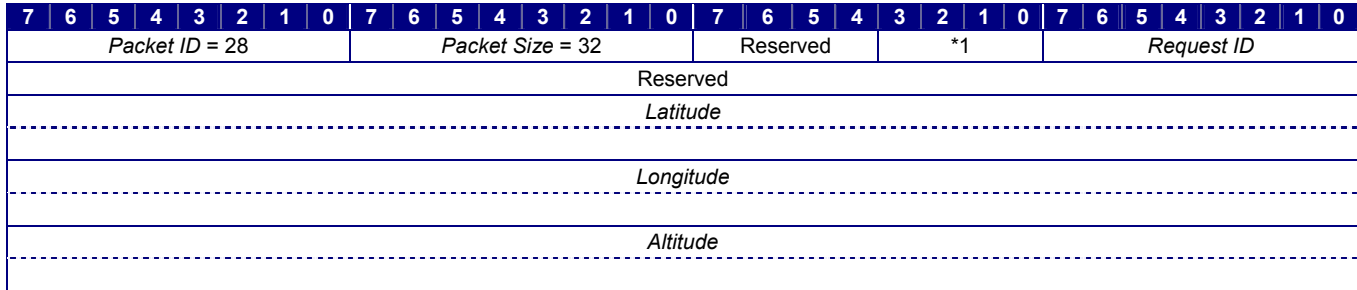


Figure 78 – Data Exchange for Environmental Conditions Request (Two Aerosols)

The *Layer ID* parameter of each response packet would correspond to the layer, thus identifying the aerosol. The concentrations of the two aerosols are independent of each other, so each layer requires its own respective **Weather Conditions Aerosol Response** packet.

The contents of the **Environmental Conditions Request** packet are as follows:



*1 *Request Type*

Figure 79 – Environmental Conditions Request Packet Structure

Table 34 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 34 – Environmental Conditions Request Parameter Definitions

| Parameter | Description |
|---|--|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 28</p> | <p>This parameter identifies this data packet as the Environmental Conditions Request packet. The value of this parameter must be 28.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 32</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 32.</p> |

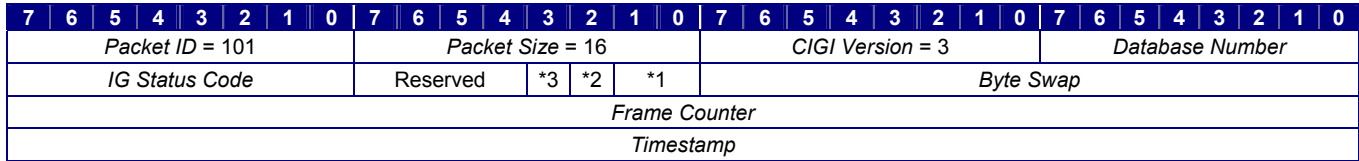
| Parameter | Description |
|--|---|
| <p>Request Type</p> <p>Type: unsigned 4-bit field</p> <p>Units: N/A</p> <p>Values: 1 Maritime Surface Conditions 2 Terrestrial Surface Conditions 4 Weather Conditions 8 Aerosol Concentrations</p> | <p>This parameter specifies the desired response type for the request. The numerical values listed at left may be combined by addition or bit-wise OR. The resulting value may be any combination of the following:</p> <p>Maritime Surface Conditions – The IG will respond with a Maritime Surface Conditions Response packet (Section 4.2.11).</p> <p>Terrestrial Surface Conditions – The IG will respond with a Terrestrial Surface Conditions Response packet (Section 4.2.12).</p> <p>Weather Conditions – The IG will respond with a Weather Conditions Response packet (Section 4.2.9).</p> <p>Aerosol Concentrations – The IG will send exactly one Aerosol Concentration Response packet (Section 4.2.10) for each weather layer (regardless of scope) that encompasses that location.</p> |
| <p>Request ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter identifies the environmental conditions request. When the IG returns a responds to the request, each response packet(s) will contain this value in its <i>Request ID</i> parameter.</p> |
| <p>Latitude</p> <p>Type: double float</p> <p>Units: degrees</p> <p>Values: -90.0 – 90.0</p> <p>Datum: Equator</p> | <p>This parameter specifies the geodetic latitude at which the environmental state is requested.</p> |
| <p>Longitude</p> <p>Type: double float</p> <p>Units: degrees</p> <p>Values: -180.0 – 180.0</p> <p>Datum: Prime Meridian</p> | <p>This parameter specifies the geodetic longitude at which the environmental state is requested.</p> |
| <p>Altitude</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Mean Sea Level</p> | <p>This parameter specifies the geodetic altitude at which the environmental state is requested.</p> <p>This parameter is used only for weather conditions and aerosol concentrations requests.</p> |

4.2 IG-to-Host Packets

4.2.1 Start of Frame

The **Start of Frame** packet is used to signal the beginning of a new frame. Every IG-to-Host message must contain *exactly one* **Start of Frame** packet. This packet must be the *first* packet in the message.

The contents of the **Start of Frame** packet are as follows:



- *1 *IG Mode*
- *2 *Timestamp Valid*
- *3 *Earth Reference Model*

Figure 80 – Start of Frame Packet Structure

Table 35 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 35 – Start of Frame Parameter Definitions

| Parameter | Description |
|---|---|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 101</p> | <p>This parameter identifies this data packet as the Start of Frame packet. The value of this parameter must be 101.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 16</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 16.</p> |
| <p>CIGI Version</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 3</p> | <p>This parameter indicates the version of the CIGI interface that is currently being used by the Host. The IG can use this number to determine concurrency. The value of this parameter must be 3.</p> |

| Parameter | Description |
|--|---|
| <p>Database Number</p> <p>Type: int8</p> <p>Units: N/A</p> <p>Values: -128 Indicates database is not available -127 -- -1 Identifies database being loaded 1 – 127 Identifies database that is loaded 0 Indicates IG controls database loading</p> <p>Default: 1</p> | <p>This parameter is used to indicate to the Host which database is currently in use and if that database is being loaded into primary memory.</p> <p>The Host will set the <i>Database Number</i> parameter of the IG Control packet to direct the IG to begin loading the corresponding database. The IG will indicate that the database is being loaded by negating the value and placing it in the <i>Database Number</i> parameter of the Start of Frame packet. The Host will then acknowledge this change by setting the <i>Database Number</i> parameter of the IG Control packet to zero (0).</p> <p>When the database load is complete <i>and</i> after the Host has acknowledged the database change, the IG will set this parameter to the positive database number. The IG can now be considered mission-ready.</p> <p>If the Host requests a database that does not exist or cannot be loaded, the IG will set this parameter to -128.</p> <p>Zero (0) is used to indicate that the IG controls the database loading.</p> <p>Refer to Section 4.1.1 for more information about the IG Control packet.</p> |
| <p>IG Status Code</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Values: 0 Normal operation 1 – 255 Defined by IG</p> | <p>This parameter indicates the error status of the IG. Error codes are IG-specific. Refer to the appropriate IG documentation for a list of error codes.</p> <p>If more than one error is detected, the IG will report the one with the highest priority.</p> <p>If additional error reporting must be performed, the IG should be placed in Debug mode via the IG Control packet's <i>IG Mode</i> parameter or the IG's user interface.</p> |

| Parameter | Description |
|---|---|
| <p>IG Mode</p> <p>Type: unsigned 2-bit field</p> <p>Units: N/A</p> <p>Values: 0 Reset/Standby 1 Operate 2 Debug 3 Offline Maintenance</p> <p>Default: 0</p> | <p>This parameter indicates the current IG mode. It may be one of the following values:</p> <p>Reset/Standby – This is the IG’s initial state upon start-up. When set to this mode, the IG will initialize/reinitialize the simulation. All entities that were instantiated during a previous mission will be destroyed. All environmental properties, views, components, and sensors will revert to their default settings. Any Host-defined rates, trajectories, and collision detection segments and volumes will be removed. The IG will only send the Start of Frame data packet to the Host and will ignore Host inputs except for the <i>IG Mode</i> parameter of the IG Control data packet. The IG will remain in this mode until directed otherwise by the Host or the IG’s user interface.</p> <p>Operate – This is the normal real-time operating mode for the IG. All packets issued by the Host will be processed by the IG. The IG should not perform diagnostics in this mode.</p> <p>Debug – This mode is similar to the Operate mode but provides data and/or error logging and other debugging features to aid integration or troubleshooting of the Host and IG interface. Because of the overhead of these debugging features, the IG may not always operate in a hard real-time fashion.</p> <p>Offline Maintenance – In this mode, the IG ignores all data from the Host and sends only Start of Frame packets. This mode can be activated only from the IG. Because the IG Control packets from the Host are ignored by the IG, the IG must be placed into Reset/Standby mode before the Host can initiate further mode changes.</p> |
| <p>Timestamp Valid</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Invalid 1 Valid</p> | <p>This parameter indicates whether the <i>Timestamp</i> parameter contains a valid value.</p> <p>Because the <i>Timestamp</i> parameter is required for asynchronous operation, <i>Timestamp Valid</i> must be set to Valid (1) in this mode.</p> |

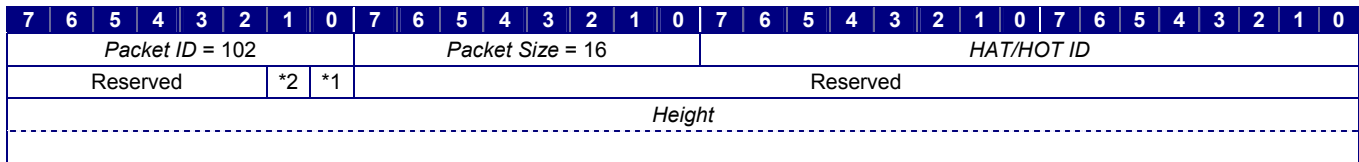
| Parameter | Description |
|---|--|
| <p>Earth Reference Model</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 WGS 84 1 Host-Defined</p> <p>Default: 0</p> | <p>This parameter indicates whether the IG is using a custom (Host-defined) Earth Reference Model (ERM) or the default WGS 84 reference ellipsoid for coordinate conversion calculations. Host-defined ERMs are defined with the Earth Reference Model Definition packet (see Section 4.1.19).</p> <p>If the Host defines an ERM that the IG cannot support, this value is set to WGS 84 (0). In such cases, the Host must redefine the ERM or use the WGS 84 reference ellipsoid.</p> |
| <p>Byte Swap</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> <p>Values: 8000h No byte swap (see note at right) 80h Byte swap</p> | <p>This parameter is used by the Host to determine whether it needs to byte-swap incoming data. Refer to Section 2.1.3 for details on this mechanism.</p> <p>Note: The IG <i>must</i> set this value to 8000h, or 32768.</p> |
| <p>Frame Counter</p> <p>Type: unsigned int32</p> <p>Units: N/A</p> | <p>This parameter contains a number that identifies the frame. This number correlates the IG-to-Host message to the successive Host-to-IG response message.</p> |
| <p>Timestamp</p> <p>Type: unsigned int32</p> <p>Units: 10 microseconds (μs)</p> | <p>This parameter indicates the number of 10μs “ticks” since some initial reference time. This will enable the IG to correct for latencies as described in Section 2.1.1.1.</p> <p>The 10μs unit allows the simulation to run for approximately 12 hours before a timestamp rollover occurs. The Host software should contain logic to detect and correct for rollover.</p> <p>The use of this parameter is required for asynchronous operation.</p> <p>The use of this parameter is optional for synchronous operation. If this parameter does not contain a valid timestamp, the <i>Timestamp Valid</i> parameter should be set to zero (0).</p> |

4.2.2 HAT/HOT Response

The **HAT/HOT Response** packet is sent by the IG in response to a **HAT/HOT Request** packet (Section 4.1.24) whose *Request Type* parameter was set to HAT (0) or HOT (1). This packet provides either the Height Above Terrain (HAT) or Height Of Terrain (HOT) for the test point. This packet does not contain the material code or surface normal of the terrain.

The IG can only return the HAT or HOT for a point that is within the bounds of the current database. If the HAT or HOT cannot be returned, the *Valid* parameter will be set to Invalid (0).

The contents of the **HAT/HOT Response** packet are as follows:



*1 *Valid*
*2 *Response Type*

Figure 81 – HAT/HOT Response Packet Structure

Table 36 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 36 – HAT/HOT Response Parameter Definitions

| Parameter | Description |
|---|---|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 102</p> | <p>This parameter identifies this data packet as the HAT/HOT Response packet. The value of this parameter must be 102.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 16</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 16.</p> |
| <p>HAT/HOT ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter identifies the HAT or HOT response. This value corresponds to the value of the <i>HAT/HOT ID</i> parameter in the associated HAT/HOT Request packet.</p> |

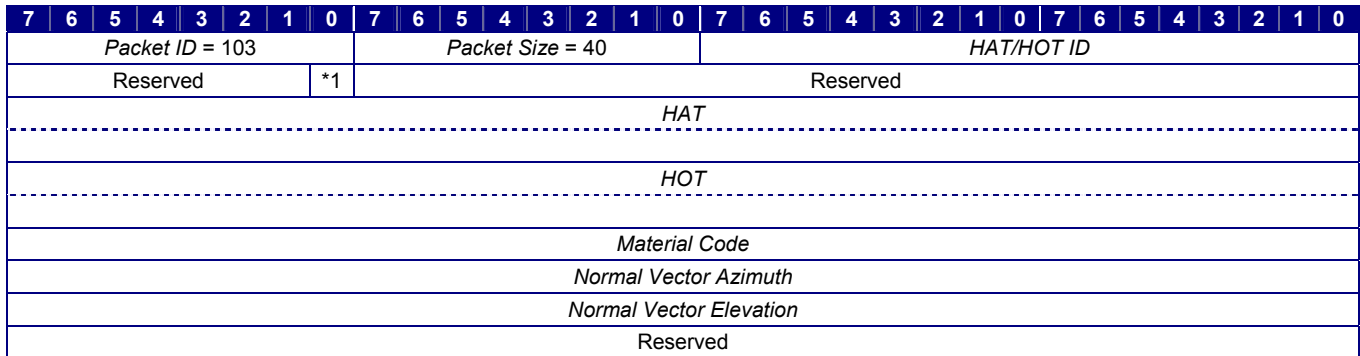
| Parameter | Description |
|---|--|
| <p>Valid</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Invalid 1 Valid</p> | <p>This parameter indicates whether the <i>Height</i> parameter contains a valid number. A value of zero (0) indicates that the test point was beyond the database bounds.</p> |
| <p>Response Type</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 HAT 1 HOT</p> | <p>This parameter indicates whether the <i>Height</i> parameter represents Height Above Terrain or Height Of Terrain.</p> |
| <p>Height</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: For HAT: Terrain/Sea Surface Height For HOT: Mean Sea Level</p> | <p>This parameter contains the requested height. If <i>Request Type</i> is set to HAT (0), this value represents the Height Above Terrain. If <i>Request Type</i> is set to HOT (1), this value represents the Height Of Terrain.</p> <p>This parameter is valid only if the <i>Valid</i> parameter is set to one (1).</p> |

4.2.3 HAT/HOT Extended Response

The **HAT/HOT Extended Response** packet is sent by the IG in response to a **HAT/HOT Request** packet (Section 4.1.24) whose *Request Type* parameter was set to Extended (2). This packet provides the Height Above Terrain (HAT) and Height Of Terrain (HOT) for the test point. This packet also contains the material code and surface-normal unit vector of the terrain.

The IG can only return the HAT and HOT for a point that is within the bounds of the current database. Likewise, the material code and normal vector can only be calculated within the database bounds. If these data cannot be returned, the *Valid* parameter will be set to zero (0).

The contents of the **HAT/HOT Extended Response** packet are as follows:



*1 *Valid*

Figure 82 – HAT/HOT Extended Response Packet Structure

Table 37 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 37 – HAT/HOT Extended Response Parameter Definitions

| Parameter | Description |
|---|--|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 103</p> | <p>This parameter identifies this data packet as the HAT/HOT Extended Response packet. The value of this parameter must be 103.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 40</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 40.</p> |

| Parameter | Description |
|--|---|
| <p>HAT/HOT ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter identifies the HAT/HOT response. This value corresponds to the value of the <i>HAT/HOT ID</i> parameter in the associated HAT/HOT Request packet.</p> |
| <p>Valid</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Invalid 1 Valid</p> | <p>This parameter indicates whether the remaining parameters in this packet contain valid numbers. A value of zero (0) indicates that the test point was beyond the database bounds.</p> |
| <p>HAT</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Terrain/Sea Surface Height</p> | <p>This parameter indicates the height of the test point above the terrain. A negative value indicates that the test point is below the terrain.</p> <p>This parameter is valid only if the <i>Valid</i> parameter is set to one (1).</p> |
| <p>HOT</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Mean Sea Level</p> | <p>This parameter indicates the height of terrain above or below the test point. This value is relative to the ellipsoid height, or Mean Sea Level.</p> <p>This parameter is valid only if the <i>Valid</i> parameter is set to one (1).</p> |
| <p>Material Code</p> <p>Type: unsigned int32</p> <p>Units: N/A</p> | <p>This parameter indicates the material code of the terrain surface at the point of intersection with the HAT/HOT test vector.</p> <p>This parameter is valid only if the <i>Valid</i> parameter is set to one (1).</p> |
| <p>Normal Vector Azimuth</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: -180.0 – 180.0</p> <p>Datum: True North</p> | <p>This parameter indicates the azimuth of the normal unit vector of the surface intersected by the HAT/HOT test vector. This value is the horizontal angle from True North to the vector.</p> <p>This parameter is valid only if the <i>Valid</i> parameter is set to one (1).</p> |

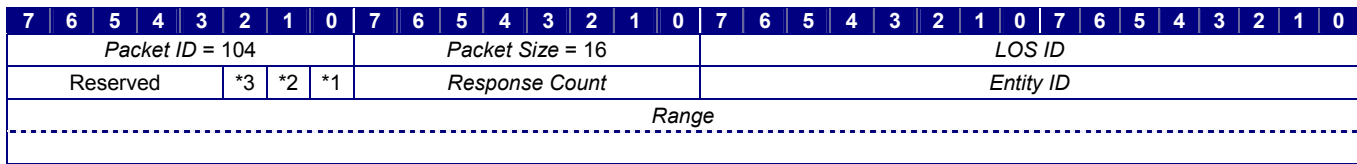
| Parameter | Description |
|---|--|
| Normal Vector Elevation Type: single float Units: degrees Values: -90.0 – 90.0 Datum: Geodetic reference plane (Section 3.3.1.2) | This parameter indicates the elevation of the normal unit vector of the surface intersected by the HAT/HOT test vector. This value is the vertical angle from the geodetic reference plane to the vector. This parameter is valid only if the <i>Valid</i> parameter is set to one (1). |

4.2.4 Line of Sight Response

The **Line of Sight Response** packet is used in response to both the **Line of Sight Segment Request** and **Line of Sight Vector Request** packets. This packet contains the distance from the Line of Sight (LOS) segment or vector source point to the point of intersection with a polygon surface. The packet is sent when the *Request Type* parameter of the request packet is set to Basic (0).

A **Line of Sight Response** packet will be sent for each intersection along the LOS segment or vector. The *Response Count* parameter will contain the total number of responses that are being returned. This will allow the Host to determine when all response packets for the given request have been received.

The contents of the **Line of Sight Response** packet are as follows:



- *1 Valid
- *2 Entity ID Valid
- *3 Visible

Figure 83 – Line of Sight Response Packet Structure

Table 38 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 38 – Line of Sight Response Parameter Definitions

| Parameter | Description |
|--|---|
| Packet ID Type: unsigned int8 Units: N/A Value: 104 | This parameter identifies this data packet as the Line of Sight Response packet. The value of this parameter must be 104. |
| Packet Size Type: unsigned int8 Units: Bytes Value: 16 | This parameter indicates the number of bytes in this data packet. The value of this parameter must be 16. |
| LOS ID Type: unsigned int16 Units: N/A | This parameter identifies the LOS response. This value corresponds to the value of the <i>LOS ID</i> parameter in the associated Line of Sight Segment Request packet (Section 4.1.25) or Line of Sight Vector Request packet (Section 4.1.26). |

| Parameter | Description |
|--|--|
| <p>Valid</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Invalid 1 Valid</p> | <p>This parameter indicates whether the <i>Range</i> parameter is valid. The range will be invalid if no intersection occurs, or if an intersection occurs before the minimum range or beyond the maximum range specified in a LOS vector request.</p> |
| <p>Entity ID Valid</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Invalid 1 Valid</p> | <p>This parameter indicates whether the LOS test vector or segment intersects with an entity (Valid) or a non-entity (Invalid).</p> |
| <p>Visible</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Occluded (not visible) 1 Visible</p> | <p>This parameter is used in response to a Line of Sight Segment Request packet. It indicates whether the destination point is visible from the source point.</p> <p>This value should be ignored if the packet is in response to a Line of Sight Vector Request packet</p> <p>Note: If the LOS segment destination point is within the body of a target entity model, this parameter will be set to Occluded (0) and the <i>Entity ID</i> parameter will contain the ID of that entity.</p> |
| <p>Response Count</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter indicates the total number of Line of Sight Response packets the IG will return for the corresponding request.</p> <p>Note: If <i>Visible</i> is set to Visible (1), then <i>Response Count</i> should be set to 1.</p> |
| <p>Entity ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter indicates the entity with which an LOS test vector or segment intersects. This parameter should be ignored if <i>Entity ID Valid</i> is set to Invalid (0).</p> |
| <p>Range</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: LOS vector or segment source point</p> | <p>This parameter indicates the distance along the LOS test segment or vector from the source point to the point of intersection with a polygon surface.</p> |

4.2.5 Line of Sight Extended Response

The **Line of Sight Extended Response** packet is used in response to both **Line of Sight Segment Request** and **Line of Sight Vector Request** packets. This packet contains positional data describing the Line of Sight (LOS) intersection point (see Section 4.2.4 for details on these data). In addition, it contains the material code and surface-normal unit vector of the polygon at the point of intersection. The packet is sent when the *Request Type* parameter of the request packet is set to Extended (1).

A **Line of Sight Extended Response** packet will be sent for each intersection along the LOS segment or vector. The *Response Count* parameter will contain the total number of responses that are being returned. This will allow the Host to determine when all response packets for the given request have been received.

For responses to **Line of Sight Segment Request** packets, the *Range*, *Altitude*, *Latitude*, and *Longitude* parameters specify the range to and position of the intersection point along the LOS test segment. If the destination point specified in the request is occulted, these parameters specify the range to and position of a point on the surface occulting the destination. If the destination point is not occulted, these parameters simply provide the range to and position of the destination point. Figure 84 illustrates two LOS test segments and the data returned with the responses:

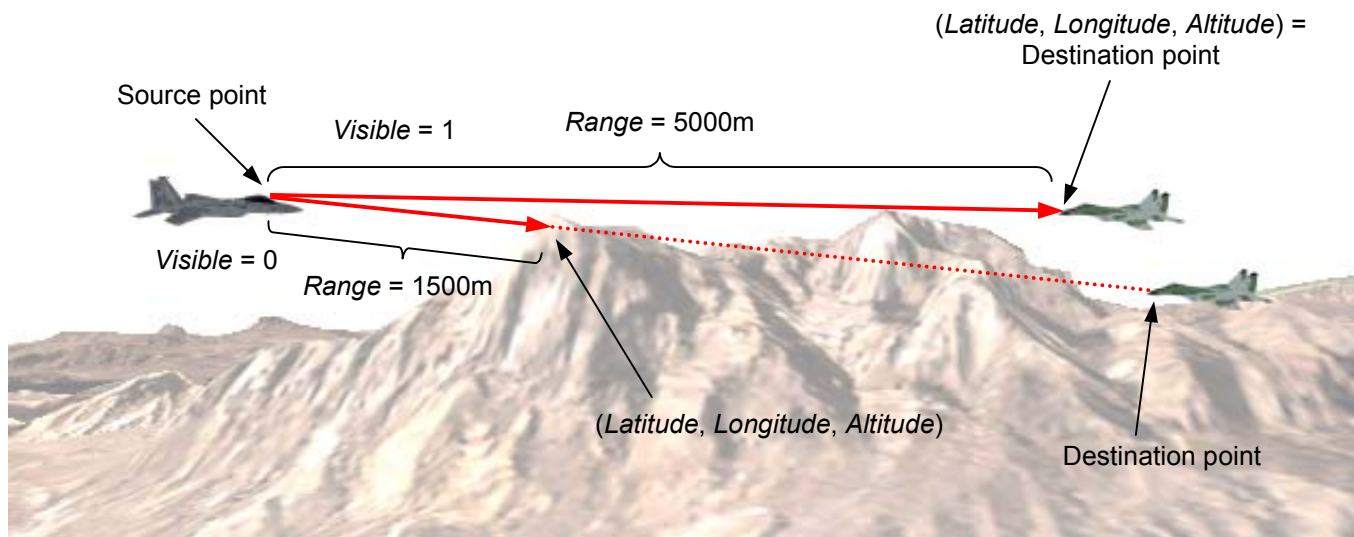


Figure 84 – Responses to Line of Sight Segment Requests

For responses to **Line of Sight Vector Request** packets, the *Range*, *Altitude*, *Latitude*, and *Longitude* parameters specify the range to and position of the point of intersection between the test vector and a surface. If no intersection occurs within the valid range specified in the request, the *Valid* parameter is set to Invalid (0). Figure 85 illustrates two LOS test vectors and the data returned with the responses:

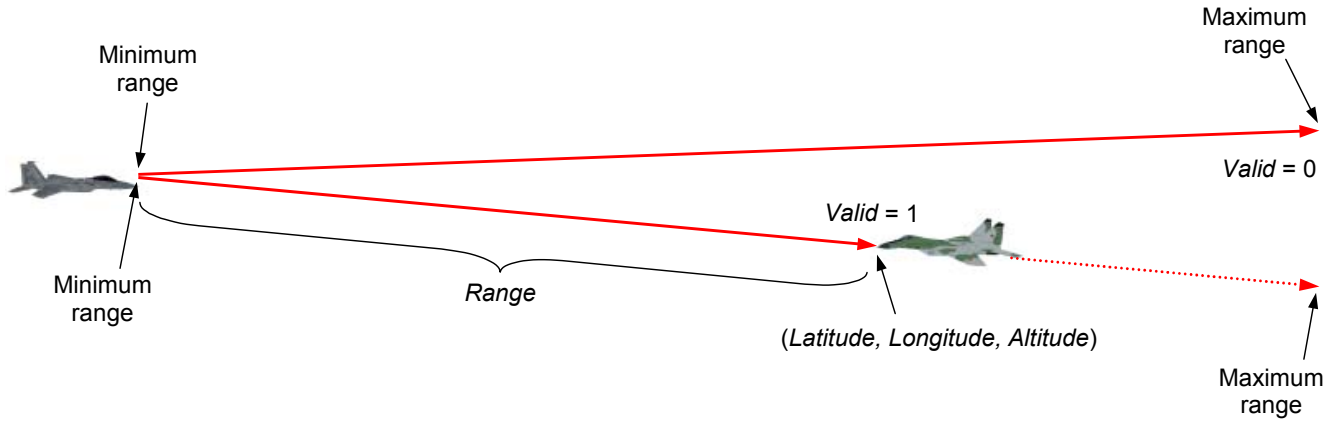


Figure 85 – Responses to Line of Sight Vector Requests

The contents of the **Line of Sight Extended Response** packet are as follows:

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | | |
|-------------------------|---|---|---|---|----|----|----|------------------|----|----------------|---|---|---|---|---|--------|---|-----------|---|---|---|---|---|-------|---|---|---|---|---|---|---|--|--|
| Packet ID = 105 | | | | | | | | Packet Size = 56 | | | | | | | | LOS ID | | | | | | | | | | | | | | | | | |
| Reserved | | | | | *5 | *4 | *3 | *2 | *1 | Response Count | | | | | | | | Entity ID | | | | | | | | | | | | | | | |
| Range | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ----- | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Latitude/X Offset | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ----- | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Longitude/Y Offset | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ----- | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Altitude/Z Offset | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ----- | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Red | | | | | | | | Green | | | | | | | | Blue | | | | | | | | Alpha | | | | | | | | | |
| Material Code | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Normal Vector Azimuth | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Normal Vector Elevation | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

- *1 Valid
- *2 Entity ID Valid
- *3 Range Valid
- *4 Visible
- *5 Intersection Point Coordinate System

Figure 86 – Line of Sight Extended Response Packet Structure

Table 39 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 39 – Line of Sight Extended Response Parameter Definitions

| Parameter | Description |
|---|---|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 105</p> | <p>This parameter identifies this data packet as the Line of Sight Extended Response packet. The value of this parameter must be 105.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 56</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 56.</p> |
| <p>LOS ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter identifies the LOS response. This value corresponds to the value of the <i>LOS ID</i> parameter in the associated Line of Sight Segment Request or Line of Sight Vector Request packet.</p> |
| <p>Valid</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Invalid 1 Valid</p> | <p>This parameter indicates whether this packet contains valid data. A value of Invalid (0) indicates that the LOS test segment or vector did not intersect any geometry.</p> |
| <p>Entity ID Valid</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Invalid 1 Valid</p> | <p>This parameter indicates whether the LOS test vector or segment intersects with an entity (Valid) or a non-entity (Invalid).</p> |
| <p>Range Valid</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Invalid 1 Valid</p> | <p>This parameter indicates whether the <i>Range</i> parameter is valid. The range will be invalid if an intersection occurs before the minimum range or beyond the maximum range specified in an LOS vector request. The range will also be invalid if this packet is in response to an LOS segment request.</p> <p>If <i>Valid</i> is set to Invalid (0), this parameter will also be set to Invalid (0).</p> |

| Parameter | Description |
|--|--|
| <p>Visible</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Occluded (not visible) 1 Visible</p> | <p>This parameter is used in response to a Line of Sight Segment Request packet and indicates whether the destination point is visible from the source point.</p> <p>This value should be ignored if the packet is in response to a Line of Sight Vector Request packet</p> <p>Note: If the LOS segment destination point is within the body of a target entity model, this parameter will be set to Occluded (0) and the <i>Entity ID</i> parameter will contain the ID of that entity.</p> |
| <p>Intersection Point Coordinate System</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Geodetic 1 Entity</p> | <p>This parameter indicates the coordinate system relative to which the intersection point is specified. If this parameter is set to Geodetic (0), then the LOS intersection point is given by latitude, longitude, and altitude.</p> <p>If this parameter is set to Entity (1), then the intersection point is defined relative to the reference point of the entity specified by <i>Entity ID</i>.</p> <p>This parameter is ignored if <i>Entity ID Valid</i> is set to Invalid (0). In such cases, the point is specified using the Geodetic coordinate system.</p> |
| <p>Response Count</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter indicates the total number of Line of Sight Extended Response packets the IG will return for the corresponding request.</p> <p>Note: If <i>Visible</i> is set to Visible (1), then <i>Response Count</i> should be set to 1.</p> |
| <p>Entity ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter indicates the entity with which a LOS test vector or segment intersects. This parameter should be ignored if <i>Entity ID Valid</i> is set to Invalid (0).</p> |
| <p>Range</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: LOS vector or segment source point</p> | <p>This parameter indicates the distance along the LOS test segment or vector from the source point to the point of intersection with an object.</p> |

| Parameter | Description |
|---|---|
| <p>Latitude (Geodetic Coordinate System)</p> <p>Type: double float</p> <p>Units: degrees</p> <p>Values: -90 – 90</p> <p>Datum: Equator</p> | <p>If the <i>Entity ID Valid</i> parameter is set to Invalid (0) or if <i>Intersection Point Coordinate System</i> is set to Geodetic (0), this parameter indicates the geodetic latitude of the point of intersection along the LOS test segment or vector.</p> <p>If this packet is in response to an LOS segment request and <i>Visible</i> is set to Occluded (0), this point is on the occulting surface. If this packet is in response to an LOS segment request and <i>Visible</i> is set to Visible (1), this point is simply the destination point.</p> |
| <p>X Offset (Entity Coordinate System)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Entity reference point</p> | <p>If the <i>Entity ID Valid</i> parameter is set to Valid (1) and <i>Intersection Point Coordinate System</i> is set to Entity (1), this parameter specifies the offset of the point of intersection of the LOS test segment or vector along the intersected entity's X axis.</p> |
| <p>Longitude (Geodetic Coordinate System)</p> <p>Type: double float</p> <p>Units: degrees</p> <p>Values: -180 – 180</p> <p>Datum: Prime Meridian</p> | <p>If the <i>Entity ID Valid</i> parameter is set to Invalid (0) or if <i>Intersection Point Coordinate System</i> is set to Geodetic (0), this parameter indicates the geodetic longitude of the point of intersection along the LOS test segment or vector.</p> <p>If this packet is in response to an LOS segment request and <i>Visible</i> is set to Occluded (0), this point is on the occulting surface. If this packet is in response to an LOS segment request and <i>Visible</i> is set to Visible (1), this point is simply the destination point.</p> |
| <p>Y Offset (Entity Coordinate System)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Entity reference point</p> | <p>If the <i>Entity ID Valid</i> parameter is set to Valid (1) and <i>Intersection Point Coordinate System</i> is set to Entity (1), this parameter specifies the offset of the point of intersection of the LOS test segment or vector along the intersected entity's Y axis.</p> |

| Parameter | Description |
|---|--|
| <p>Altitude (Geodetic Coordinate System)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Mean Sea Level</p> | <p>If the <i>Entity ID Valid</i> parameter is set to Invalid (0) or if <i>Intersection Point Coordinate System</i> is set to Geodetic (0), this parameter indicates the geodetic altitude of the point of intersection along the LOS test segment or vector.</p> <p>If this packet is in response to a LOS segment request and <i>Visible</i> is set to Occluded (0), this point is on the occulting surface. If this packet is in response to a LOS segment request and <i>Visible</i> is set to Visible (1), this point is simply the destination point.</p> |
| <p>Z Offset (Entity Coordinate System)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Entity reference point</p> | <p>If the <i>Entity ID Valid</i> parameter is set to Valid (1) and <i>Intersection Point Coordinate System</i> is set to Entity (1), this parameter specifies the offset of the point of intersection of the LOS test segment or vector along the intersected entity's Z axis.</p> |
| <p>Red</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter indicates the red color component of the surface at the point of intersection.</p> |
| <p>Green</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter indicates the green color component of the surface at the point of intersection.</p> |
| <p>Blue</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter indicates the blue color component of the surface at the point of intersection.</p> |
| <p>Alpha</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter indicates the alpha component of the surface at the point of intersection.</p> |
| <p>Material Code</p> <p>Type: unsigned int32</p> <p>Units: N/A</p> | <p>This parameter indicates the material code of the surface intersected by the LOS test segment or vector.</p> |

| Parameter | Description |
|---|---|
| <p><i>Normal Vector Azimuth</i></p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: -180.0 – 180.0</p> <p>Datum: True North</p> | <p>This parameter indicates the azimuth of a unit vector normal to the surface intersected by the LOS test segment or vector. This value is the horizontal angle from True North to the segment or vector.</p> <p>This parameter is valid only if the <i>Valid</i> parameter is set to one (1).</p> |
| <p><i>Normal Vector Elevation</i></p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: -90.0 – 90.0</p> <p>Datum: Geodetic reference plane</p> | <p>This parameter indicates the elevation of a unit vector normal to the surface intersected by the LOS test segment or vector. This value is the vertical angle from the geodetic reference plane to the segment or vector.</p> <p>This parameter is valid only if the <i>Valid</i> parameter is set to one (1).</p> |

4.2.6 Sensor Response

The **Sensor Response** packet is used to report the gate size and position on a sensor display to the Host.

The sensor gate size and position are defined with respect to the 2D view coordinate system. The +X axis is to the right of the screen and the +Y axis is up. The origin is at the intersection of the viewing vector with the view plane. The gate position is measured in degrees along each axis from the origin to the center of the gate as shown below:

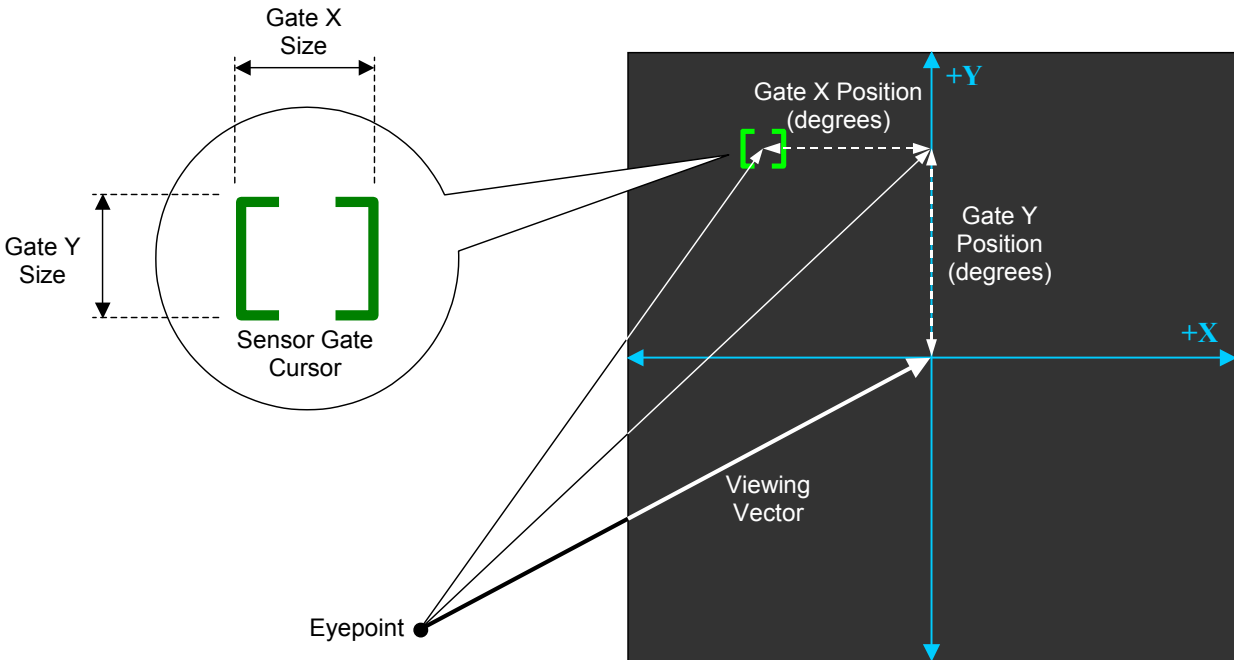


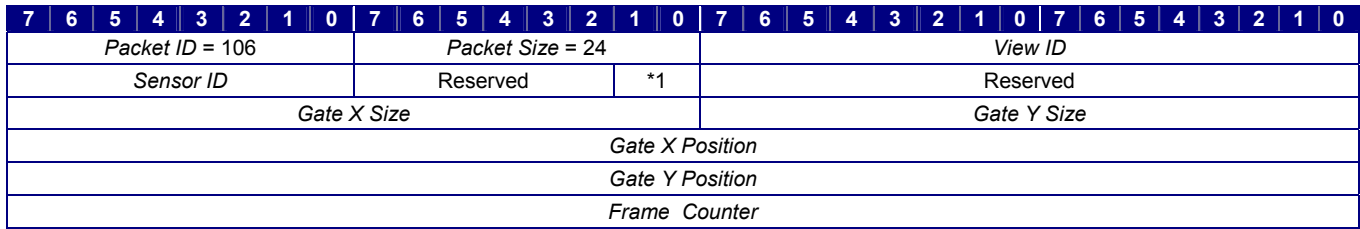
Figure 87 – Sensor Gate Size and Position

The *Gate X Position* and *Gate Y Position* angles correspond to the horizontal and vertical angles formed between the sensor's viewing vector and a vector from the sensor eyepoint to the track point. Scaling of the sensor view can be performed with a **View Definition** packet (Section 4.1.21).

The *Frame Counter* parameter contains the IG's frame counter value (see Section 2.1.1.2) at the time that the IG calculates the gate and line-of-sight intersection data. The Host can compare this value with the *Frame Counter* value in the message's **Start of Frame** (Section 4.2.1) packet to calculate the sensor sampling rate and latency.

Either this packet or the **Sensor Extended Response** packet (Section 4.2.7) must be sent to the Host during each frame that the specified sensor is active.

The contents of the **Sensor Response** packet are as follows:



*1 *Sensor Status*

Figure 88 – Sensor Response Packet Structure

Table 40 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 40 – Sensor Response Parameter Definitions

| Parameter | Description |
|--|--|
| <p><i>Packet ID</i></p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 106</p> | <p>This parameter identifies this data packet as the Sensor Response packet. The value of this parameter must be 106.</p> |
| <p><i>Packet Size</i></p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 24</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 24.</p> |
| <p><i>View ID</i></p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the view that represents the sensor display.</p> |
| <p><i>Sensor ID</i></p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter specifies the sensor to which the data in this packet apply.</p> |

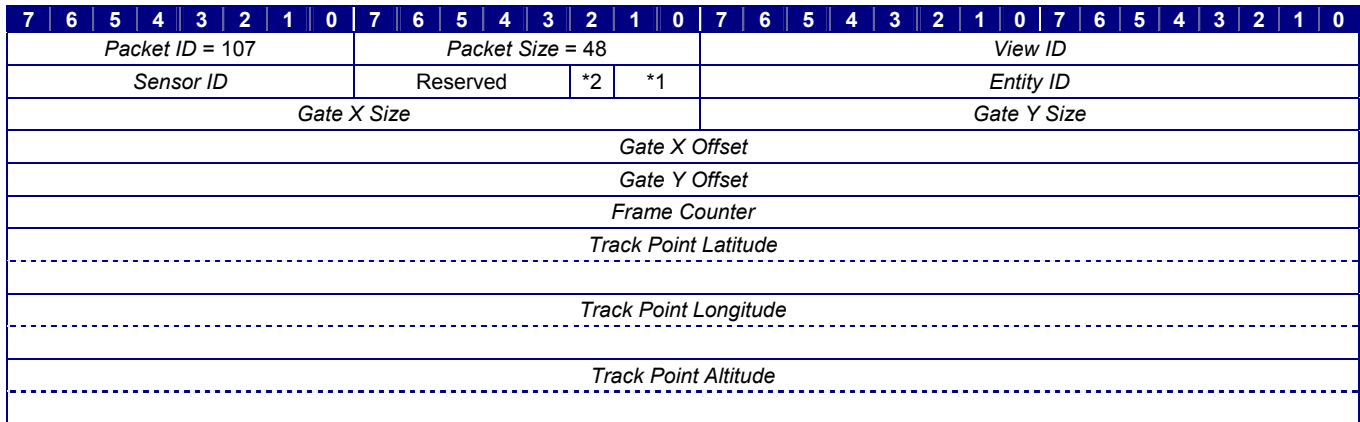
| Parameter | Description |
|--|---|
| <p>Sensor Status</p> <p>Type: unsigned 2-bit field</p> <p>Units: N/A</p> <p>Values: 0 Searching for target 1 Tracking target 2 Impending breaklock 3 Breaklock</p> | <p>This parameter indicates the current tracking state of the sensor.</p> |
| <p>Gate X Size</p> <p>Type: unsigned int16</p> <p>Units: pixels or raster lines (see note at right)</p> | <p>This parameter specifies the gate symbol size along the view's X axis.</p> <p>Note: This size is specified in either pixels or raster lines depending upon the orientation of the display.</p> |
| <p>Gate Y Size</p> <p>Type: unsigned int16</p> <p>Units: pixels or raster lines (see note at right)</p> | <p>This parameter specifies the gate symbol size along the view's Y axis.</p> <p>Note: This size is specified in either pixels or raster lines depending upon the orientation of the display.</p> |
| <p>Gate X Position</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Datum: Viewing vector</p> | <p>This parameter specifies the gate symbol's position along the view's X axis. This position is given as the horizontal angle formed at the sensor eyepoint between the sensor's viewing vector and the center of the track point.</p> |
| <p>Gate Y Position</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Datum: Viewing vector</p> | <p>This parameter specifies the gate symbol's position along the view's Y axis. This position is given as the vertical angle formed at the sensor eyepoint between the sensor's viewing vector and the center of the track point.</p> |
| <p>Frame Counter</p> <p>Type: unsigned int32</p> <p>Units: N/A</p> | <p>This parameter indicates the IG's frame counter at the time that the IG calculates the gate and line-of-sight intersection data.</p> |

4.2.7 Sensor Extended Response

The **Sensor Extended Response** packet, like the **Sensor Response** packet (Section 4.2.6), is used to report the gate size and position on a sensor display to the Host. This packet also contains the geodetic position of the sensor track point and the entity ID of the target.

Either this packet or the **Sensor Response** packet must be sent to the Host during each frame that the specified sensor is active.

The contents of the **Sensor Extended Response** packet are as follows:



*1 Sensor Status
 *2 Entity ID Valid

Figure 89 – Sensor Extended Response Packet Structure

Table 41 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 41 – Sensor Extended Response Parameter Definitions

| Parameter | Description |
|---|---|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 107</p> | <p>This parameter identifies this data packet as the Sensor Extended Response packet. The value of this parameter must be 107.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 48</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 48.</p> |

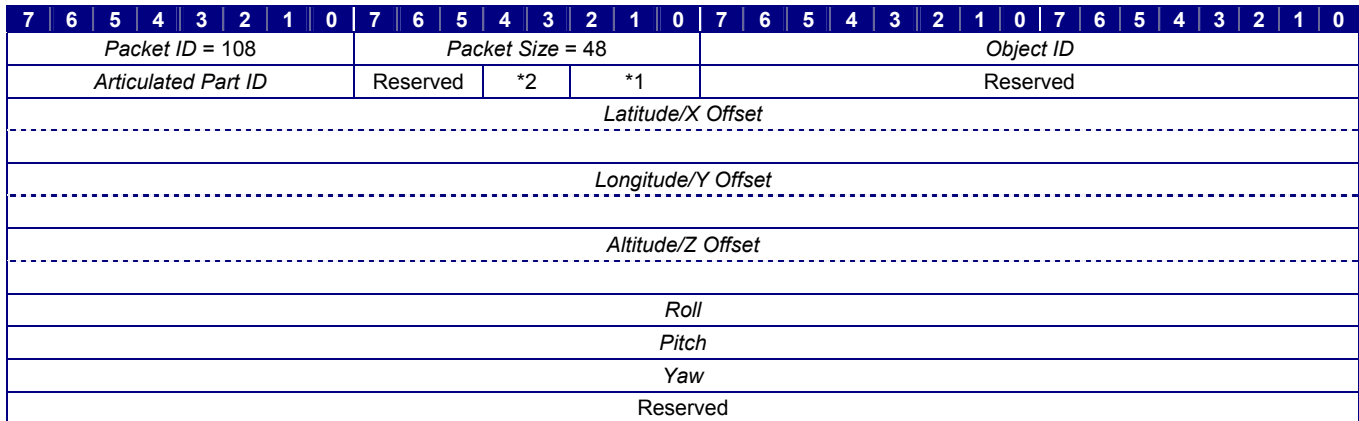
| Parameter | Description |
|--|---|
| <p>View ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies the view that represents the sensor display.</p> |
| <p>Sensor ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter specifies the sensor to which the data in this packet apply.</p> |
| <p>Sensor Status</p> <p>Type: unsigned 2-bit field</p> <p>Units: N/A</p> <p>Values: 0 Searching for target 1 Tracking target 2 Impending breaklock 3 Breaklock</p> | <p>This parameter indicates the current tracking state of the sensor.</p> |
| <p>Entity ID Valid</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Invalid (non-entity target) 1 Valid (entity target)</p> | <p>This parameter indicates whether the target is an entity or a non-entity object. If this parameter is set to Valid (1), then <i>Entity ID</i> identifies the target entity.</p> |
| <p>Entity ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter indicates the entity ID of the target. This parameter is ignored if <i>Entity ID Valid</i> is set to Invalid (0).</p> |
| <p>Gate X Size</p> <p>Type: unsigned int16</p> <p>Units: pixels or raster lines (see note at right)</p> | <p>This parameter specifies the gate symbol size along the view's X axis.</p> <p>Note: This size is specified in either pixels or raster lines depending upon the orientation of the display.</p> |
| <p>Gate Y Size</p> <p>Type: unsigned int16</p> <p>Units: pixels or raster lines (see note at right)</p> | <p>This parameter specifies the gate symbol size along the view's Y axis.</p> <p>Note: This size is specified in either pixels or raster lines depending upon the orientation of the display.</p> |

| Parameter | Description |
|--|---|
| <p>Gate X Position</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Datum: Viewing vector</p> | <p>This parameter specifies the gate symbol's position along the view's X axis. This position is given as the horizontal angle formed at the sensor eyepoint between the sensor's viewing vector and the center of the track point.</p> |
| <p>Gate Y Position</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Datum: Viewing vector</p> | <p>This parameter specifies the gate symbol's position along the view's Y axis. This position is given as the vertical angle formed at the sensor eyepoint between the sensor's viewing vector and the center of the track point.</p> |
| <p>Frame Counter</p> <p>Type: unsigned int32</p> <p>Units: N/A</p> | <p>This parameter indicates the IG's frame counter at the time that the IG calculates the gate and line-of-sight intersection data.</p> |
| <p>Track Point Latitude</p> <p>Type: double float</p> <p>Units: degrees</p> <p>Values: -90.0 – 90.0</p> <p>Datum: Equator</p> | <p>This parameter indicates the geodetic latitude of the point being tracked by the sensor. This parameter is valid only when the Sensor Status parameter is set to one (1) or two (2).</p> |
| <p>Track Point Longitude</p> <p>Type: double float</p> <p>Units: degrees</p> <p>Values: -180.0 – 180.0</p> <p>Datum: Prime Meridian</p> | <p>This parameter indicates the geodetic longitude of the point being tracked by the sensor. This parameter is valid only when the Sensor Status parameter is set to one (1) or two (2).</p> |
| <p>Track Point Altitude</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Mean Sea Level</p> | <p>This parameter indicates the geodetic altitude of the point being tracked by the sensor. This parameter is valid only when the Sensor Status parameter is set to one (1) or two (2).</p> |

4.2.8 Position Response

The **Position Response** packet is sent by the IG in response to a **Position Request** packet (Section 4.1.27). This packet describes the position and orientation of an entity, articulated part, view, view group, or motion tracker.

The contents of the **Position Response** packet are as follows:



*1 *Object Class*
 *2 *Coordinate System*

Figure 90 – Position Response Packet Structure

Table 42 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 42 – Position Response Parameter Definitions

| Parameter | Description |
|---|--|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 108</p> | <p>This parameter identifies this data packet as the Position Response packet. The value of this parameter must be 108.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 48</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 48.</p> |

| Parameter | Description |
|---|--|
| <p>Object ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> <p>Values: If <i>Object Class</i> = 0: 0 – 65,535 If <i>Object Class</i> = 1: 0 – 65,535 If <i>Object Class</i> = 2: 0 – 65,535 If <i>Object Class</i> = 3: 1 – 255 If <i>Object Class</i> = 4: 0 – 255</p> | <p>This parameter identifies the entity, view, view group, or motion tracking device whose position is being reported. If <i>Object Class</i> is set to Articulated Part (1), this parameter indicates the entity whose part is identified by the <i>Articulated Part ID</i> parameter.</p> |
| <p>Articulated Part ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter identifies the articulated part whose position is being reported. The entity to which the part belongs is specified by the <i>Object ID</i> parameter.</p> <p>This parameter is valid only when <i>Object Class</i> is set to Articulated Part (1).</p> |
| <p>Object Class</p> <p>Type: unsigned 3-bit field</p> <p>Units: N/A</p> <p>Values: 0 Entity 1 Articulated Part 2 View 3 View Group 4 Motion Tracker</p> | <p>This parameter indicates the type of object whose position is being reported.</p> |
| <p>Coordinate System</p> <p>Type: unsigned 2-bit field</p> <p>Units: N/A</p> <p>Values: 0 Geodetic 1 Parent Entity 2 Submodel</p> | <p>This parameter indicates the coordinate system in which the position and orientation are specified.</p> <p>Geodetic – Position is specified as a geodetic latitude, longitude, and altitude. Orientation is given with respect to the reference plane shown in Figure 17, page 22.</p> <p>Parent Entity – Position and orientation are with respect to the entity to which the specified child entity, articulated part, view, or view group is attached. This value is invalid for top-level entities.</p> <p>Submodel – Position and orientation are with respect to the articulated part's reference coordinate system as described in Section 3.3.3. This value is valid only when <i>Object Class</i> is set to Articulated Part (1).</p> <p>Note: If <i>Object Class</i> is set to Motion Tracker (4), this parameter is ignored and the positional and rotational data are relative to the tracking device boresight state.</p> |

| Parameter | Description |
|---|--|
| <p>Latitude (Geodetic Coordinate System)</p> <p>Type: double float</p> <p>Units: degrees</p> <p>Values: -90.0 – 90.0</p> <p>Datum: Equator</p> | <p>If <i>Coordinate System</i> is set to Geodetic (0), this parameter indicates the geodetic latitude of the entity, articulated part, view, or view group.</p> |
| <p>X Offset (All other coordinate systems)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: If <i>Coordinate System</i> = 1: Parent entity's reference point If <i>Coordinate System</i> = 2: Submodel's reference point If <i>Object Class</i> = 4: Tracker boresight</p> | <p>If <i>Coordinate System</i> is set to Parent Entity (1), this parameter indicates the X offset from the parent entity's origin to the child entity, articulated part, view, or view group.</p> <p>If <i>Coordinate System</i> is set to Submodel (2), this parameter indicates the X offset from the articulated part submodel's reference point (see Section 3.3.3)</p> <p>If <i>Object Class</i> is set to Motion Tracker (4), this parameter indicates the X position reported by the tracking device.</p> |
| <p>Longitude (Geodetic Coordinate System)</p> <p>Type: double float</p> <p>Units: degrees</p> <p>Values: -180.0 – 180.0</p> <p>Datum: Prime Meridian</p> | <p>If <i>Coordinate System</i> is set to Geodetic (0), this parameter indicates the geodetic longitude of the entity, articulated part, view, or view group.</p> |
| <p>Y Offset (All other coordinate systems)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: If <i>Coordinate System</i> = 1: Parent entity's reference point If <i>Coordinate System</i> = 2: Submodel's reference point If <i>Object Class</i> = 4: Tracker boresight</p> | <p>If <i>Coordinate System</i> is set to Parent Entity (1), this parameter indicates the Y offset from the parent entity's origin to the child entity, articulated part, view, or view group.</p> <p>If <i>Coordinate System</i> is set to Submodel (2), this parameter indicates the Y offset from the articulated part submodel's reference point (see Section 3.3.3)</p> <p>If <i>Object Class</i> is set to Motion Tracker (4), this parameter indicates the Y position reported by the tracking device.</p> |

| Parameter | Description |
|---|--|
| <p>Altitude (Geodetic Coordinate System)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: Mean Sea Level</p> | <p>If <i>Coordinate System</i> is set to Geodetic (0), this parameter indicates the geodetic altitude of the entity, articulated part, view, or view group.</p> |
| <p>Z Offset (All other coordinate systems)</p> <p>Type: double float</p> <p>Units: meters</p> <p>Datum: If <i>Coordinate System</i> = 1: Parent entity's reference point If <i>Coordinate System</i> = 2: Submodel's reference point If <i>Object Class</i> = 4: Tracker boresight</p> | <p>If <i>Coordinate System</i> is set to Parent Entity (1), this parameter indicates the Z offset from the parent entity's origin to the child entity, articulated part, view, or view group.</p> <p>If <i>Coordinate System</i> is set to Submodel (2), this parameter indicates the Z offset from the articulated part submodel's reference point (see Section 3.3.3)</p> <p>If <i>Object Class</i> is set to Motion Tracker (4), this parameter indicates the Z position reported by the tracking device.</p> |
| <p>Roll</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: -180.0 – 180.0</p> <p>Datum: If <i>Coordinate System</i> = 0: Geodetic reference plane If <i>Coordinate System</i> = 1: Parent entity's reference plane If <i>Coordinate System</i> = 2: Submodel's reference plane If <i>Object Class</i> = 4: Tracker boresight</p> | <p>This parameter indicates the roll angle of the specified entity, articulated part, view, or view group.</p> <p>If <i>Object Class</i> is set to Motion Tracker (4), this parameter indicates the roll angle reported by the tracking device.</p> |
| <p>Pitch</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: -90.0 – 90.0</p> <p>Datum: If <i>Coordinate System</i> = 0: Geodetic reference coordinate system If <i>Coordinate System</i> = 1: Parent entity's reference coordinate system If <i>Coordinate System</i> = 2: Submodel's reference coordinate system If <i>Object Class</i> = 4: Tracker boresight</p> | <p>This parameter indicates the pitch angle of the specified entity, articulated part, view, or view group.</p> <p>If <i>Object Class</i> is set to Motion Tracker (4), this parameter indicates the pitch angle reported by the tracking device.</p> |

| Parameter | Description |
|--|---|
| <p>Yaw</p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: 0.0 – 360.0</p> <p>Datum: If <i>Coordinate System</i> = 0: Geodetic reference plane If <i>Coordinate System</i> = 1: Parent entity's reference plane If <i>Coordinate System</i> = 2: Submodel's reference plane If <i>Object Class</i> = 4: Tracker boresight</p> | <p>This parameter indicates the yaw angle of the specified entity, articulated part, view, or view group.</p> <p>If <i>Object Class</i> is set to Motion Tracker (4), this parameter indicates the yaw angle reported by the tracking device.</p> |

4.2.9 Weather Conditions Response

The **Weather Conditions Response** packet is sent in response to an **Environmental Conditions Request** packet (Section 4.1.28) whose *Request Type* parameter specifies Weather Conditions. The packet describes atmosphere properties at the requested geodetic position.

Figure 91 illustrates a hypothetical scenario wherein the Host requests the weather conditions at two points, A and B, and the IG returns a response for each point:

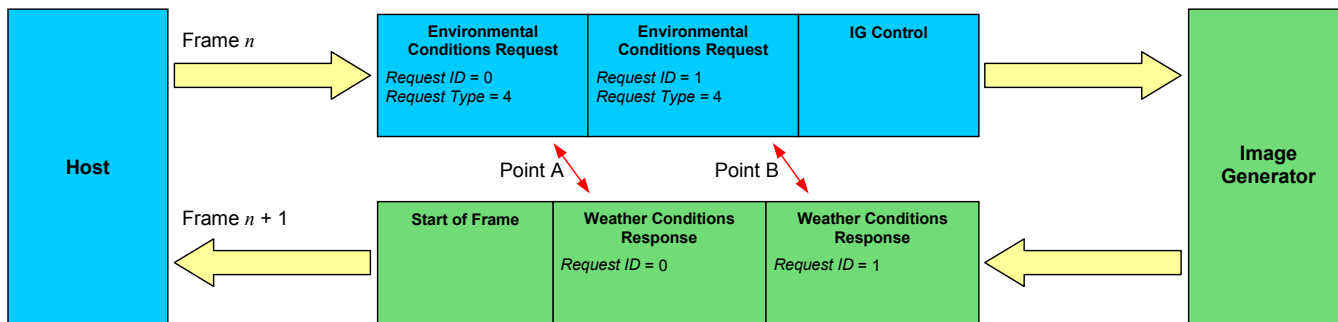


Figure 91 – Data Exchange for Weather Conditions Request

In the above example, the *Request ID* parameter of each **Environmental Conditions Request** packet is unique and is equal to the *Request ID* parameter in the corresponding **Weather Conditions Response** packet.

The contents of the **Weather Conditions Response** packet are as follows:

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|-----------------------|---|---|---|---|---|---|---|------------------|---|---|---|---|---|---|---|------------|---|---|---|---|---|---|---|----------|---|---|---|---|---|---|---|
| Packet ID = 109 | | | | | | | | Packet Size = 32 | | | | | | | | Request ID | | | | | | | | Humidity | | | | | | | |
| Air Temperature | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Visibility Range | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Horizontal Wind Speed | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Vertical Wind Speed | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Wind Direction | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Barometric Pressure | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Reserved | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Figure 92 – Weather Conditions Response Packet Structure

Table 43 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 43 – Weather Conditions Response Parameter Definitions

| Parameter | Description |
|---|--|
| <p><i>Packet ID</i></p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 109</p> | <p>This parameter identifies this data packet as the Weather Conditions Response packet. The value of this parameter must be 109.</p> |
| <p><i>Packet Size</i></p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 32</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 32.</p> |
| <p><i>Request ID</i></p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter identifies the environmental conditions request to which this response packet corresponds.</p> |
| <p><i>Humidity</i></p> <p>Type: unsigned int8</p> <p>Units: percent</p> <p>Values: 0 – 100</p> | <p>This parameter indicates the humidity at the requested location.</p> |
| <p><i>Air Temperature</i></p> <p>Type: single float</p> <p>Units: degrees Celsius (°C)</p> | <p>This parameter indicates the air temperature at the requested location.</p> |
| <p><i>Visibility Range</i></p> <p>Type: single float</p> <p>Units: meters</p> <p>Values: ≥ 0</p> | <p>This parameter indicates the visibility range at the requested location.</p> |
| <p><i>Horizontal Wind Speed</i></p> <p>Type: single float</p> <p>Units: m/s</p> <p>Values: ≥ 0</p> <p>Default: 0</p> | <p>This parameter indicates the local wind speed parallel to the ellipsoid-tangential reference plane.</p> |

| Parameter | Description |
|---|--|
| <p><i>Vertical Wind Speed</i></p> <p>Type: single float</p> <p>Units: m/s</p> <p>Default: 0</p> | <p>This parameter indicates the local vertical wind speed.</p> <p>Note: A positive value indicates an updraft, while a negative value indicates a downdraft.</p> |
| <p><i>Wind Direction</i></p> <p>Type: single float</p> <p>Units: degrees</p> <p>Values: 0.0 – 360.0</p> <p>Default: 0</p> <p>Datum: True North</p> | <p>This parameter indicates the local wind direction.</p> <p>Note: This is the direction from which the wind is blowing.</p> |
| <p><i>Barometric Pressure</i></p> <p>Type: single float</p> <p>Units: millibars (mb) or hectopascals (hPa)</p> <p>Values: ≥ 0</p> | <p>This parameter indicates the atmospheric pressure at the requested location.</p> |

4.2.10 Aerosol Concentration Response

The **Aerosol Concentration Response** packet is sent in response to an **Environmental Conditions Request** packet (Section 4.1.28) whose *Request Type* parameter specifies Aerosol Concentrations. The packet describes the concentration of airborne particles associated with a specific weather layer.

The aerosol type is determined by the weather layer ID. If two or more global or regional weather layers overlap and have the same layer ID, the concentration of that aerosol is the average of the concentrations due to each layer.

Figure 93 illustrates a hypothetical scenario wherein the Host requests the aerosol concentrations at two points, A and B, and the IG returns one or more responses for each point:

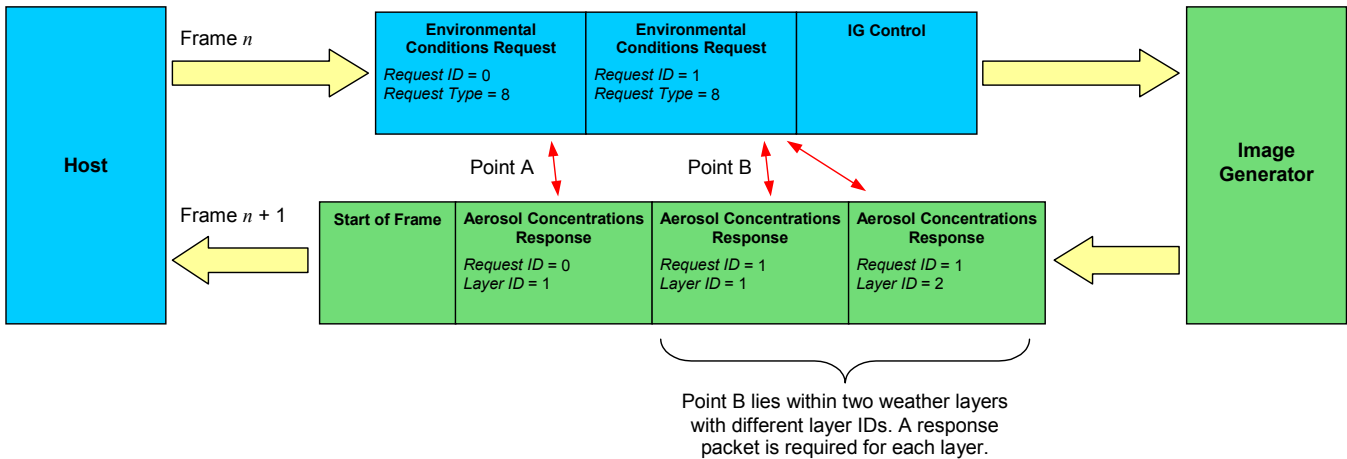


Figure 93 – Data Exchange for Aerosol Concentrations Request

In the above example, the *Request ID* parameter of each **Environmental Conditions Request** packet is unique and is equal to the *Request ID* parameter in the corresponding **Aerosol Concentration Response** packet or packets. Because Point B is located within two distinct weather layers, two separate response packets are required.

The contents of the **Aerosol Concentration Response** packet are as follows:

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-----------------------|---|---|---|---|---|---|---|-----------------|---|---|---|---|---|---|---|------------|---|---|---|---|---|---|---|----------|---|---|---|---|---|---|---|
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Packet ID = 110 | | | | | | | | Packet Size = 8 | | | | | | | | Request ID | | | | | | | | Layer ID | | | | | | | |
| Aerosol Concentration | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Figure 94 – Aerosol Concentration Response Packet Structure

Table 44 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 44 – Aerosol Concentration Response Parameter Definitions

| Parameter | Description |
|--|--|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 110</p> | <p>This parameter identifies this data packet as the Aerosol Concentration Response packet. The value of this parameter must be 110.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 8</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 8.</p> |
| <p>Request ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter identifies the environmental conditions request to which this response packet corresponds.</p> |
| <p>Layer ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter identifies the weather layer whose aerosol concentration is being described. Thus, this parameter indicates the aerosol type to which this packet corresponds.</p> |
| <p>Aerosol Concentration</p> <p>Type: single float</p> <p>Units: g/m³</p> <p>Values: ≥ 0</p> | <p>This parameter identifies the concentration of airborne particles. The type of particle is identified by the <i>Layer ID</i> parameter.</p> |

4.2.11 Maritime Surface Conditions Response

The **Maritime Surface Conditions Response** packet is sent in response to an **Environmental Conditions Request** packet (Section 4.1.28) whose *Request Type* parameter specifies Maritime Surface Conditions. The packet describes the sea surface state at the requested geodetic latitude and longitude.

Figure 95 illustrates a hypothetical scenario wherein the Host requests the maritime surface conditions at two points, A and B, and the IG returns a response for each point:

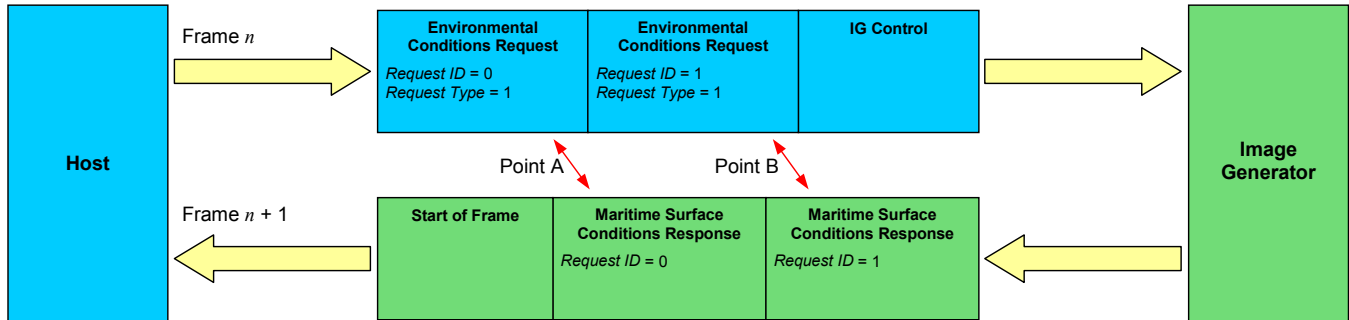


Figure 95 – Data Exchange for Maritime Surface Conditions Request

In the above example, the *Request ID* parameter of each **Environmental Conditions Request** packet is unique and is equal to the *Request ID* parameter in the corresponding **Maritime Surface Conditions Response** packet.

The contents of the **Maritime Surface Conditions Response** packet are as follows:

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---------------------------|---|---|---|---|---|---|---|------------------|---|---|---|---|---|---|---|------------|---|---|---|---|---|---|---|----------|---|---|---|---|---|---|---|
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Packet ID = 111 | | | | | | | | Packet Size = 16 | | | | | | | | Request ID | | | | | | | | Reserved | | | | | | | |
| Sea Surface Height | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Surface Water Temperature | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Surface Clarity | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Figure 96 – Maritime Surface Conditions Response Packet Structure

Table 43 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 45 – Maritime Surface Conditions Response Parameter Definitions

| Parameter | Description |
|---------------------|--|
| Packet ID | This parameter identifies this data packet as the Maritime Surface Conditions Response packet. The value of this parameter must be 111. |
| Type: unsigned int8 | |
| Units: N/A | |
| Value: 111 | |

| Parameter | Description |
|--|---|
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 16</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 16.</p> |
| <p>Request ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter identifies the environmental conditions request to which this response packet corresponds.</p> |
| <p>Sea Surface Height</p> <p>Type: single float</p> <p>Units: meters</p> <p>Datum: Mean Sea Level</p> | <p>This parameter indicates the height of the sea surface at equilibrium (i.e., without waves).</p> <p>Note that the instantaneous elevation of the water including wave displacement may be determined from a Height Of Terrain request.</p> |
| <p>Surface Water Temperature</p> <p>Type: single float</p> <p>Units: degrees Celsius (°C)</p> | <p>This parameter indicates the water temperature at the sea surface.</p> |
| <p>Surface Clarity</p> <p>Type: single float</p> <p>Units: percent</p> <p>Values: 0 – 100</p> | <p>This parameter indicates the clarity of the water at its surface. A value of 100% indicates pristine water, while a value of 0% indicates extremely turbid water.</p> |

4.2.12 Terrestrial Surface Conditions Response

The **Terrestrial Surface Conditions Response** packet is sent in response to an **Environmental Conditions Request** packet (Section 4.1.28) whose *Request Type* parameter specifies Terrestrial Surface Conditions. The packet describes the terrain surface conditions at the requested geodetic latitude and longitude.

Figure 97 illustrates a hypothetical scenario wherein the Host requests the terrain surface conditions at two points, A and B, and the IG returns one or more responses for each point:

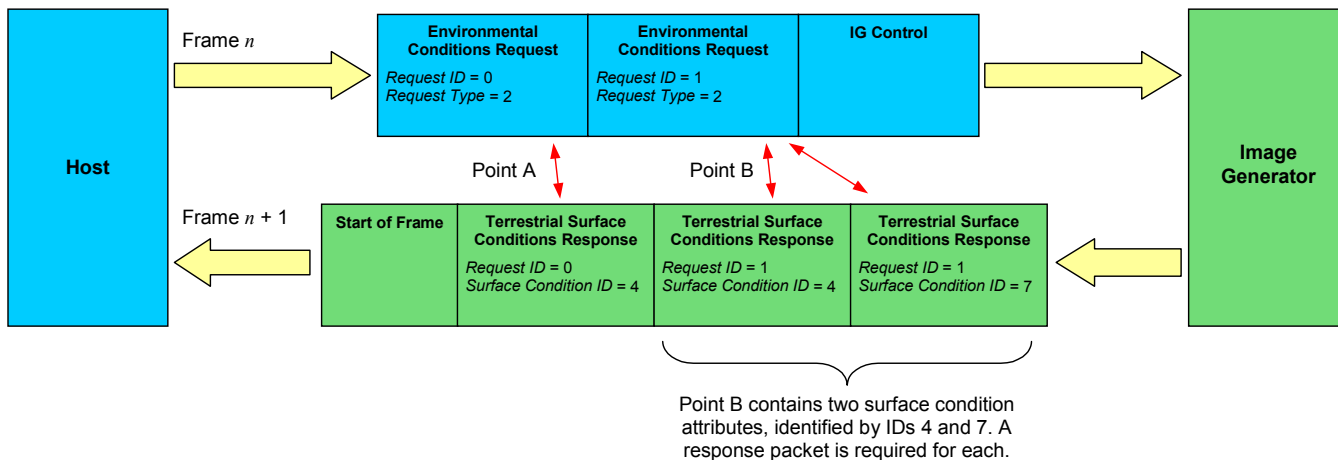


Figure 97 – Data Exchange for Terrestrial Surface Conditions Request

In the above example, the *Request ID* parameter of each **Environmental Conditions Request** packet is unique and is equal to the *Request ID* parameter in the corresponding **Terrestrial Surface Conditions Response** packet or packets. Because Point B falls within a region for which two surface condition attributes have been assigned, two separate response packets are required.

The contents of the **Terrestrial Surface Conditions Response** packet are as follows:

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|----------------------|---|---|---|---|---|---|---|-----------------|---|---|---|---|---|---|---|------------|---|---|---|---|---|---|---|----------|---|---|---|---|---|---|---|
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Packet ID = 112 | | | | | | | | Packet Size = 8 | | | | | | | | Request ID | | | | | | | | Reserved | | | | | | | |
| Surface Condition ID | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Figure 98 – Terrestrial Surface Conditions Response Packet Structure

Table 46 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 46 – Terrestrial Surface Conditions Response Parameter Definitions

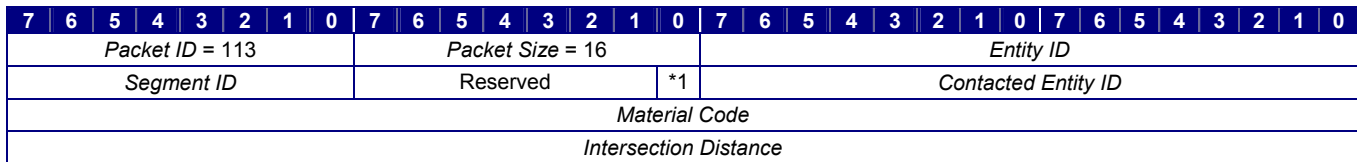
| Parameter | Description |
|---|--|
| <p><i>Packet ID</i></p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 112</p> | <p>This parameter identifies this data packet as the Terrestrial Surface Conditions Response packet. The value of this parameter must be 112.</p> |
| <p><i>Packet Size</i></p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 8</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 8.</p> |
| <p><i>Request ID</i></p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter identifies the environmental conditions request to which this response packet corresponds.</p> |
| <p><i>Surface Condition ID</i></p> <p>Type: unsigned int32</p> <p>Units: N/A</p> <p>Values: 0 – 65,535</p> | <p>This parameter indicates the presence of a specific surface condition or contaminant at the test point. Surface condition codes are IG-dependent.</p> |

4.2.13 Collision Detection Segment Notification

The **Collision Detection Segment Notification** packet is used to notify the Host when a collision occurs between a collision detection segment and a polygon. When a segment intersects a polygon whose material code matches the collision mask defined for the segment (see **Collision Detection Segment Definition** packet, Section 4.1.22), the IG sends a **Collision Detection Segment Notification** packet indicating where and with what the collision occurred. If a segment intersects multiple polygons with material codes matching the mask, only the closest intersection is returned. Segments are not tested against polygons belonging to same the entity as the segment.

If a collision detection segment has been disabled, it will be excluded from all collision testing.

The contents of the **Collision Detection Segment Notification** packet are as follows:



*1 *Collision Type*

Figure 99 – Collision Detection Segment Notification Packet Structure

Table 47 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 47 – Collision Detection Segment Notification Parameter Definitions

| Parameter | Description |
|---|---|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 113</p> | <p>This parameter identifies this data packet as the Collision Detection Segment Notification packet. The value of this parameter must be 113.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 16</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 16.</p> |
| <p>Entity ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter indicates the entity to which the collision detection segment belongs.</p> |

| Parameter | Description |
|--|---|
| <p>Segment ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter indicates the ID of the collision detection segment along which the collision occurred. This parameter, along with <i>Entity ID</i>, allows the Host to match this response with the corresponding request.</p> |
| <p>Collision Type</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Non-entity 1 Entity</p> | <p>This parameter indicates whether the collision occurred with another entity or with a non-entity object such as the terrain.</p> |
| <p>Contacted Entity ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter indicates the entity with which the collision occurred.</p> <p>If <i>Collision Type</i> is set to Non-entity (0), this parameter is ignored.</p> |
| <p>Material Code</p> <p>Type: unsigned int32</p> <p>Units: N/A</p> | <p>This parameter indicates the material code of the surface at the point of collision.</p> |
| <p>Intersection Distance</p> <p>Type: single float</p> <p>Units: meters</p> <p>Datum: <i>X1</i>, <i>Y1</i>, and <i>Z1</i> specified in Collision Detection Segment Definition packet</p> | <p>This parameter indicates the distance along the collision test vector from the source endpoint (defined by the <i>X1</i>, <i>Y1</i>, and <i>Z1</i> parameters in the Collision Detection Segment Definition packet) to the point of intersection.</p> |

4.2.14 Collision Detection Volume Notification

The **Collision Detection Volume Notification** packet is used to notify the Host when a collision occurs between two collision detection volumes (see **Collision Detection Volume Definition** packet, Section 4.1.23). Volumes belonging to the same entity are not tested against each other.

The IG sends a **Collision Detection Volume Notification** packet for each volume involved in a collision. For instance, if two volumes collide, two **Collision Detection Volume Notification** packets will be sent. If a collision occurs that involves three volumes, a total of six **Collision Detection Volume Notification** packets will be sent.

Unlike with collision detection segment testing, where the result is a single point, the result of a collision detection volume test is the geometric intersection of two volumes. This intersection is usually an irregular volume with many vertices; therefore, the collision response data contains no spatial information describing the intersection.

Because collision detection volume testing does not involve polygon surfaces, no material code is returned with the collision response data.

If a collision detection volume has been disabled, it will be excluded from all collision testing.

The contents of the **Collision Detection Volume Notification** packet are as follows:

| | | | | | | | | | | | | | | | | | | | | | | | |
|----------------------------|---|---|---|---|---|---|---|-------------------------|---|---|---|---|---|---|---|-------------------------------|---|---|---|---|---|---|---|
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| <i>Packet ID = 114</i> | | | | | | | | <i>Packet Size = 16</i> | | | | | | | | <i>Entity ID</i> | | | | | | | |
| <i>Volume ID</i> | | | | | | | | Reserved | | | | | | | | *1 <i>Contacted Entity ID</i> | | | | | | | |
| <i>Contacted Volume ID</i> | | | | | | | | Reserved | | | | | | | | Reserved | | | | | | | |
| Reserved | | | | | | | | | | | | | | | | | | | | | | | |

*1 *Collision Type*

Figure 100 – Collision Detection Volume Notification Packet Structure

Table 48 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 48 – Collision Detection Volume Notification Parameter Definitions

| Parameter | Description |
|---|--|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 114</p> | <p>This parameter identifies this data packet as the Collision Detection Volume Notification packet. The value of this parameter must be 114.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 16</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 16.</p> |

| Parameter | Description |
|--|---|
| <p>Entity ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter indicates the entity to which the collision detection volume belongs.</p> |
| <p>Volume ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter indicates the ID of the collision detection volume within which the collision occurred. This parameter, along with <i>Entity ID</i>, allows the Host to match this response with the corresponding request.</p> |
| <p>Collision Type</p> <p>Type: 1-bit field</p> <p>Units: N/A</p> <p>Values: 0 Non-entity 1 Entity</p> | <p>This parameter indicates whether the collision occurred with another entity or with a non-entity object such as the terrain.</p> |
| <p>Contacted Entity ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter indicates the entity with which the collision occurred.</p> <p>If <i>Collision Type</i> is set to Non-entity (0), this parameter is ignored.</p> |
| <p>Contacted Volume ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> | <p>This parameter indicates the ID of the collision detection volume with which the collision occurred.</p> |

4.2.15 Animation Stop Notification

The **Animation Stop Notification** packet is used to indicate to the Host when an animation has played to the end of its animation sequence.

If an animation is set to play continuously, no **Animation Stop Notification** packet will be sent.

The contents of the **Animation Stop Notification** packet are as follows:

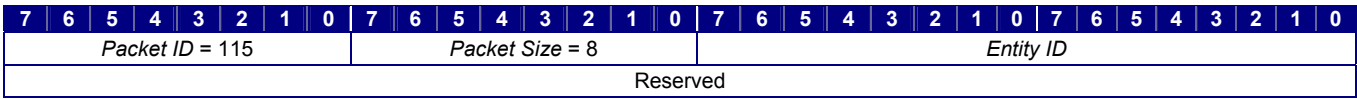


Figure 101 – Animation Stop Notification Packet Structure

Table 49 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 49 – Animation Stop Notification Parameter Definitions

| Parameter | Description |
|--|--|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 115</p> | <p>This parameter identifies this data packet as the Animation Stop Notification packet. The value of this parameter must be 115.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 8</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 8.</p> |
| <p>Entity ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter indicates the entity ID of the animation that has stopped.</p> |

4.2.16 Event Notification

The **Event Notification** packet is used to pass event data to the Host. The Host may enable and disable individual events using either the **Component Control** (Section 4.1.4) or **Short Component Control** (Section 4.1.5) packet.

This packet contains three user-defined 32-bit word values that may contain data describing the attributes of the event (e.g., time of occurrence, position). These data may be formatted as needed; however, they must be byte-swapped as 32-bit fields when byte swapping is necessary. Refer to the description of the **Component Control** packet (Section 4.1.4) for more information.

The contents of the **Event Notification** packet are as follows:

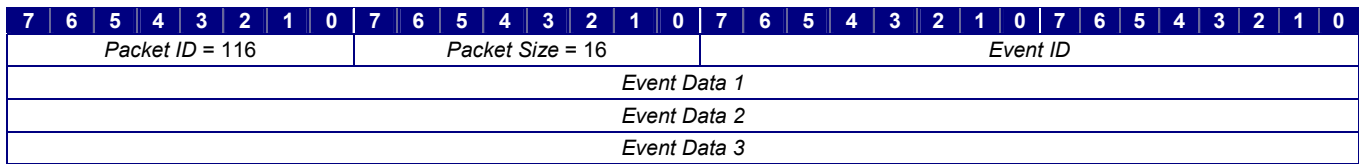


Figure 102 – Event Notification Packet Structure

Table 50 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 50 – Event Notification Parameter Definitions

| Parameter | Description |
|---|---|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 116</p> | <p>This parameter identifies this data packet as the Event Notification packet. The value of this parameter must be 116.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: 16</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 16.</p> |
| <p>Event ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter indicates which event has occurred.</p> <p>Event ID assignments are IG-specific.</p> |

| Parameter | Description |
|---|--|
| <p>Event Data 1</p> <p>Type: word</p> <p>Units: Event-specific</p> <p>Values: Event-specific</p> | <p>This parameter is one of three 32-bit words used for user-defined event data. If this parameter is not needed to describe the event, this value is ignored.</p> <p>Note: This parameter will be byte-swapped as a 32-bit value if the receiver and sender use different byte ordering schemes. If the parameter is used to store multiple 8- or 16-bit values, the data should be packed so that byte swapping will be performed correctly.</p> |
| <p>Event Data 2</p> <p>Type: word</p> <p>Units: Event-specific</p> <p>Values: Event-specific</p> | <p>This parameter is one of three 32-bit words used for user-defined event data. If this parameter is not needed to describe the event, this value is ignored.</p> <p>Note: This parameter will be byte-swapped as a 32-bit value if the receiver and sender use different byte ordering schemes. If the parameter is used to store multiple 8- or 16-bit values, the data should be packed so that byte swapping will be performed correctly.</p> |
| <p>Event Data 3</p> <p>Type: word</p> <p>Units: Event-specific</p> <p>Values: Event-specific</p> | <p>This parameter is one of three 32-bit words used for user-defined event data. If this parameter is not needed to describe the event, this value is ignored.</p> <p>Note: This parameter will be byte-swapped as a 32-bit value if the receiver and sender use different byte ordering schemes. If the parameter is used to store multiple 8- or 16-bit values, the data should be packed so that byte swapping will be performed correctly.</p> |

4.2.17 Image Generator Message

The **Image Generator Message** packet is used to pass error, debugging, and other text messages to the Host. These messages may be saved to a log file and/or written to the console or other user interface. Because file and console I/O are not typically real-time in nature, it is recommended that the IG only send **Image Generator Message** packets while in Debug mode.

Each message is composed of multiple eight-bit character data. The text message must be terminated by NULL, or zero (0). If the terminating byte is not the last byte of the eight-byte double-word, then the remainder of the double-word must be padded with zeroes. Zero-length messages must be terminated with four bytes containing NULL (to maintain 64-bit alignment). The maximum text length is 100 characters, including a terminating NULL.

The *Packet Size* parameter must contain the total number of bytes within the message, including the two-byte header, the message ID, the terminating NULL and any padding. This value must be an even multiple of eight (8). For example, if the string, "Error 1234," were sent to the Host, the packet size would be 16. Figure 103 illustrates the byte allocation for the packet:

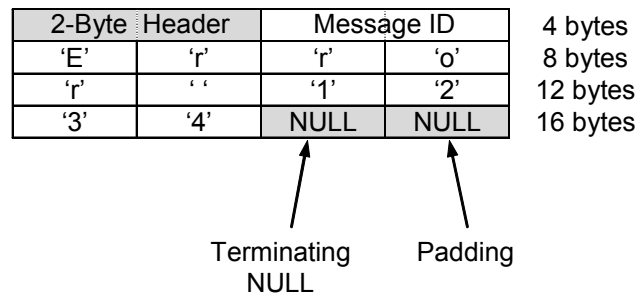


Figure 103 – Example of Image Generator Message Packet

The *Message ID* parameter identifies the message. Typically, this ID will correspond to a common, fixed message. In these cases, the Host can retrieve the message from a look-up table without the IG having to use unnecessary bandwidth to reproduce the text. The ID might also correspond to a common message while the remainder of the packet contains additional text to supplement the message.

The contents of the **Image Generator Message** packet are as follows:

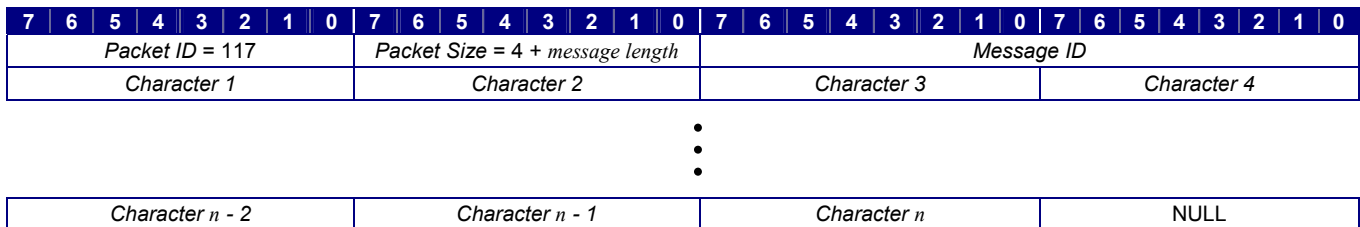


Figure 104 – Image Generator Message Packet Structure

Table 51 defines each parameter’s data type, units, and usage. If a default value and/or reference datum are applicable for a parameter, or if the domain differs from the range of values listed in Table 2, those values are also listed.

Table 51 – Image Generator Message Parameter Definitions

| Parameter | Description |
|---|--|
| <p>Packet ID</p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 117</p> | <p>This parameter identifies this data packet as the Image Generation Message packet. The value of this parameter must be 117.</p> |
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: bytes</p> <p>Value: $8 \leq (4 + \text{message length}) \leq 104$</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 4 plus the length of the message text, including NULL characters.</p> <p>The minimum size of the Image Generation Message packet is eight (8) bytes.</p> <p>The maximum packet size is 104 bytes. This allows for a message length of up to 100 characters, including the terminating NULL.</p> <p>Note: Because all packets must begin and end on a 64-bit boundary, the value of this parameter must be an even multiple of eight (8).</p> |
| <p>Message ID</p> <p>Type: unsigned int16</p> <p>Units: N/A</p> | <p>This parameter specifies a numerical identifier for the message.</p> |
| <p>Character <i>n</i></p> <p>Type: char</p> <p>Units: N/A</p> | <p>These 8-bit data are used to store the ANSI codes for each character in the message string.</p> <p>Note: The maximum number of characters, including a terminating NULL, is 100.</p> |

4.3 User-Defined Packets

User-defined data packets may be used to facilitate transmission of data not specifically supported by an existing CIGI packet. User-defined data packets may be contained in both IG-to-Host and Host-to-IG messages.

When user-defined data packets are introduced into a particular CIGI application, they should adhere to the standard data packet format in order to maintain continuity across data packets. Standard data packet format includes the *Packet ID* in the first byte and the *Packet Size* in the second byte. All parameters used to identify an instance of a packet (in other words, all parameters that, if identical, would allow two packets to represent the same object) should be contained within the first two 32-bit words. It is recommended that if bytes are allocated for such parameters as *Entity ID* and *View ID*, these values be positioned and sized in similar fashion as other instances of like information within the interface.

The size of each user-defined data packet depends on the amount of data contained in the packet. The developer should place the total number of bytes, including the two bytes of header, in the *Packet Size* field of this packet so that the receiver can properly interpret the packet.

Note: All user-defined packets must begin and end on a 64-bit boundary. The value of the *Packet Size* parameter must therefore be an even multiple of eight (8).

Note that when a user-defined data packet is introduced into a particular implementation of CIGI, that implementation will no longer conform to the baseline definition of the interface and thus may not be acceptable to the general CIGI user community. Ideally, each Host and IG device should be capable of being configured to ignore all user-defined packets.

The general format for user-defined packets is as follows:

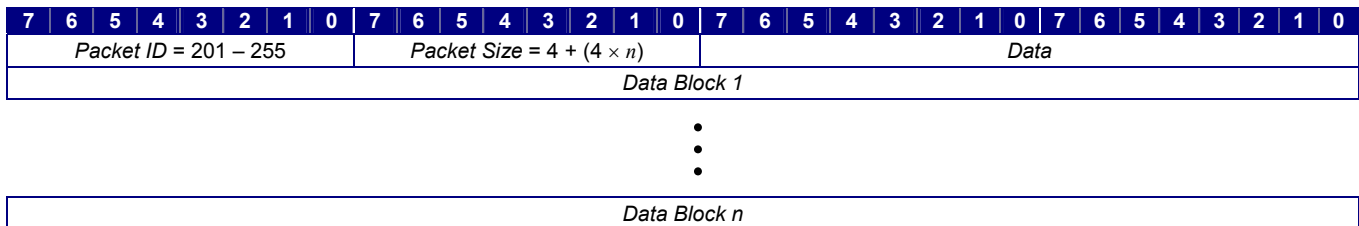


Figure 105 – General User-Defined Packet Structure

Table 52 defines each parameter’s data type, units, and usage.

Table 52 – General User-Defined Packet Parameter Definitions

| Parameter | Description |
|---|--|
| <p><i>Packet ID</i></p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 201 – 255</p> | <p>This parameter identifies this data packet as a user-defined packet. The value of this parameter must be within the range of 201 through 255.</p> |

| Parameter | Description |
|---|--|
| <p>Packet Size</p> <p>Type: unsigned int8</p> <p>Units: Bytes</p> <p>Value: $4 + (4 \times n) \geq 8$</p> | <p>This parameter indicates the number of bytes in this data packet. The value of this parameter must be 4 times the number of data words, plus 4 for the word that includes the two-byte header.</p> <p>Note: Because all packets must begin and end on a 64-bit boundary, the value of this parameter must be an even multiple of eight (8).</p> |
| <p>Data</p> <p>Type: Packet-specific</p> <p>Units: Packet-specific</p> | <p>This field consists of two bytes of user-defined data. The data may be arranged and formatted as needed.</p> |
| <p>Data Block <i>n</i></p> <p>Type: Packet-specific</p> <p>Units: Packet-specific</p> | <p>These 32-bit blocks represent user-defined data. The data may be arranged and formatted as needed.</p> |

APPENDIX I – ACRONYMS

| | |
|------|----------------------------------|
| CIGI | Common Image Generator Interface |
| DCS | Dynamic Coordinate System |
| ERM | Earth Reference Model |
| FOV | Field of View |
| HAT | Height Above Terrain |
| HOT | Height Of Terrain |
| IG | Image Generator |
| I/O | Input/Output |
| IP | Internet Protocol |
| LOS | Line of Sight |
| LSW | Least Significant Word |
| MSL | Mean Sea Level |
| MSW | Most Significant Word |
| NED | North-East-Down |
| SOF | Start of Frame |
| UDP | User Datagram Protocol |

APPENDIX II – CHANGES FROM CIGI 2

General Changes

1. Big-endian byte ordering is no longer enforced. The sender now packages data in its native byte format, and the receiver byte-swaps if necessary. This distributes the overhead of byte-swapping between the two devices and eliminates unnecessary processing when both the IG and the Host use little-endian byte ordering.
2. All packets are double word-aligned for reasons relating to performance.
3. The packet opcodes have been reassigned to match their subsection numbers in this document. For example, The **Rate Control** packet's opcode is now 6, which corresponds to Section 4.1.6. The **Line of Sight Response** packet's opcode is 106, which corresponds to Section 4.2.6.
4. All identifying parameters have been contained within the first two words of each packet. These parameters are those that, when combined, uniquely identify an entity, component, articulated part, view, or other object. This allows for fast searches through a CIGI message buffer for a particular packet.
5. All bit fields have been shifted to fill the low-order bits within a byte first.
6. All fixed-point data have been changed to floating-point data.
7. A set of guidelines has been created to facilitate forward- and backward-compatibility between CIGI 3 and future versions of the interface.
8. Support has been added for orthographic views.
9. Increased the number of allowable views and view groups.
10. The number of motion-tracked input devices has been increased from one (1) to 256. All related data have been moved into a new **Motion Tracker Control** packet.
11. The **Environment Control** packet has been removed. The parameters in this packet have been divided among the **Celestial Sphere Control** and **Atmosphere Control** packets.
12. Special Effects have been renamed "Animations" to imply more generality in their use.
13. The **Special Effect Definition** packet has been removed. The *Animation Direction* parameter (formerly *Sequence Direction*) has been moved to the **Entity Control** packet. All other animation-specific properties can be set via the **Component Control** or **Short Component Control** packet.
14. Support has been added for custom Earth Reference Models. These may be defined by the **Earth Reference Model Definition** packet. The *Earth Reference Model* parameter has been added to the **Start of Frame** packet to indicate whether the IG is using WGS 84 or a Host-defined ERM.
15. The **Height Above Terrain Request** and **Height of Terrain Request** packets have been combined into the **HAT/HOT Request** packet. The respective response packets have been combined into the **HAT/HOT Response** packet.
16. Alternate HAT/HOT and LOS response packets have been added, and the existing response packets have been shortened. These changes allow for short responses containing basic information, thereby reducing bandwidth requirements, or for more verbose responses when necessary. The new packets are the **HAT/HOT Extended Response** and **Line of Sight Extended Response**.
17. Support has been added for spherical collision detection volumes.

18. Support has been added for querying the IG of positional and environmental state data. The Host may query the IG for the position of a given entity, articulated part, view, or motion tracker. The Host may also request the weather conditions, aerosol concentration, or ground or sea surface conditions at a given point.
19. Support has been added for environmental regions. These may be defined and manipulated with the **Environmental Region Control** packet. This allows for regional weather layers and surface conditions.
20. Support has been added for global, regional, and entity-assigned surface conditions. The **Maritime Surface Conditions Control** packet is used to specify deep- and shallow-regime sea surface conditions. The **Terrestrial Surface Conditions Control** packet is used to specify ground surface condition attributes.
21. Support for multiple aerosols has been added. Each weather layer ID is associated with an aerosol type.
22. The **Animation Stop Notification** packet has been added to indicate to the Host when an animation has completed its playback sequence.
23. The range of opcodes reserved for user-defined packets has been changed to 201 – 255.
24. Various packet and parameter names have been renamed for consistency and/or clarity.

IG Control

1. The value of *CIGI Version* has been changed to 3.
2. The *IG Mode* parameter has been moved within the packet.
3. A “magic number” called *Byte Swap* has been added. This parameter will allow the receiving device to detect when byte-swapping is necessary.
4. The range of the *Database Number* parameter has been increased to 0 – 127.
5. The data type of the *Timestamp* parameter (formerly *Timing Value*) has been changed from that of single-precision float to unsigned 32-bit integer. The unit of this parameter has been changed from 1 μ s to 10 μ s. A *Timestamp Valid* flag has also been added.
6. The *Tracking Device Enable* and *Tracking Device Boresight* parameters have been moved to the **Motion Tracker Control** packet.

Entity Control

1. The bit fields have been rearranged.
2. The *Entity State* enumerated values have been renamed for clarity. Their functions remain the same.
3. The *Animation State* (formerly *Effect Animation State*) enumerated values have been changed for ease of use. The new values fit the standard “tape player” analogy.
4. The *Animation Direction* and *Animation Loop Mode* parameters have been added.
5. The *Ground/Ocean Clamp* parameter has been added.
6. *Percent Opacity* has been replaced with *Alpha*. The *Inherit Alpha* parameter has been added to provide more control over how child entities behave when their parent’s alpha is changed.
7. The *Internal Temperature* parameter has been removed to reduce the size of the **Entity Control** packet. This parameter was primarily used in sensor applications. The use of this parameter was loosely defined

in CIGI 2, since the skin temperature of an entity can vary significantly over the body of an entity. All temperature components must now be specified with a **Component Control** or **Short Component Control** packet.

8. The *Ground/Ocean Clamp* parameter has been added.
9. The *Heading* parameter has been renamed to *Yaw*.
10. The order of the *Latitude/X Offset*, *Longitude/Y Offset*, and *Altitude/Z Offset* parameters has been changed for consistency.
11. The most- and least-significant words of the *Latitude/X Offset*, *Longitude/Y Offset*, and *Altitude/Z Offset* parameters are no longer specified.

Conformal Clamped Entity Control

This packet has been added to provide a short version of the **Entity Control** packet for conformal ground- or ocean-clamped entities.

Component Control

1. The opcode has been changed to 4.
2. The *Instance ID*, *Component ID*, and *Component Class* parameters have been rearranged to fit into the first 64 bits of the packet. This allows a component to be uniquely identified by the first two words.
3. The *Component Class* parameter has been shortened to accommodate the preceding change. The enumerated values of this parameter have also been changed.
4. The *Component Value* parameter has been shortened to allow it to fit into a portion of the previously unused space of the packet. The range of this value has been shortened; however, one of the user-defined data fields may be used when a larger range is needed.
5. The *Component Data 1* and *Component Data 2* parameters have been changed from single-precision floating-point data to 32-bit, user-defined data.
6. The *Component Data 3* and *Component Data 4* parameters have been added. These parameters are of user-defined format.

Short Component Control

This packet has been added to provide a short version of the **Component Control** packet for components that do not require four user-defined data fields.

Articulated Part Control

1. The opcode has been changed to 6.
2. The bit fields have been moved within the packet to fill low-order bits first.
3. The *Articulated Part ID* parameter has been changed from a signed 8-bit integer to an unsigned 8-bit integer.

Short Articulated Part Control

This packet has been added to provide a short version of the **Articulated Part Control** packet for articulations that require manipulation of no more than two degrees of freedom. This packet can also be used to articulate two different articulate parts, each in one degree of freedom.

Rate Control

1. The opcode has been changed to 8.
2. The *Articulated Part ID* parameter has been changed from a signed 8-bit integer to an unsigned 8-bit integer.
3. The *Apply to Articulated Part* flag has been added.

Environment Control

This packet has been deleted. The data within this packet have been moved to the **Celestial Sphere Control** and **Atmosphere Control** packets.

Celestial Sphere Control

1. This packet has been added to allow the separation of date/time and sky model properties from atmospheric properties. The *Hour*, *Minute*, *Date*, and *Ephemeris Model Enable* parameters have been moved from the CIGI 2 **Environment Control** packet.
2. The *Date/Time Valid* parameter has been added to allow attributes to be set without disrupting the IG's ephemeris model.
3. The *Sun Enable*, *Moon Enable*, *Star Field Enable*, and *Star Field Intensity* parameters have been added.

Atmosphere Control

1. This packet has been added to allow the separation of date/time and sky model properties from atmospheric properties. All parameters relating to atmospheric properties and weather have been moved from the CIGI 2 **Environment Control** packet.
2. The *MODTRAN Enable* parameter has been renamed to *Atmospheric Model Enable* to make its use more general.
3. The *Wind Speed* parameter in the CIGI 2 **Environmental Control** packet has been replaced with the *Global Horizontal Wind Speed* and *Global Vertical Wind Speed* parameters to allow for three-dimensional wind vectors.
4. The *Aerosol* parameter has been removed. CIGI 2 defined this parameter as the concentration of water suspended in the atmosphere. This is redundant, given the *Global Humidity* parameter. It also limits the types of aerosol that can be created.

Environmental Region Control

This packet has been added to allow the definition and/or control of regional weather and surface conditions.

Weather Control

1. The opcode has been changed to 12.

2. The bit fields have been moved within the packet to fill low-order bits first.
3. The *Entity ID* parameter has been changed to *Entity/Region ID* to allow weather layers to be assigned to environmental regions.
4. The *Phenomenon Type* parameter has been renamed to *Layer ID* to better describe its intended use. The enumerated values for this parameter have been slightly changed, and additional values have been added. This parameter has also been shortened to accommodate additional bit fields.
5. The *Cloud Type* parameter has been added.
6. The *Scope* parameter has been added to distinguish between global, regional, and entity-assigned weather.
7. The *Random Lightning Enable* parameter has been added.
8. The *Opacity/Runway Visibility Range* parameter has been replaced with *Visibility Range*. Visibility is now specified as a range through all weather, not just ground fog layers.
9. The *Elevation* parameter has been renamed to *Base Elevation*.
10. The *Winds Aloft Speed* parameter has been replaced with the *Horizontal Wind Direction* and *Vertical Wind Speed* parameters to allow for three-dimensional wind vectors.
11. The *Humidity*, *Barometric Pressure*, and *Aerosol Concentration* parameters have been added to allow these properties to vary from layer to layer or entity to entity.

Maritime Surface Conditions Control

This packet has been added to support sea surface conditions.

Wave Control

This packet has been added to support the definition and control of multiple waveforms.

Terrestrial Surface Conditions Control

This packet has been added to support ground surface conditions.

View Control

1. The opcode has been changed to 16.
2. The *View ID*, *Group ID*, and *Entity ID* parameters have been rearranged.
3. The range of the *View ID* parameter has been increased to 0 – 65,535.
4. The range of the *View Group* parameter has been increased to 1 – 255.
5. The bit field parameters have been rearranged to accommodate the enlarged *View ID* and *View Group* parameters.

Sensor Control

1. The opcode has been changed to 17.
2. The range of the *View ID* parameter has been increased to 0 – 65,535.

3. The range of the *View Group* parameter has been increased to 1 – 255.
4. The bit field parameters have been rearranged to accommodate the enlarged *View ID* and *View Group* parameters.
5. The *Response Type* parameter has been added to allow the Host to indicate whether it needs a **Sensor Response** or **Sensor Extended Response** packet from the IG.
6. The *AC Coupling* parameter's unit has been changed to μs , and its range has been extended.

Motion Tracker Control

This packet has been added to enable control of multiple tracked input devices.

Earth Reference Model Definition

This packet has been added to enable the Host to specify an ERM other than WGS 84.

Trajectory Definition

1. The opcode has been changed to 20.
2. The *Acceleration Factor* parameter has been replaced with *Acceleration Azimuth*, *Acceleration Elevation*, and *Acceleration Magnitude*. This will allow the Host to define acceleration as a 3D vector.

Special Effect Definition

This packet has been removed. Animation-specific properties may be set via **Component Control** or **Short Component Control** packets.

View Definition

1. The opcode has been changed to 21.
2. The range of the *View ID* parameter has been increased to 0 – 65,535.
3. The range of the *View Group* parameter has been increased to 1 – 255.
4. The bit field parameters have been rearranged to accommodate the enlarged *View ID* and *View Group* parameters.
5. The *Projection Type* parameter has been added to allow for support of orthographic views.
6. The *Tracker Assign* parameter has been removed. Assignment of motion trackers to views is now done via the **Motion Tracker Control** packet.

Collision Detection Segment Definition

1. The opcode has been changed to 22.
2. The *Segment ID* parameter has been changed to an unsigned 8-bit integer.
3. The *Segment Enable* parameter has been moved within the packet.
4. All fixed-point data have been changed to single-precision floating-point data.
5. The *Collision Mask* parameter has been renamed to *Material Mask* for clarity.

6. Padding has been added to the packet to enforce 8-byte alignment.

Collision Detection Volume Definition

1. The opcode has been changed to 23.
2. The *Volume ID* parameter has been changed to an unsigned 8-bit integer.
3. The *Volume Enable* parameter has been moved within the packet.
4. All fixed-point data have been changed to single-precision floating-point data.
5. The *Volume Type* parameter has been added to allow for both cuboid and spherical volumes.
6. The *Height* parameter has been renamed to *Height/Radius* to indicate its use for cuboid volumes.
7. Padding has been added to the packet to enforce 8-byte alignment.

Height Above Terrain Request

This packet has been combined with the **Height of Terrain Request** packet to form the **HAT/HOT Request** packet.

Height of Terrain Request

This packet has been combined with the **Height Above Terrain Request** packet to form the **HAT/HOT Request** packet.

HAT/HOT Request

1. A *Request Type* parameter has been added to allow the Host to request either a HAT, HOT, or combined extended response from the IG.
2. The most- and least-significant words of the *Latitude*, *Longitude*, and *Altitude* parameters are no longer specified.
3. The *Latitude*, *Longitude*, and *Altitude* parameters have been rearranged for consistency.

Line of Sight Segment Request

1. This packet has been renamed from “Line of Sight Occult Request.”
2. The opcode has been changed to 25.
3. A *Request Type* parameter has been added to allow the Host to request either a basic or extended response from the IG.
4. The *Material Mask* parameter has been added.
5. The *Alpha Threshold* parameter has been added.
6. Padding has been added to the packet to enforce 8-byte alignment.
7. The most- and least-significant words of the *Source Latitude*, *Source Longitude*, *Source Altitude*, *Destination Latitude*, *Destination Longitude*, and *Destination Altitude* parameters are no longer specified.

8. The *Source Latitude*, *Source Longitude*, *Source Altitude*, *Destination Latitude*, *Destination Longitude*, and *Destination Altitude* parameters have been rearranged for consistency.

Line of Sight Vector Request

1. This packet has been renamed from “Line of Sight Range Request.”
2. The opcode has been changed to 26.
3. A *Request Type* parameter has been added to allow the Host to request either a basic or extended response from the IG.
4. The *Material Mask* parameter has been added.
5. The *Alpha Threshold* parameter has been added.
6. Padding has been added to the packet to enforce 8-byte alignment.
7. The most- and least-significant words of the *Source Latitude*, *Source Longitude*, and *Source Altitude* parameters are no longer specified.

Position Request

This packet has been added to enable the Host to query the IG for the position of a given entity, articulated part, view, or motion tracker.

Environmental Conditions Request

This packet has been added to enable the Host to query the IG for weather conditions, aerosol concentrations, or ground or sea surface conditions at a given point.

Start of Frame

1. The value of *CIGI Version* has been changed to 3.
2. The *IG Mode* parameter has been moved to the low-order bit of the byte.
3. The value zero (0) is no longer valid for the *Database Number* parameter. This fixes an inconsistency in prior versions of CIGI.
4. A “magic number” called *Byte Swap* has been added. This parameter will allow the receiving device to detect when byte-swapping is necessary.
5. An *Earth Reference Model* parameter has been added to indicate whether the IG is using WGS 84 or a Host-defined ERM.
6. The data type of the *Timestamp* parameter (formerly *Timing Value*) has been changed from that of single-precision float to unsigned 32-bit integer. The unit of this parameter has been changed from 1 μ s to 10 μ s. A *Timestamp Valid* flag has also been added.

Height Above Terrain Response

This packet has been combined with the **Height of Terrain Response** packet to form the **HAT/HOT Response** packet.

Height of Terrain Response

This packet has been combined with the **Height Above Terrain Response** packet to form the **HAT/HOT Response** packet.

HAT/HOT Response

1. The *Material Code* parameter has been moved to the **HAT/HOT Extended Response** packet.
2. The *Valid* field has been moved to the low-order bit of the byte.
3. The most- and least-significant words of the *Height* parameter (formerly *Altitude*) are no longer specified.

HAT/HOT Extended Response

This packet has been added to provide extended HAT and HOT data.

Line of Sight Response

1. The opcode has been changed to 104.
2. The *Latitude*, *Longitude*, *Altitude*, and *Material Code* parameters have been moved to the **Line of Sight Extended Response** packet.
3. The *Occult Response* parameter has been changed to *Visible*.
4. The *Entity ID* and *Entity ID Valid* parameters have been added.
5. The bit fields have been moved within the packet to fill low-order bits first.

Line of Sight Extended Response

This packet has been added to provide extended LOS data.

Sensor Response

1. The opcode has been changed to 106.
2. The *View ID* parameter has been changed to an unsigned 16-bit integer.
3. The *Sensor ID* parameter has been changed to an unsigned 8-bit integer.
4. The *Sensor Status* parameters have been moved within the packet.
5. The *Target X Offset* and *Target Y Offset* parameters have been renamed to *Gate X Position* and *Gate Y Position*, respectively. Both parameters have been changed from fixed-point data to single-precision floating-point data.
6. The *Frame Counter* parameter has been added to allow the Host to calculate sensor sampling rate and latency.

Collision Detection Segment Notification

1. This packet has been renamed from “Collision Detection Segment Response.”
2. The opcode has been changed to 113.

3. The *Segment ID* parameter has been changed to an unsigned 8-bit integer.
4. The *Collision Type* parameter (formerly *Entity/Non-Entity Contact*) has been moved to accommodate the enlarged *Segment ID* parameter.
5. The *Collision Point X*, *Collision Point Y*, and *Collision Point Z* parameters have been replaced with the *Intersection Distance* parameter, which defines the intersection point by specifying a distance along the collision segment.

Collision Detection Volume Notification

1. This packet has been renamed from “Collision Detection Volume Response.”
2. The opcode has been changed to 114.
3. The *Volume ID* parameter has been changed to an unsigned 8-bit integer.
4. The *Collision Type* parameter (formerly *Entity/Non-Entity Contact*) has been moved to accommodate the enlarged *Volume ID* parameter.
5. The *Contacted Volume ID* parameter has been added.

Sensor Extended Response

This packet has been added to provide extended sensor response data.

Weather Conditions Response

This packet has been added to provide the weather conditions at a given point.

Aerosol Concentration Response

This packet has been added to provide the concentration of a single aerosol at a given point.

Maritime Surface Conditions Response

This packet has been added to provide the sea surface conditions at a given location.

Terrestrial Surface Conditions Response

This packet has been added to indicate the presence of a single terrestrial surface condition attribute at a given point.

Animation Stop Notification

This packet has been added to allow the IG to notify the Host when an animation has completed its animation sequence.

Event Notification

This packet has been added to allow the IG to notify the Host when an event occurs.

Image Generator Message

The maximum packet length for this packet has been established as 104 bytes to minimize bandwidth and to ease implementation.