

### APPENDIX III – CORRECTIONS

This appendix contains corrections to this ICD. Changes and additions are indicated by **highlighted text**. Deletions are indicated by ~~struckthrough text~~. These pages supercede the corresponding sections within the document. Changes included here will be incorporated into the next revision of the ICD.

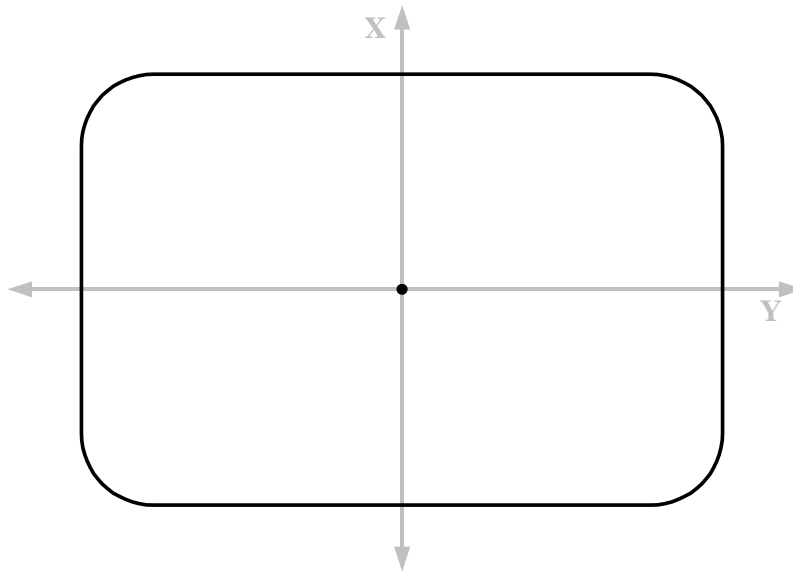
This appendix will be updated periodically. Visit the CIGI web site (<http://cigi.sourceforge.net>) for the latest version.

The list below gives the sections and page numbers that contain the corrections, describes each change, and provides the revision date for each change.

Revision Date	Section	Page	Page(s) Affected	Description
20 Jan. 2004	4.1.28	220	157–158	The 4 <sup>th</sup> byte of the first word of the Environmental Conditions 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.
20 Jan. 2004	4.2.12	230	196	The range of the <i>Surface Conditions ID</i> parameter in Table 46 has been defined.
21 Jan. 2004	4.1.11	235	85	The range of valid values for the <i>Transition Perimeter</i> parameter has been changed to $\geq 0$ .
31 Mar. 2004	4.1.20	237	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.
31 Mar. 2004	4.2.17	239	204	Figure 101 has been corrected to show the <i>Message ID</i> parameter.
16 Nov. 2006	3.3.3	242	25	The Figure 20 and text have been clarified to emphasize that a submodel coordinate system may be arbitrarily rotated within the model.

#### 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**

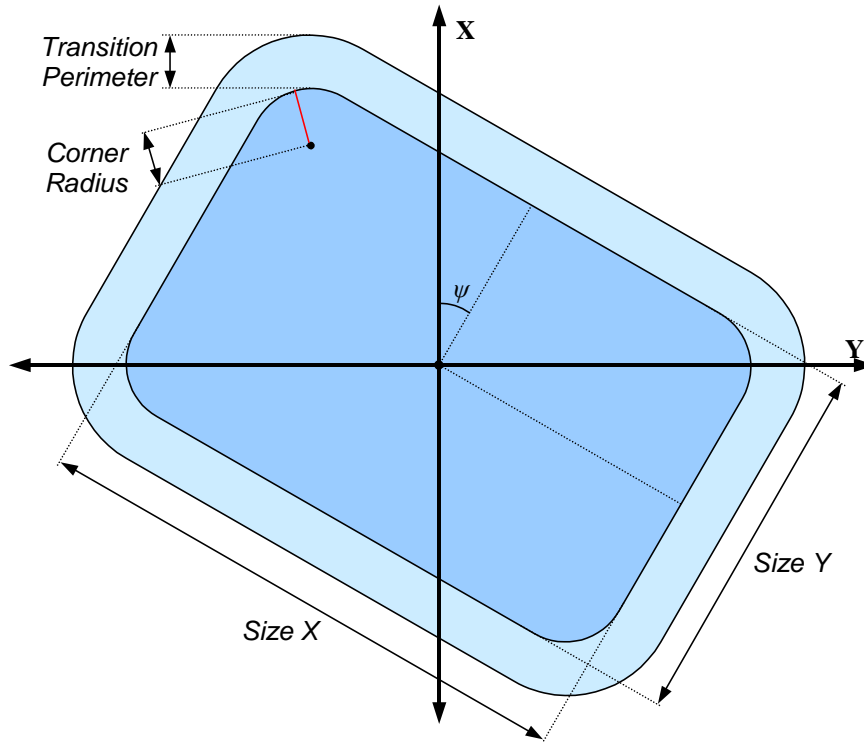
Up to 256 weather layers may be defined within a region. Weather layers can be created and manipulated with the **Weather Control** packet (Section 4.1.12). Up to one set of maritime and/or terrestrial surface condition parameters may be defined per region.

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*.

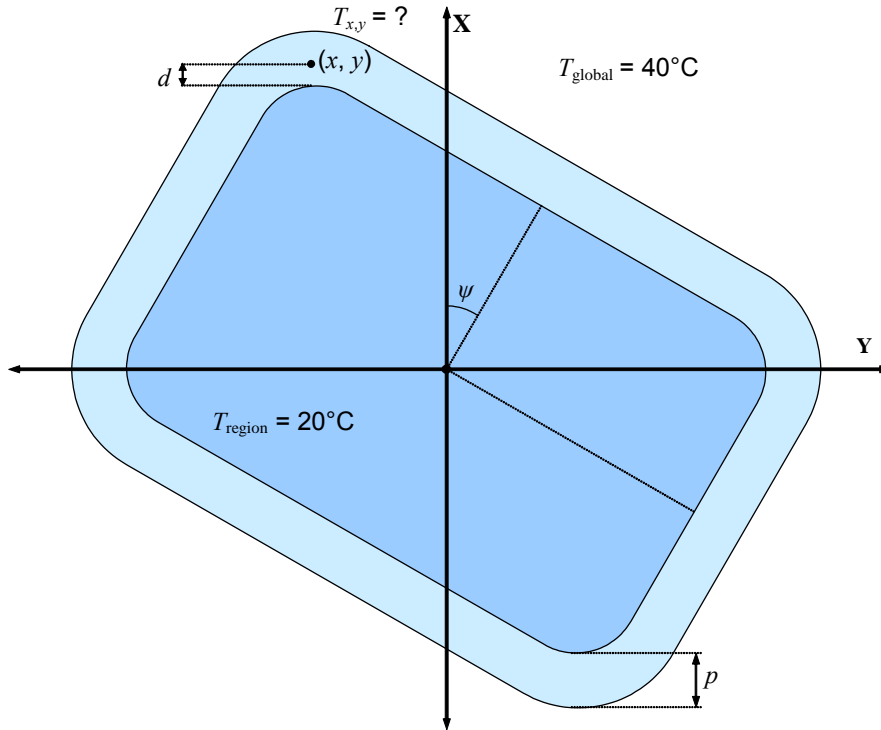
The *Rotation* parameter specifies an angle of rotation (clockwise) about the *Z* axis of the local NED coordinate system. Figure 41 shows a rounded rectangle on the NED reference plane rotated by a positive angle  $\psi$ .



**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,  $T_{\text{region}}$ , is defined to be 20°C and the global air temperature,  $T_{\text{global}}$ , 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.



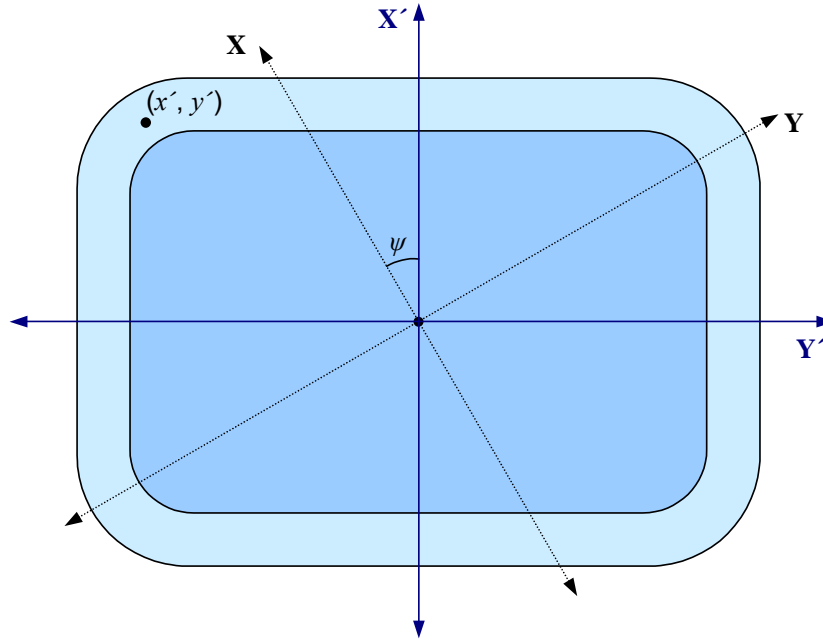
**Figure 1 – Interpolation of Temperature within Transition Perimeter**

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:

$$x' = y \sin \psi + x \cos \psi \tag{1}$$

$$y' = y \cos \psi - x \sin \psi \tag{2}$$

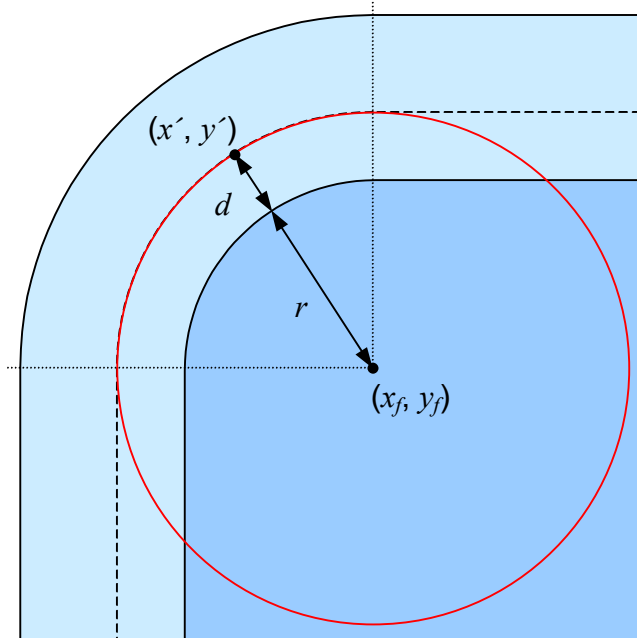
Figure 43 shows the rounded rectangle relative to the new coordinate system:



**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:

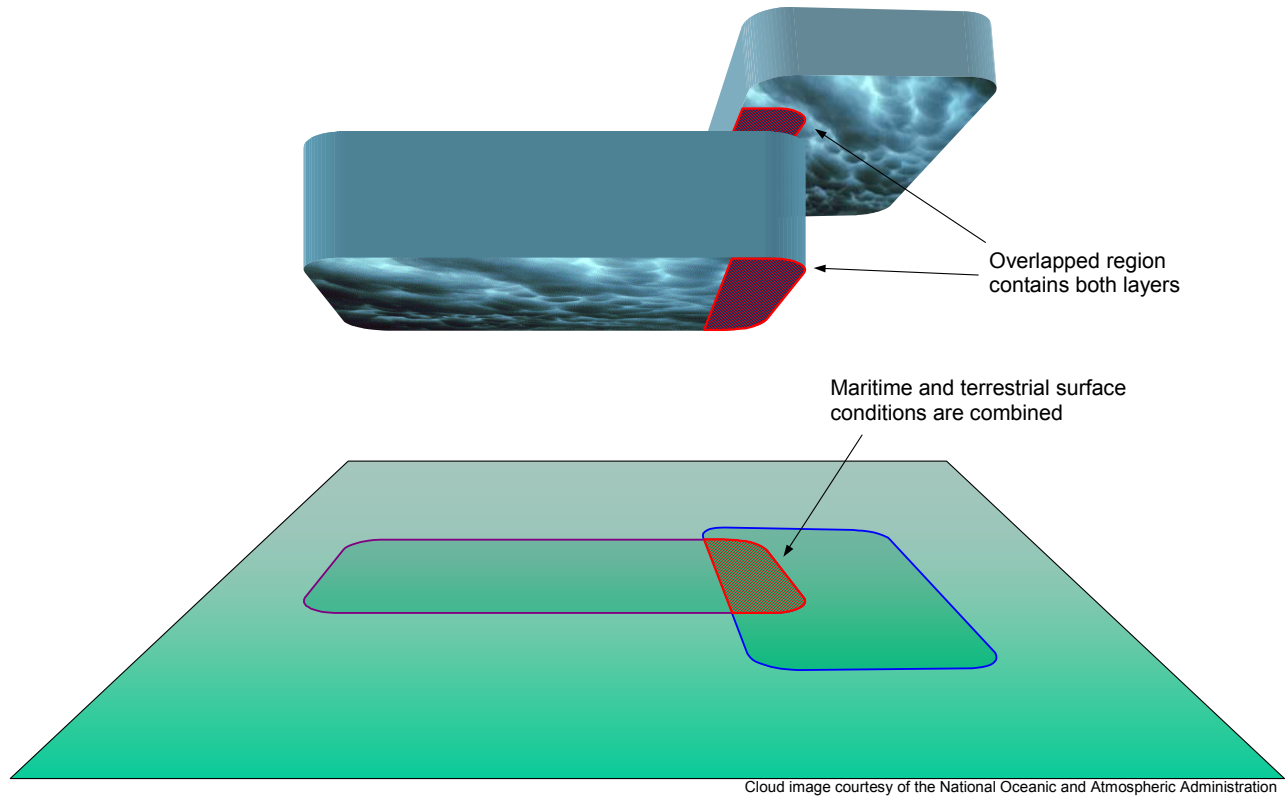
$$T_{x,y} = \frac{d (T_{\text{global}} - T_{\text{region}})}{p} + T_{\text{region}} \quad (6)$$

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.

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	7	6	5	4	3	2	1	0
Packet ID = 11								Packet Size = 48								Region ID															
*6	*5	*4	*3	*2	*1	Reserved																									
Latitude																															
Longitude																															
Size X																															
Size Y																															
Corner Radius																															
Rotation																															
Transition Perimeter																															
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 46 – 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><b>Packet ID</b></p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 11</p>	<p>This parameter identifies this data packet as the <b>Environmental Region Control</b> packet. The value of this parameter must be 11.</p>
<p><b>Packet Size</b></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><b>Region ID</b></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><b>Region State</b></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><b>Inactive</b> – Any weather layers and surface conditions defined within the region are disabled regardless of their individual enable states.</p> <p><b>Active</b> – Any weather layers and surface conditions defined within the region are enabled according to their individual enable states.</p> <p><b>Destroyed</b> – The environmental region is permanently deleted, as are all weather layers and surface conditions assigned to the region.</p>
<p><b>Merge Weather Properties</b></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 <b>Weather Control</b> 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><b>Merge Aerosol Concentrations</b></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 <b>Weather Control</b> 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>

Parameter	Description
<p><b>Merge Maritime Surface Conditions</b></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 <b>Maritime Surface Conditions Control</b> 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>
<p><b>Merge Terrestrial Surface Conditions</b></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 <b>Terrestrial Surface Conditions Control</b> 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><b>Latitude</b></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><b>Longitude</b></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>

Parameter	Description
<p><b>Size X</b></p> <p>Type: single float</p> <p>Units: meters</p> <p>Values: &gt; 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>
<p><b>Size Y</b></p> <p>Type: single float</p> <p>Units: meters</p> <p>Values: &gt; 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><b>Corner Radius</b></p> <p>Type: single float</p> <p>Units: meters</p> <p>Values: 0 to lesser of (<math>\frac{1}{2} \times \text{Size X}</math>) or (<math>\frac{1}{2} \times \text{Size Y}</math>)</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><b>Rotation</b></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><b>Transition Perimeter</b></p> <p>Type: single float</p> <p>Units: meters</p> <p>Values: <math>\geq 0</math></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>

#### 4.1.28 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 73:

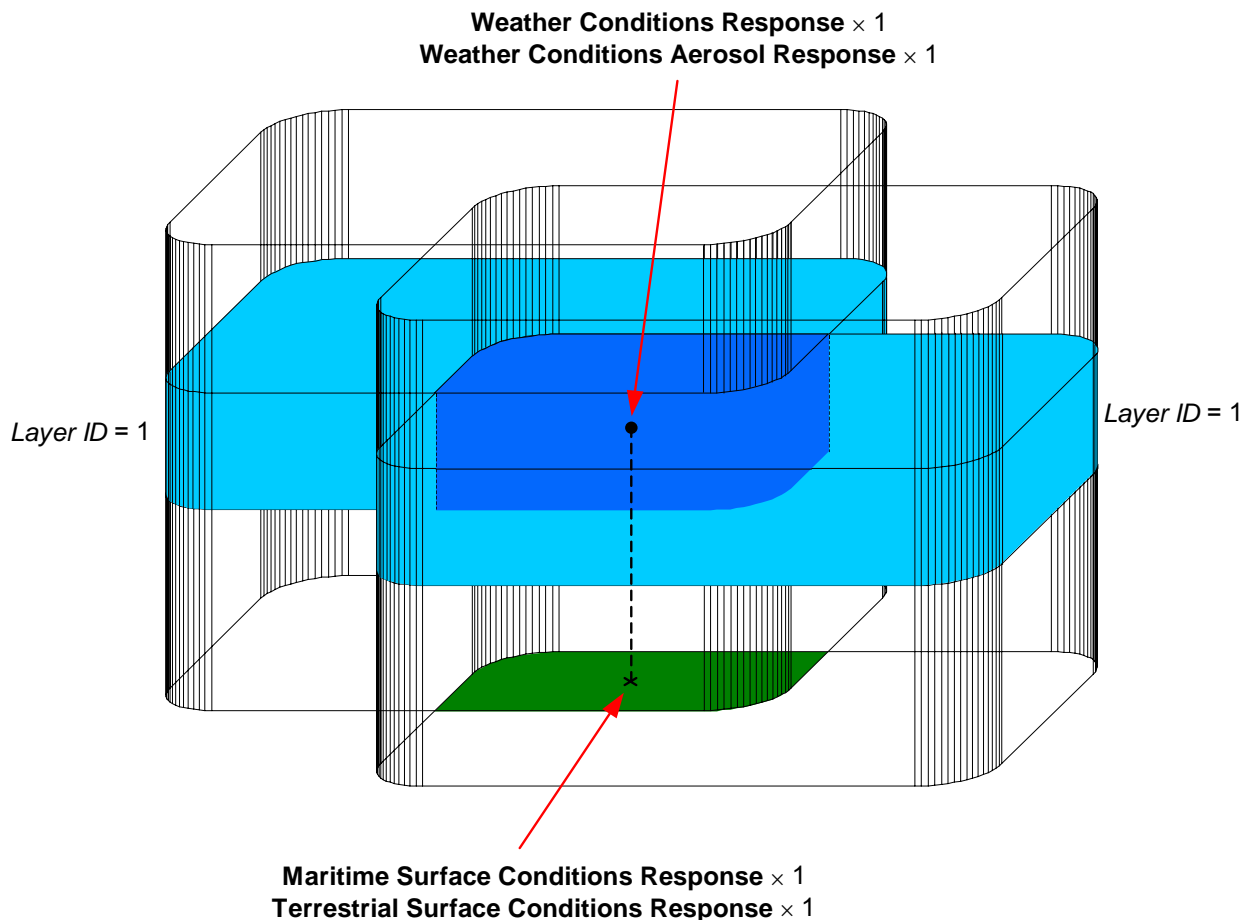
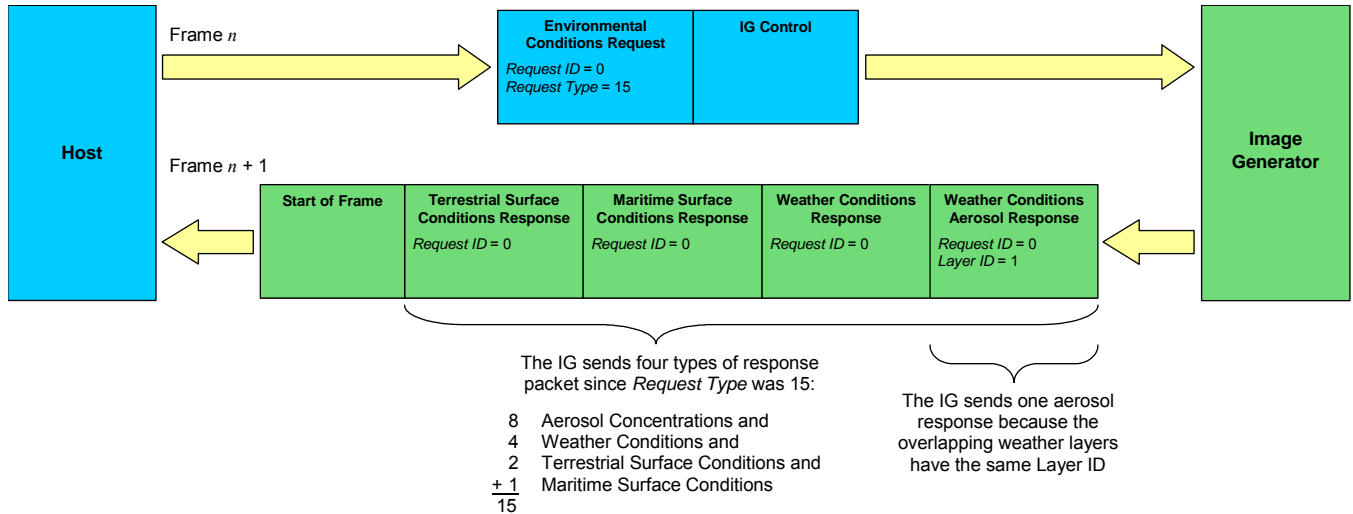


Figure 73 – Environmental Conditions Request (Weather Layers with Same ID)

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 74.

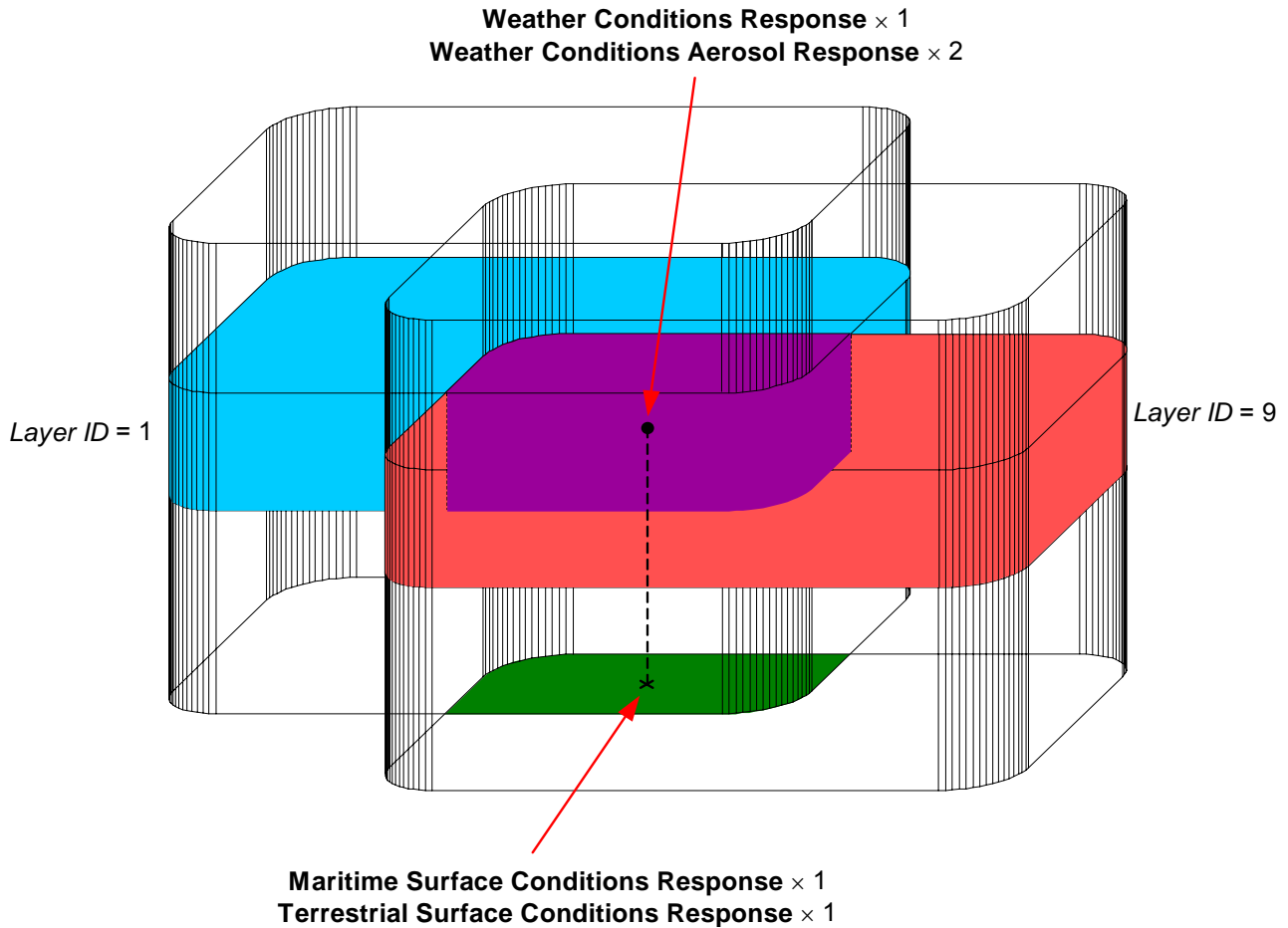
The IG would answer the request with each of the required response packets. Note that the IG would populate the *Request ID* parameter of each response packet with the value of the *Request ID* parameter in the **Environmental Conditions Request** packet. The following diagram illustrates this exchange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



**Figure 74 – Data Exchange for Environmental Conditions Request (One Aerosol)**

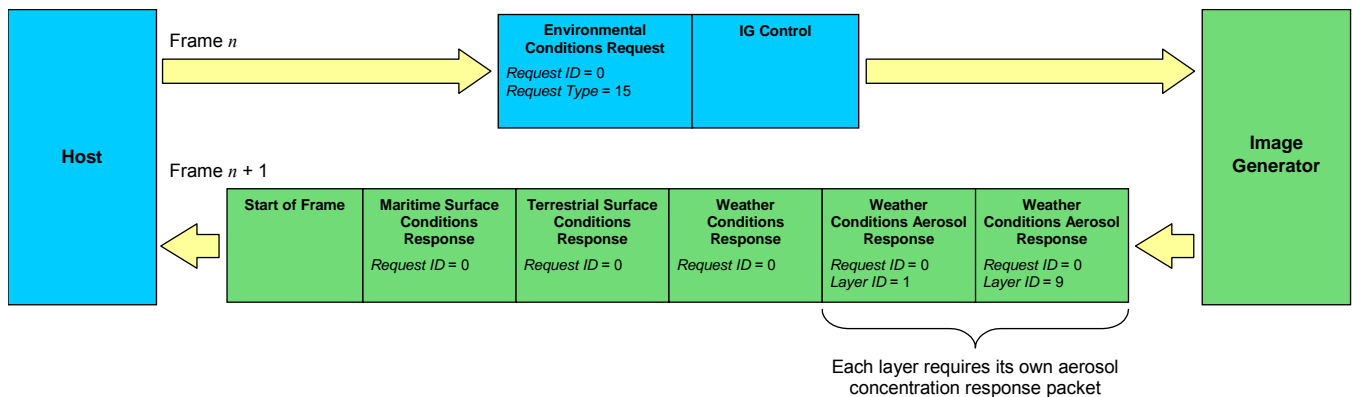
Because the *Layer ID* of both weather layers is the same, the IG would send only one **Weather Conditions Aerosol Response** packet. This packet would contain the average (or the result of some other appropriate combining function) of the concentrations of the aerosol contained within Layer 1 of each 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 75 – Environmental Conditions Request (Weather Layers with Different IDs)**

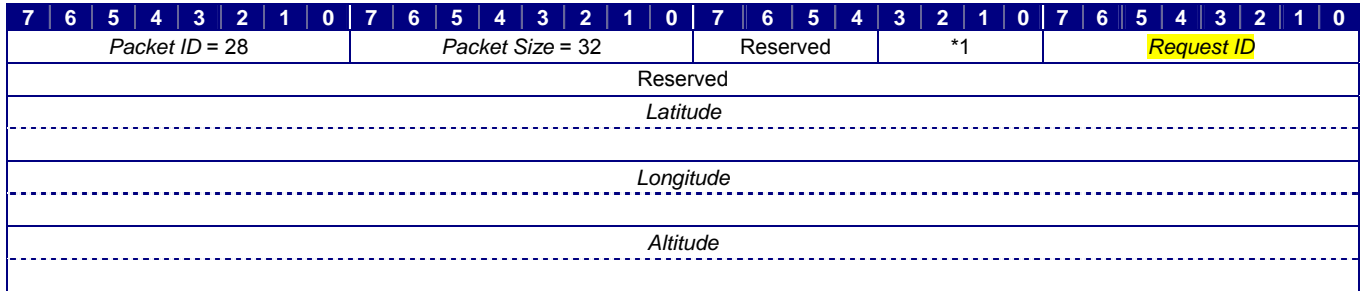
The figure above shows a cloud layer (Layer 1) overlapping with a dust layer (Layer 9). Given the same environmental conditions request, the IG would now send two **Weather Conditions Aerosol Response** packets:



**Figure 76 – 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 77 – 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><b><i>Packet ID</i></b></p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 28</p>	<p>This parameter identifies this data packet as the <b>Environmental Conditions Request</b> packet. The value of this parameter must be 28.</p>
<p><b><i>Packet Size</i></b></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>

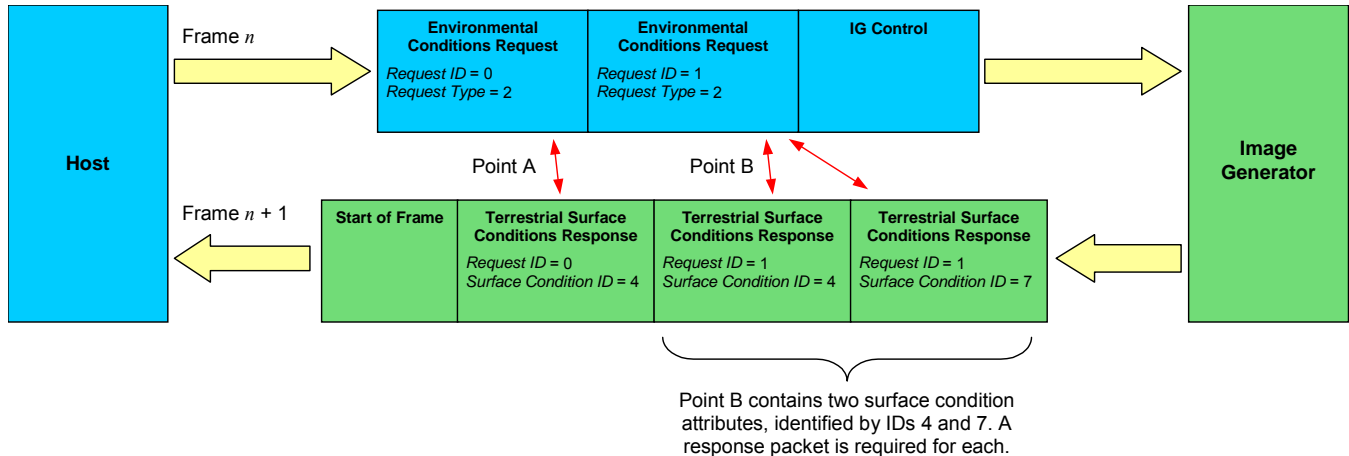
Parameter	Description
<p><b>Request Type</b></p> <p>Type: unsigned 4-bit field</p> <p>Units: N/A</p> <p>Values: 1 Maritime Surface Conditions 2 Terrestrial Surface Conditions 4 Weather Conditions 8 Aerosol Concentrations</p>	<p>This parameter specifies the desired response type for the request. The numerical 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><b>Maritime Surface Conditions</b> – The IG will respond with a <b>Maritime Surface Conditions Response</b> packet (Section 4.2.11).</p> <p><b>Terrestrial Surface Conditions</b> – The IG will respond with a <b>Terrestrial Surface Conditions Response</b> packet (Section 4.2.12).</p> <p><b>Weather Conditions</b> – The IG will respond with a <b>Weather Conditions Response</b> packet (Section 4.2.9).</p> <p><b>Aerosol Concentrations</b> – The IG will send exactly one <b>Aerosol Concentration Response</b> packet (Section 4.2.10) for each weather layer (regardless of scope) that encompasses that location.</p>
<p><b>Request ID</b></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><b>Latitude</b></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><b>Longitude</b></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><b>Altitude</b></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>



### 4.2.12 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 95 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 95 – 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 96 – 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
<b>Packet ID</b> Type: unsigned int8 Units: N/A Value: 112	This parameter identifies this data packet as the <b>Terrestrial Surface Conditions Response</b> packet. The value of this parameter must be 112.

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

### 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
<i>Packet ID = 20</i>								<i>Packet Size = 24</i>								<i>Entity ID</i>							
<i>Acceleration X</i>																							
<i>Acceleration Y</i>																							
<i>Acceleration Z</i>																							
<i>Retardation Rate</i>																							
<i>Terminal Velocity</i>																							

**Figure 62 – 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><b>Packet ID</b></p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 20</p>	<p>This parameter identifies this data packet as the <b>Trajectory Definition</b> packet. The value of this parameter must be 20.</p>
<p><b>Packet Size</b></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><b>Entity ID</b></p> <p>Type: unsigned int16</p> <p>Units: N/A</p>	<p>This parameter identifies the entity for which the trajectory is defined.</p>
<p><b>Acceleration X</b></p> <p>Type: single float</p> <p>Units: m/s<sup>2</sup></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>

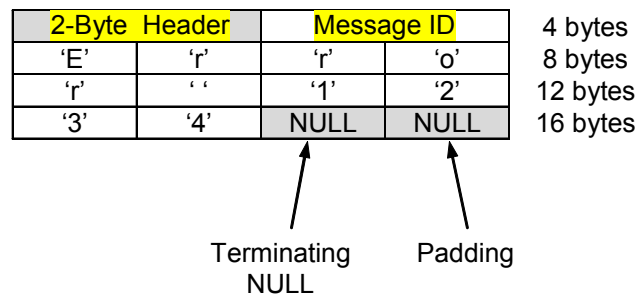
Parameter	Description
<p><b>Acceleration Y</b></p> <p>Type: single float</p> <p>Units: <math>m/s^2</math></p> <p>Default: 0</p> <p>Datum: Ellipsoid-tangential NED reference coordinate system</p>	<p>This parameter specifies the X component of the acceleration vector.</p>
<p><b>Acceleration Z</b></p> <p>Type: single float</p> <p>Units: <math>m/s^2</math></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><b>Retardation Rate</b></p> <p>Type: single float</p> <p>Units: <math>m/s^2</math></p> <p>Default: 0</p>	<p>This parameter specifies the magnitude of an acceleration applied against the entity's linear velocity as defined by the <b>Rate Control</b> packet. This is used to simulate drag and other frictional forces acting upon the entity.</p>
<p><b>Terminal Velocity</b></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>

### 4.2.17 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.

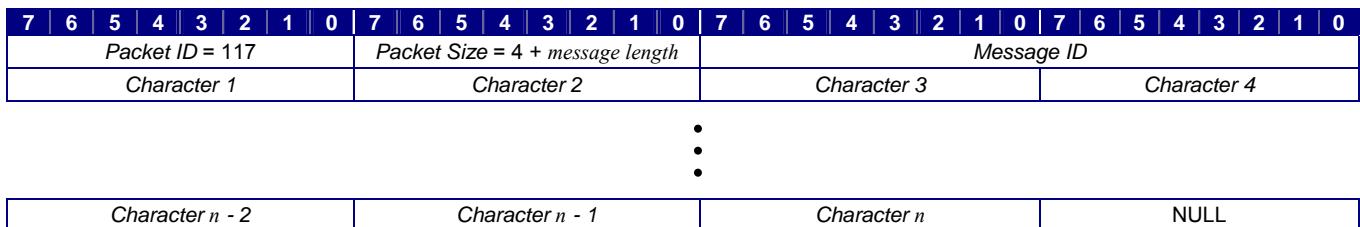
The *Packet Size* parameter must contain the total number of bytes within the message, including the two-byte header, the message ID, the terminating NULL and any padding. This value must be an even multiple of eight (8). For example, if the string, "Error 1234," were sent to the Host, the packet size would be 16. Figure 101 illustrates the byte allocation for the packet:



**Figure 101 – 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 102 – 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><b>Packet ID</b></p> <p>Type: unsigned int8</p> <p>Units: N/A</p> <p>Value: 117</p>	<p>This parameter identifies this data packet as the <b>Image Generation Message</b> packet. The value of this parameter must be 117.</p>
<p><b>Packet Size</b></p> <p>Type: unsigned int8</p> <p>Units: bytes</p> <p>Value: <math>8 \leq (4 + \text{message length}) \leq 104</math></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 <b>Image Generation Message</b> 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><b>Message ID</b></p> <p>Type: unsigned int16</p> <p>Units: N/A</p>	<p>This parameter specifies a numerical identifier for the message.</p>
<p><b>Character <i>n</i></b></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>

### 3.3.3 Submodel Coordinate Systems

A submodel is a hierarchy of geometry nodes within a model (entity) for which a coordinate system is defined. Position and rotation of submodels are defined with respect to this coordinate system. Transformations performed on the coordinate system affect the submodel geometry as a whole. The order of rotation is as shown in Figure 18.

The submodel coordinate system may be defined with an arbitrary position and orientation relative to the entity model's coordinate system in a way that makes sense for the submodel. For example, a leading-edge flap might have a submodel coordinate system defined as shown in Figure 20a so that applying a positive pitch angle will rotate the flap above the wing. A trailing-edge flap's submodel coordinate system, however, might need to be rotated to achieve a positive pitch above the wing as shown in Figure 20b.

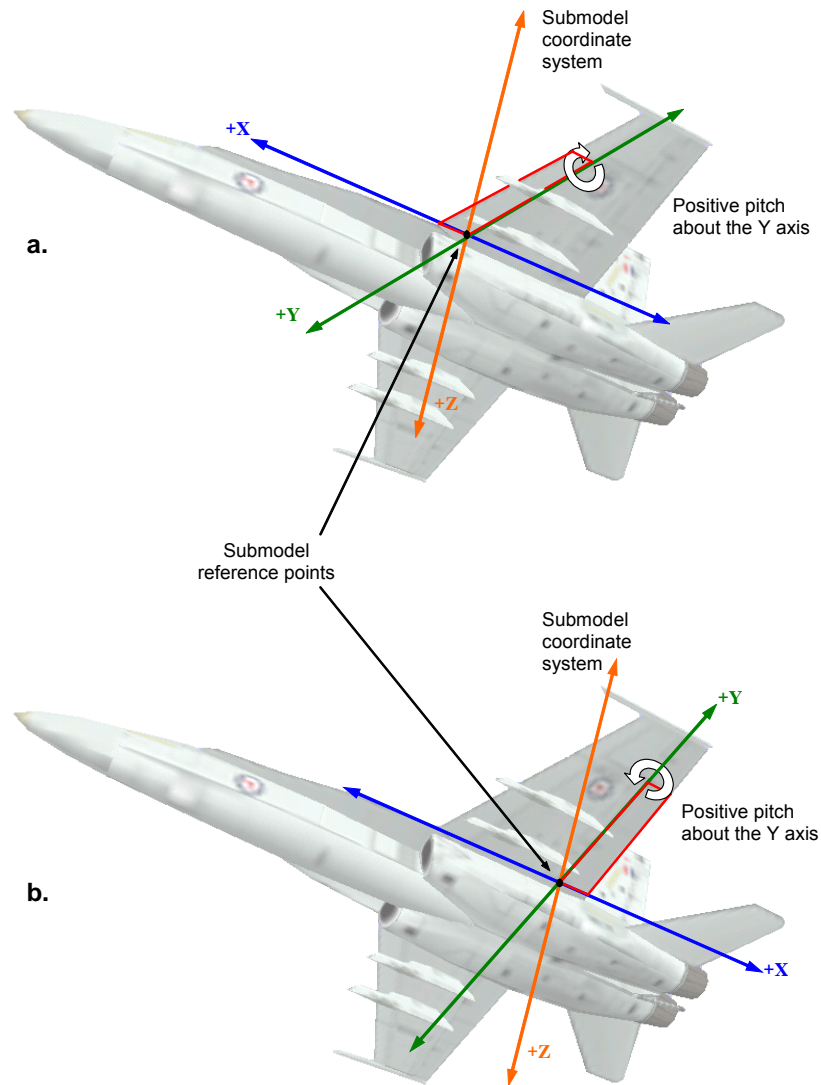


Figure 20 – Examples of Submodel Coordinate Systems

Note: Regardless of its orientation, the submodel coordinate system must be a right-handed coordinate system.

Rotations applied to a submodel are not cumulative. In other words, specifying a rotation and translation will override any previous values.

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