OpenFlight®
Scene Description
Database Specification

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Contents

1 OpenFlight® Scene Description

This document describes the OpenFlight Scene Description Database Specification, commonly referred to as simply “OpenFlight”. OpenFlight is a 3D scene description file format that was created and is maintained by MultiGen-Paradigm, Inc. While OpenFlight databases are typically created and edited using MultiGen-Paradigm software tools, the format is widely adopted and as a result, many tools exist to read and write OpenFlight database files.

The primary audience for this document includes software developers whose applications are intended to read and/or write OpenFlight database files. To this end, this document discusses concepts incorporated in OpenFlight and contains a detailed description of the physical layout of OpenFlight files as represented on disk.

OpenFlight Concepts

The OpenFlight database format supports both simple and relatively sophisticated real-time software applications. The full implementation of OpenFlight supports variable levels of detail, degrees of freedom, sound, instancing (both within a file and to external files), replication, animation sequences, bounding volumes for real-time culling, scene lighting features, light points and light point strings, transparency, texture mapping, material properties, and many other features.

A simple application that interprets an OpenFlight database can implement a subset of the database specification and use databases that contain that subset. Such an application could simply scan for the color palette, faces, and vertices, and ignores groups, objects, and other more sophisticated features.

Database Hierarchy

The OpenFlight database hierarchy organizes the visual database into logical groupings and facilitates real-time functions such as field-of-view culling, level-of-detail switching, and instancing. Each OpenFlight database is organized in a tree structure.

The database tree structure consists of nodes (historically called beads). Most nodes can have child nodes as well as sibling nodes. In general, nodes can be thought of in three hierachical classes. Starting from the top of the hierarchy, these three node classes include container nodes, geometry nodes and vertex nodes.

Container nodes are nodes that impose some logical grouping or behavior on the set of nodes it contains. The group node, for example allows you to “collect” similar nodes under one common parent for whatever reason your application needs. You might choose to group your nodes spatially or by some other criteria important to your application. Another common container node,

the level of detail node, imposes a particular visual behavior on the nodes it contains. It defines a range of distances inside which the nodes it contains are visible.

Geometry nodes are nodes that actually represent some physical (renderable) geometry. The attributes of geometry nodes typically include visual attributes such as color, material, texture, etc. The two main geometry nodes in OpenFlight are the face and mesh nodes. Other geometry nodes include the light point and text node. Though OpenFlight allows it, there are very few cases in which at least one geometry node is not contained somewhere below a container node.

Vertex nodes are the building blocks of geometry nodes. Individually, a vertex node represents a discrete point in space. Collected together under a geometry node such as a face node, a set of vertex nodes define a closed (or unclosed) loop. A closed loop of vertex nodes defines a face (or polygon). The "front" side of the face is determined by the ordering in which the vertex nodes appear under the face node. An unclosed loop of vertex nodes defines a set of line segments, again oriented according to the order in which the vertex nodes appear.

Each node type has data attributes specific to its function in the database. The principal node types in OpenFlight are described here:

Header: There is one header node per database file. It is always the first node in the file and represents the top of the database hierarchy and tree structure. For more information, see "Header Record" on page 19.

Group: A group node distinguishes a logical subset of the database. Group nodes can be transformed (translated, rotated, scaled, etc.). The transformation applies to itself and to all its children. Groups can have child nodes and sibling nodes of any type, except a header node. For more information, see "Group Record" on page 22.

Object: An object node contains a logical collection of geometry. It is effectively a low-level group node that offers some attributes distinct from the group node. For more information, see "Object Record" on page 25.

Face: A face node represents geometry. Its children are limited to a set of vertices that describe a polygon, line, or point. For a polygon, the front side of the face is viewed from an in-order traversal of the vertices. Face attributes include color, texture, material, and transparency. For more information, see "Face Record" on page 26.

Mesh: A mesh node defines geometric primitives that share attributes and vertices. See For more information, see "Mesh Nodes" on page 28.

Light point: A light point node represents a collection of light point vertices or a replicated string of a single light point vertex. A light point is visible as one or more self-illuminated small points that do not illuminate surrounding objects. For more information, see "Light Point Nodes" on page 34.

Light point system: A light point system enables you to collect a set of light points and enable/disable or brighten/dim them as a group. For more information, see "Light Point System Record" on page 37.

Subface: A subface node is a face node that is assumed to be coplanar to, and drawn on top of, its superface. Subfaces can themselves be superfaces to allow multiple levels of "nesting". This construct resolves the display of coplanar faces. A subface is introduced, after a face node, by a push subface control record and concluded by a pop subface control record. Note that the OpenFlight format does not enforce a subface to be coplanar with its superface but this is recommended.

Light source: A light source node serves as the location and orientation of a light source. The light source position and direction are transformed by the transformations above it in the tree (if any). For more information, see "Light Source Record" on page 44.

Sound: A sound node serves as the location for a sound emitter. The emitter position is the sound offset transformed by the transformations above it in the tree (if any). For more information, see "Sound Record" on page 43.

Text: A text node draws text in a string with a specified font, without injecting the actual geometry into the database as face nodes. This is a leaf node and therefore cannot have any children. For more information, see "Text Record" on page 47.

Vertex: A vertex node represents a point in space, expressed as a double precision 3D coordinates. Each vertex is stored in the vertex palette record. Vertex attributes include x, y, z and optionally include color, normal and texture mapping information. Vertex nodes are the children of face nodes and light point nodes. For more information, see "Vertex List Record" on page 39, "Morph Vertex List Record" on page 39 and "Vertex Palette Records" on page 66.

Morph vertex: A morph vertex node is a second vertex node. The vertex and morph vertex represent the two endpoints of a path between which the actual vertex may be interpolated. One endpoint represents the minimum (non morphed) weighting and the other represents the maximum (fully morphed) weighting. Each endpoint (or weight) is a reference into the vertex palette record. All vertex attributes may be morphed. Morph vertex nodes are the children of face nodes. For more information, see For more information, see "Morph Vertex List Record" on page 39.

Clip region: A clip node defines a set of clipping planes. Any geometry, of the clip node's children, that falls outside the specified clipping planes is not displayed. For more information, see "Clip Region Record" on page 47.

Degree of freedom: A degree of freedom (DOF) node serves as a local coordinate system with a predefined set of internal transformations. It specifies the articulation of parts in the database and set limits on the motion of those parts. For more information, see "Degree of Freedom Record" on page 37.

Level of detail: A level of detail (LOD) node serves as a switch to turn the display of everything below it on or off based on its range from the viewer, according to its switch-in, switch-out distance and center location. For more information, see "Level of Detail Record" on page 41.

Switch: A switch node is a more general case of an LOD node. It allows the selection of zero or more children by invoking a selector mask. Any combination of children can be selected per

mask and the number of definable masks is unlimited. For more information, see "Switch Record" on page 49.

External reference: An external reference node serves to reference a node in another database file, or an entire database file. The referenced (child) node or database is considered an external part of the referencing (parent) database. For more information, see "External Reference Record" on page 41.

Node Attributes

Nodes in the OpenFlight scene contain attributes whose values describe different properties or characteristics of the node. Most attributes are represented directly on the node itself and are geared toward describing the specific characteristics of that type of node. The level of detail (LOD) node, for example, defines a switch in and switch out distance. Used together, these distances define a range within which the geometry contained in the LOD is visible.

Other attributes are represented indirectly on a node, using a lookup index into a table (palette) of attributes to describe the characteristics of a node. The face node, for example, defines several indirect attributes, including color index, material index and texture index. The values of these index attributes are used to map specific colors, materials and textures to the face node. The definitions of the colors, materials and textures referenced by these index attributes are stored in palettes in the database rather than directly on the nodes themselves.

This mechanism of indirect attribute mapping via palettes has some advantages. It can both save space in the OpenFlight file and can simplify the task of making global changes to nodes in the database.

To see how this indirection saves space, consider the material index attribute on the face node. A material is defined by over 15 separate color and other visual attributes. If each of these attributes were maintained per face in the database, the size of the database would get large quickly. Since it is common to map a single material to hundreds (or even thousands) of faces in the database, it is much more efficient to store a single material index attribute per face rather than storing the entire material definition.

Also, in terms of changing the appearance of a particular material in your database, when you do change the material definition in the palette, the faces that reference that material get updated automatically. This can make global changes much more simple to accomplish.

Palettes

In the previous section, indirect attribute mapping was introduced. As part of that discussion, the notion of database palettes was also mentioned briefly. In fact, indirect attribute mapping is not possible without a robust implementation of database palettes. A database palette is a collection (or set) of attribute definitions. As mentioned in the previous section, the material pal-

ette defines a set of materials, each material being composed of several different color and visual attributes.

The OpenFlight database supports many different palettes. The most obvious palettes are the color, material and texture palettes. Most palettes support variable numbers of elements while others enforce fixed size constraints. The material and texture palettes are both variable sized palettes that can contain zero or more entries. The color palette, in contrast, is a fixed size palette that contains exactly 1024 entries.

Database palettes are not limited to supporting indirect attribute mapping. The vertex palette for example, defines a set of "shared" vertex nodes that can be indirectly referenced by multiple faces and/or light point nodes in the database. Similar to the space savings achieved by attribute palettes, the vertex palette also saves much disk space in the OpenFlight file when many geometry nodes share references to the same exact point in space (vertex).

All the database palettes supported by OpenFlight are described in "Palette Records" on page 66. Specific palettes in OpenFlight include:

- "Color Palette Record" on page 70
- "Material Palette Record" on page 71
- "Texture Palette Record" on page 73
- "Texture Mapping Palette Record" on page 86
- "Sound Palette Record" on page 80
- "Line Style Palette Record" on page 85
- "Light Source Palette Record" on page 81
- "Light Point Appearance Palette Record" on page 82
- "Light Point Animation Palette Record" on page 85
- "Vertex Palette Records" on page 66
- "Name Table Record" on page 71
- "Eyepoint and Trackplane Palette Record" on page 73
- "Linkage Palette Record" on page 77

Instancing

Instancing is the ability to define all or part of a database once, then reference it one or more times while applying various transformations. This allows you to define a piece of geometry once and place it multiple times in the scene. OpenFlight supports internal and external instancing with operations such as Rotate, Translate, Scale, and Put.

An internal instance is a subtree of the database that has been declared as an instance definition. An instance definition represents the root of a stand-alone subtree within the database. It is introduced by an instance definition record that contains a unique instance definition number. An

instance definition is invoked by an instance reference record in a subsequent part of the database tree.

An external instance refers to an entire database file. It is introduced by an external reference node. An external reference node contains the name of the (child) database file to attach to that point in the referencing (parent) database tree. It also includes attributes that determine whether the child uses its own color, material, and texture palettes, or those of its parent.

Instance definitions can themselves contain instance definitions and references. Internal instances cannot reference themselves. External instances should not reference themselves directly or indirectly. The result of such use is undefined.

Instance definition and instance reference records are described in "Hierarchy Instancing Records" on page 18. External reference records are desribed in "External Reference Record" on page 41.

Replication

Replication instances a subtree of the database several times, applying a transformation each time. For example, a string of trees can be represented by a single group node that is instantiated and translated to a new position several times.

Replication is legal for group, face, and light point nodes. Therefore a replication record is an ancillary record of a group, face, or light point node. In conjunction with a replication record there will be one or more ancillary transformation records.

Bounding Volumes

Bounding volumes can be used by the application to determine if a particular subtree of the database is in view. A bounding volume can be a box, a sphere, or a cylinder. Each group node can have only one bounding volume. The volume normally encompasses the full geometric extent of the group node's children, including any instances and replications. A bounding volume record is an ancillary record of a group node.

Multitexture

OpenFlight supports eight textures per polygon or mesh as well as eight uv values per vertex. The texture information stored directly on the face, mesh and vertex record is referred to as "the base texture" or "texture layer 0". Each additional texture layer is stored in ancillary records to the face, mesh and vertex list records and is referred to as "texture layer N" (for N=1..7). See "Multitexture" on page 54 for more information.

2 OpenFlight File Format

The hierarchical structure of an OpenFlight database is stored on disk as a file. The file consists of a linear stream of binary records. Byte ordering in the file is big endian. All OpenFlight records begin with a 4 byte sequence. The first two bytes of this sequence identifies the record type (opcode) and the second two bytes specify the length of the record. Note that the length includes this 4 byte sequence so the minimum length of any record (that does not contain any additional data) will be 4. Given this very regular structure, OpenFlight records can be read from disk and parsed easily.

- All OpenFlight records are a multiple of 4 bytes in length. When a record contains less than a full multiple of 4 bytes of data, the record is padded up (bytes added to the end of the record) to be a multiple of 4 bytes in length. In some cases, OpenFlight records are padded up to be multiples of 8 bytes in length.
- The length of all records (and fields in all records) as well as the offset of all fields are expressed in bytes.
- Unless explicitly stated otherwise, bit fields and masks are counted starting at 0 (i.e., the first bit is bit number 0).
- Unless explicitly stated otherwise, the elements of matrix records stored in OpenFlight appear in row major order. That is, the elements of the matrix appear in the following order:

```
row0col0, row0col1, row0col2, row0col3,
row1col0, row1col1, row1col2, row1col3,
row2col0, row2col1, row2col2, row2col3,
row3col0, row3col1, row3col2, row3col3
```

- The length of all OpenFlight records is limited to the largest value that can be encoded with 2 bytes or 16 bits (65535). For fixed-size records, this maximum size is sufficient. For variable-size records, this limitation is addressed with the Continuation Record. For more information, see "Continuation Record" on page 65.
- The maximum number of children nodes under any primary node is 65534.

OpenFlight Record Types

There are four major categories of records: control records, node primary records, ancillary records and continuation records.

Control records mark the hierarchy of the tree. A push control record (a record containing the push opcode) indicates an increase in the depth of the tree. A push control record drops you down one level in the tree. A pop control record (a record containing a pop opcode) returns you to the previous level of hierarchy. All records between a push and a pop represent sibling nodes

at the same level of hierarchy. Other control records include: instance definition, instance reference, push subface, pop subface, push attribute, and pop attribute.

Each node is represented on disk by one primary record and zero or more ancillary records. The primary record identifies a node type and includes most of the node attribute data. Additional node attributes, such as comments, long ID, and transformations, are stored in subsequent ancillary records. Ancillary records follow the primary record, but precede any control records. Child nodes are introduced by a push control record and are concluded by a pop control record.

Palette records are ancillary records of the header node. Palette records generally follow the header node's primary record, with the exception of behavior (linkage) palette records. Behavior palette records, if present, are the last (non-control) records in the file.

Continuation records are used to "continue" a record in the OpenFlight Scene Description file stream, when the original record is larger than 65535 bytes. The continuation record appears in the stream immediately following the record that it "continues". The data contained in the continuation record is defined by the original record and is assumed to be directly appended onto the content of the original record. Multiple continuation records may follow a record, in which case all continuation records would be appended (in sequence) to the original record

Many records include an eight character ASCII ID consisting of the first seven characters of the node name plus a terminating <nil> character. If the node ID is longer than seven characters, an ancillary long ID record containing the complete ID follows the node primary record.

For example, a record with an object opcode is followed by a push control record. Next comes a record with a face opcode, also followed by a push control record. After that comes the vertex list record(s) that describe the vertices of the face, and then a pop control record. This, in turn, may be followed by another face record for the next face in the same object, or by a pop record to return to object level.

The fields within each OpenFlight record are stored in big-endian byte order. OpenFlight database files have the extension ".flt" by convention.

Control Records

Control records indicate a change in the level of the database hierarchy. The three basic types of control records are: level changes, instance definition, and instance reference. Level changes are indicated by push and pop control records. Instance definitions and references are indicated by instance definition and instance reference control records.

Hierarchy Level Change Records

A database contains three distinct types of hierarchy: generic, subface, and attribute. Hierarchy may be skipped by scanning past the push control record for the corresponding pop control record.

Generic — A push level control record introduces a generic subtree of the database hierarchy. A pop level control record concludes that subtree.

Subface — A push subface control record introduces a subtree of coplanar faces. A pop subface control record concludes that subtree.

Extension — A push extension control record introduces a subtree of user defined records. A pop extension control records concludes that subtree.

Attribute — A push attribute control record introduces a subtree of records reserved for internal use by MultiGen-Paradigm, Inc.. A pop attribute control record concludes that subtree.

Push Level Record

Data type	Offset	Length	Description
Int	0	2	Push Level Opcode 10
Unsigned Int	2	2	Length - length of the record

Pop Level Record

Data type	Offset	Length	Description
Int	0	2	Pop Level Opcode 11
Unsigned Int	2	2	Length - length of the record

Push Subface Record

Data type	Offset	Length	Description
Int	0	2	Push Subface Opcode 19
Unsigned Int	2	2	Length - length of the record

Pop Subface Record

Data type	Offset	Length	Description
Int	0	2	Pop Subface Opcode 20
Unsigned Int	2	2	Length - length of the record

Push Extension Record

Data type	Offset	Length	Description
Int	0	2	Push Extension Opcode 21
Unsigned Int	2	2	Length - length of the record
Char	4	18	Reserved
Unsigned Int	22	2	Vertex reference index; -1 if not vertex extension

Pop Extension Record

Data type	Offset	Length	Description
Int	0	2	Pop Extension Opcode 22
Unsigned Int	2	2	Length - length of the record
Char	4	18	Reserved
Unsigned Int	22	2	Vertex reference index; -1 if not vertex extension

Push Attribute Record

Data type	Offset	Length	Description
Int	0	2	Push Attribute Opcode 122
Unsigned Int	2	2	Length - length of the record
Int	4	4	Vertex reference index; -1 if not vertex attribute

Pop Attribute Record

Data type	Offset	Length	Description
Int	0	2	Pop Attribute Opcode 123
Unsigned Int	2	2	Length - length of the record

Hierarchy Instancing Records

An instance definition record introduces a stand-alone subtree of the database. The subtree is referenced one or more times from different branches in the database by instance reference records. At the point of reference, the subtree is copied (or possibly shared) as a child of the current parent node.

The instance definition record must appear in the file stream prior to the first instance reference record that references it. A typical usage of these records might look like:

```
INSTANCE DEFINITION 1
PUSH
     The records between this PUSH and POP define the
     stand-alone subtree that is INSTANCE DEFINITION 1
POP
...
GROUP
MATRIX
PUSH
INSTANCE REFERENCE 1
POP
GROUP
MATRIX
PUSH
INSTANCE REFERENCE 1
POP
```

In this example, both groups reference instance definition number 1, each presumably applying a different matrix to place the intance in different locations in the scene.

Instance Definition Record

Data type	Offset	Length	Description
Int	0	2	Instance Definition Opcode 62
Unsigned Int	2	2	Length - length of the record
Int	4	2	Reserved
Int	6	2	Instance definition number

Instance Reference Record

Data type	Offset	Length	Description
Int	0	2	Instance Reference Opcode 61
Unsigned Int	2	2	Length - length of the record
Int	4	2	Reserved
Int	6	2	Instance definition number

Node Primary Records

Header Record

The header record is the primary record of the header node and is always the first record in the database file. Attributes within the header record provide important information about the database file as a whole.

Format revision level indicates the OpenFlight version of the file. Correctly interpreting the attributes of other records, such as the face and vertex records, depends upon the format revision. The format revision encompasses both Flight and OpenFlight versions.

Some representative values for format revision are:

Format Revision Value	Flight/OpenFlight Version
11	Flight V11
12	Flight V12
14	OpenFlight v14.0 and v14.1
1420	OpenFlight v14.2
1510	OpenFlight v15.1
1540	OpenFlight v15.4
1550	OpenFlight v15.5
1560	OpenFlight v15.6
1570	OpenFlight v15.7
1580	OpenFlight v15.8
1600	OpenFlight v16.0

This document describes OpenFlight version 16.1, therefore the attribute descriptions are based upon a format revision level of 1600.

Geographic attributes such as projection type, latitude, and longitude may be stored in the header record. The MultiGen Series II and Creator Terrain options set the value of these attributes when creating terrain databases. Positive latitudes reference the northern hemisphere and negative longitudes reference the western hemisphere.

Delta x, y and z attributes indicate the placement of the database when several separate databases, each with a local origin of zero, are used to represent an area.

Header Record

Data Type	Offset	Length	Description
Int	0	2	Header Opcode 1
Unsigned Int	2	2	Length - length of the record
Char	4	8	7 char ASCII ID; 0 terminates (usually set to "db")
Int	12	4	Format revision level
Int	16	4	Edit revision level
Char	20	32	Date and time of last revision
Int	52	2	Next Group node ID number
Int	54	2	Next LOD node ID number
Int	56	2	Next Object node ID number
Int	58	2	Next Face node ID number
Int	60	2	Unit multiplier (always 1)
Int	62	1	Vertex coordinate units 0 = Meters 1 = Kilometers 4 = Feet 5 = Inches 8 = Nautical miles
Int	63	1	if TRUE set texwhite on new faces
Int	64	4	Flags (bits, from left to right) 0 = Save vertex normals 1 = Packed Color mode 2 = CAD View mode 3-31 = Spare
Int	68	4*6	Reserved
Int	92	4	Projection type 0 = Flat earth 1 = Trapezoidal 2 = Round earth 3 = Lambert 4 = UTM 5 = Geodetic 6 = Geocentric
Int	96	4*7	Reserved
Int	124	2	Next DOF node ID number
Int	126	2	Vertex storage type 1 = Double precision float - should always be 1

Header Record (Continued)

Data Type	Offset	Length	Description
Int	128	4	Database origin 100 = OpenFlight 200 = DIG I/DIG II 300 = Evans and Sutherland CT5A/CT6 400 = PSP DIG 600 = General Electric CIV/CV/PT2000 700 = Evans and Sutherland GDF
Double	132	8	Southwest database coordinate x
Double	140	8	Southwest database coordinate y
Double	148	8	Delta x to place database
Double	156	8	Delta y to place database
Int	164	2	Next sound node ID number
Int	166	2	Next path node ID number
Int	168	4*2	Reserved
Int	176	2	Next Clip node ID number
Int	178	2	Next Text node ID number
Int	180	2	Next BSP node ID number
Int	182	2	Next Switch node ID number
Int	184	4	Reserved
Double	188	8	Southwest corner latitude
Double	196	8	Southwest corner longitude
Double	204	8	Northeast corner latitude
Double	212	8	Northeast corner longitude
Double	220	8	Origin latitude
Double	228	8	Origin longitude
Double	236	8	Lambert upper latitude
Double	244	8	Lambert lower latitude
Int	252	2	Next Light source node ID number
Int	254	2	Next Light point node ID number
Int	256	2	Next Road node ID number
Int	258	2	Next CAT node ID number
Int	260	2	Reserved
Int	262	2	Reserved
Int	264	2	Reserved
Int	266	2	Reserved
Int	268	4	Earth ellipsoid model 0 = WGS 1984 1 = WGS 1972 2 = Bessel 3 = Clarke 1866 4 = NAD 1927 -1 = User defined ellipsoid
Int	272	2	Next Adaptive node ID number
Int	274	2	Next Curve node ID number
Int	276	2	UTM zone (for UTM projections - negative value means Southern hemisphere)
Char	278	6	Reserved

Header Record (Continued)

Data Type	Offset	Length	Description
Double	284	8	Delta z to place database (used in conjunction with existing Delta x and Delta y values)
Double	292	8	Radius (distance from database origin to farthest corner)
Unsigned int	300	2	Next Mesh node ID number
Unsigned int	302	2	Next Light Point System ID number
Int	304	4	Reserved
Double	308	8	Earth major axis (for user defined ellipsoid) in meters
Double	316	8	Earth minor axis (for user defined ellipsoid) in meters

Group Record

The group record is the primary record of the group node. Groups are the most generic hierarchical node present in the database tree. Attributes within the group record provide bounding volumes that encompass the group's children and real-time control flags.

Relative priority specifies a fixed ordering of the group relative to its sibling nodes. Ordering is from left (lesser values) to right (higher values). Nodes of equal priority may be arbitrarily ordered. All nodes have an implicit (default) relative priority value of zero.

A group can represent an animation sequence in which case each immediate child of the group represents one frame of the sequence. An animation sequence is made of one or more loops.

For a group with N children, both forward and backward loops consist of N frames. The frames of forward and backward loops are:

Direction	Frame 1	Frame 2	Frame 3	...	Frame N
Forward	Child 1	Child 2	Child 3	...	Child N
Backward	Child N	Child N-1	Child N-2	...	Child 1

Independent of the direction of the loop, a loop can optionally *swing*. A swing loop is one that plays its children in the primary direction and then plays them in the opposite direction. Note that as the loop swings from the current direction to the opposite direction, the last frame in the current direction is not repeated. Therefore, for a group with N children, the first loop of both forward swing and backward swing animations consist of M frames where M equals ((2*N)-1) frames. Subsequent loops of swing animations consist of M-1 frames.

The frames of the first loop of forward and backward swing animations are:

Direction	Frame 1	Frame 2	...	Frame N	Frame N+1	Frame N+2	...	Frame M
Forward	Child 1	Child 2	...	Child N	Child N-1	Child N-2	...	Child 1
Backward	Child N	Child N-1	...	Child 1	Child 2	Child 3	...	Child N

The frames of subsequent loops of forward and backward swing animations are:

Direction	Frame 1	Frame 2	...	Frame N	Frame N+1	Frame N+2	...	Frame M-1
Forward	Child 2	Child 3	...	Child N	Child N-1	Child N-2	...	Child 1

Backward	Child N-1	Child N-2	...	Child 1	Child 2	Child 3	...	Child N

The number of times an animation loop repeats within the sequence is specified by the loop count attribute. A loop count of 0 indicates that the loop is to repeat forever.

The duration of one loop within the sequence is specified by the loop duration attribute and is measured in seconds. A loop duration of 0 indicates that the loop is to play as fast as possible.

For finite animation sequences (those with positive, non-zero loop count values), the duration that the last frame of the last loop is extended after the sequence has finished is specified by the last frame duration attribute and is measured in seconds. A last frame duration of 0 indicates that the last frame is not displayed any longer after the sequence finishes.

Special effect ID1 and ID2 are application-defined attributes. Their values can be used to enhance the meaning of existing attributes, such as the animation flags, or extend the interpretation of the group node. Normally, the value of these attributes is zero.

Significance can be used to assist real-time culling and load balancing mechanisms, by defining the visual significance of this group with respect to other groups in the database. Normally the value of this attribute is zero.

Layer ID is used by the Instrumentation Tools in the modeling products to identify (for display) a collection of groups, independent of their locations in the hierarchy. Normally the value of this attribute is zero.

Group Record

Data type	Offset	Length	Description
Int	0	2	Group Opcode 2
Unsigned Int	2	2	Length - length of the record
Char	4	8	7 char ASCII ID; 0 terminates
Int	12	2	Relative priority
Int	14	2	Reserved
Int	16	4	Flags (bits, from left to right) 0 = Reserved 1 = Forward animation 2 = Swing animation 3 = Bounding box follows 4 = Freeze bounding box 5 = Default parent 6 = Backward animation 7-31 = Spare
Int	20	2	Special effect ID1 - application defined
Int	22	2	Special effect ID2 - application defined
Int	24	2	Significance
Int	26	1	Layer code
Int	27	1	Reserved
Int	28	4	Reserved
Int	32	4	Loop count
Float	36	4	Loop duration in seconds
Float	40	4	Last frame duration in seconds

Here are some examples that show how the values of the animation flags (forward animation, backward animation and swing animation) affect the animation. Note that these flags define how one “loop” of the animation sequence behaves.

Group Animation Flags Examples

Forward Animation	Backward Animation	Swing Animation	Result
0	0	0	Group is not animated
1	0	0	Animation loop is forward, no swing.
0	1	0	Animation loop is backward, no swing.
1	0	1	Animation loop is forward with swing.
0	1	1	Animation loop is backward with swing.
1	1	Any	Undefined, must be either forward or backward (not both).

Here are some examples that show how the loop duration, loop count and last frame duration attributes affect the animation. Note that these values are independent of the animation flags from above.

Group Animation Count Examples

Loop Duration	Loop Count	Last Frame Duration	Result

Group Animation Count Examples (Continued)

0	0	Any	Each loop plays as fast as possible. Loops are played forever. Last Frame Duration not applicable.
T	0	Any	Each loop lasts T seconds. Loops are played forever. Last Frame Duration not applicable.
0	N	0	Each loop plays as fast as possible. N loops are played. Last frame displayed as long as any other frame.
0	N	T	Each loop plays as fast as possible. N loops are played. Last frame of last (Nth) loop displayed T seconds longer than any other frame.
T_1	N	0	Each loop lasts T1 seconds. N loops are played. Last frame of last (Nth) loop displayed as long as any other frame.
T1	N	T2	Each loop lasts T1 seconds. N loops are played. Last frame of last (Nth) loop displayed T2 seconds longer than any other frame.

Object Record

The object record is the primary record of the object node. Objects are low-level grouping nodes that contain attributes pertaining to the state of it child geometry. Only face and light point nodes may be the children of object nodes.

The time-of-day object flags can be used to inhibit the display of certain objects, depending on the current time of day.

The illumination flag, when set, makes an object self-illuminating, and is not subject to lighting calculations. In practice, geometric normals should be ignored.

The flat shading flag, when set, indicates that lighting calculations should produce a faceted appearance to the object's geometry. In practice, geometric normals should be constrained to face normals.

The shadow flag indicates the object represents the shadow of the rest of the group. When used as part of a moving model (e.g., an aircraft), the application can apply appropriate distortions, creating a realistic shadow on the terrain or runway.

Relative priority specifies a fixed ordering of the object relative to its sibling nodes. Ordering is from left (lesser values) to right (higher values). Nodes of equal priority may be arbitrarily ordered. All nodes have an implicit (default) value of zero.

When used, transparency applies to all an object's children (geometry). The value should be modulated with the transparency of the geometry and material alpha calculation, as described in the Face Record, Mesh Record and Material Record sections.

Note: The MultiGen-Paradigm, Inc. modeling environment does not use the object transparency value for rendering as described above. However, when an object's transparency value is set in Creator, that value is set on all children faces of the object. Runtime applications may choose to use the transparency value at the object level at their discretion.

Object Record

Data type	Offset	Length	Description
Int	0	2	Object Opcode 4
Unsigned Int	2	2	Length - length of the record
Char	4	8	7 char ASCII ID; 0 terminates
Int	12	4	Flags (bits from to right) 0 = Don't display in daylight 1 = Don't display at dusk 2 = Don't display at night 3 = Don't illuminate 4 = Flat shaded 5 = Group's shadow object 6-31 = Spare
Int	16	2	Relative priority
Unsigned Int	18	2	Transparency 0 = Opaque 65535 = Totally clear
Int	20	2	Special effect ID1 - application defined
Int	22	2	Special effect ID2 - application defined
Int	24	2	Significance
Int	26	2	Reserved

Face Record

The face record is the primary record of the face node. A face contains attributes describing the visual state of its child vertices. Only vertex and morph vertex nodes may be children of faces. This should not be confused with the fact that faces may have subfaces.

If a face contains a non-negative material index, its apparent color is a combination of the face color and material color, as described in "Material Palette Record" on page 71. If a face contains a non-additive material with an alpha component and the transparency field is set, the total transparency is the product of the material alpha and face transparency.

Note: As mentioned in "Object Record" on page 25, the object transparency is not used in the MultiGen-Paradigm, Inc. modeling environment to determine the actual transparency value of a face.

If a face is a unidirectional or bidirectional light point, the face record is followed by a vector record (Vector Opcode 50) that contains the unit vector indicating the direction in which the

primary color is displayed. For bidirectional light points, the alternate color is displayed in the opposite direction (180 degrees opposed).

Note: This method of defining light points is obsolete after OpenFlight version 15.2. Such light point faces will be turned into the new light point record when it is read into MultiGen II v1.4 or later.

Relative priority specifies a fixed ordering of the face relative to its sibling nodes. Ordering is from left (lesser values) to right (higher values). Nodes of equal priority may be arbitrarily ordered. All nodes have an implicit (default) value of zero.

Face Record

Data type	Offset	Length	Description
Int	0	2	Face Opcode 5
Unsigned Int	2	2	Length - length of the record
Char	4	8	7 char ASCII ID; 0 terminates
Int	12	4	IR color code
Int	16	2	Relative priority
Int	18	1	Draw type 0 = Draw solid with backface culling (front side only) 1 = Draw solid, no backface culling (both sides visible) 2 = Draw wireframe and close 3 = Draw wireframe 4 = Surround with wireframe in alternate color 8 = Omnidirectional light 9 = Unidirectional light 10 = Bidirectional light
Int	19	1	Texture white = if TRUE, draw textured face white
Unsigned Int	20	2	Color name index
Unsigned Int	22	2	Alternate color name index
Int	24	1	Reserved
Int	25	1	Template (billboard) 0 = Fixed, no alpha blending 1 = Fixed, alpha blending 2 = Axial rotate with alpha blending 4 = Point rotate with alpha blending
Int	26	2	Detail texture pattern index, -1 if none
Int	28	2	Texture pattern index, -1 if none
Int	30	2	Material index, -1 if none
Int	32	2	Surface material code (for DFAD)
Int	34	2	Feature ID (for DFAD)
Int	36	4	IR material code
Unsigned Int	40	2	Transparency 0 = Opaque 65535 = Totally clear
Unsigned Int	42	1	LOD generation control
Unsigned Int	43	1	Line style index

Face Record (Continued)

Data type	Offset	Length	Description
Int	44	4	Flags (bits from left to right) 0 = Terrain 1 = No color 2 = No alternate color 3 = Packed color 4 = Terrain culture cutout (footprint) 5 = Hidden, not drawn 6 = Roofline 7-31 = Spare
Unsigned Int	48	1	Light mode 0 = Use face color, not illuminated (Flat) 1 = Use vertex colors, not illuminated (Gouraud) 2 = Use face color and vertex normals (Lit) 3 = Use vertex colors and vertex normals (Lit Gouraud)
Char	49	7	Reserved
Unsigned Int	56	4	Packed color, primary (a, b, g, r) - only b, g, r used
Unsigned Int	60	4	Packed color, alternate (a, b, g, r) - only b, g, r used
Int	64	2	Texture mapping index, -1 if none
Int	66	2	Reserved
Unsigned Int	68	4	Primary color index, -1 if none
Unsigned Int	72	4	Alternate color index, -1 if none
Int	76	2	Reserved
Int	78	2	Shader index, -1 if none

Mesh Nodes

A mesh node defines a set of geometric primitives that share attributes and vertices. Prior to OpenFlight version 15.7, the fundamental geometric construct was the face (polygon) which was represented by a unique set of attributes and vertices. Meshes, by contrast, represent “sets” of related polygons, each sharing common attributes and vertices. Using a mesh, related polygons can be represented in a much more compact format. Each mesh consists of one set of “polygon” attributes (color, material, texture, etc.), a common “vertex pool” and one or more geometric primitives that use the shared attributes and vertices. Using a mesh, you can represent triangle strips, triangle fans, quadrilateral strips and indexed face sets.

A mesh node is defined by three distinct record types:

- *Mesh Record* - defines the “polygon” attributes associated to all geometric primitives of the mesh.
- *Local Vertex Pool Record* - defines the set of vertices that are referenced by the geometric primitives of the mesh.
- *Mesh Primitive Record* - defines a geometric primitive (triangle-strip, triangle-fan, quadrilateral-strip or indexed face set) for the mesh.

A mesh node consists of one mesh record, one local vertex pool record, and one or more mesh primitive records. The mesh primitive records are delimited by push and pop control records as shown in the following example:

```
MESH
LOCAL VERTEX POOL
PUSH
MESH PRIMITIVE
MESH PRIMITIVE
...
MESH PRIMITIVE
POP
```

Mesh Record

The mesh record is the primary record of a mesh node and defines the common "face-like" attributes associated to all geometric primitives of the mesh. These attributes are identical to those of the face record. See "Face Record" on page 26.

Mesh Record

Data type	Offset	Length	Description
Int	0	2	Mesh Opcode 84
Unsigned Int	2	2	Length - length of the record
Char	4	8	7 char ASCII ID; 0 terminates
Int	12	4	Reserved
Int	16	4	IR color code
Int	20	2	Relative priority
Int	22	1	Draw type 0 = Draw solid with backface culling (front side only) 1 = Draw solid, no backface culling (both sides visible) 2 = Draw wireframe and close 3 = Draw wireframe 4 = Surround with wireframe in alternate color 8 = Omnidirectional light 9 = Unidirectional light 10 = Bidirectional light
Int	23	1	Texture white = if TRUE, draw textured face white
Unsigned Int	24	2	Color name index
Unsigned Int	26	2	Alternate color name index
Int	28	1	Reserved

Mesh Record (Continued)

Data type	Offset	Length	Description
Int	29	1	Template (billboard) 0 = Fixed, no alpha blending 1 = Fixed, alpha blending 2 = Axial rotate with alpha blending 4 = Point rotate with alpha blending
Int	30	2	Detail texture pattern index, -1 if none
Int	32	2	Texture pattern index, -1 if none
Int	34	2	Material index, -1 if none
Int	36	2	Surface material code (for DFAD)
Int	38	2	Feature ID (for DFAD)
Int	40	4	IR material code
Unsigned Int	44	2	Transparency 0 = Opaque 65535 = Totally clear
Unsigned Int	46	1	LOD generation control
Unsigned Int	47	1	Line style index
Int	48	4	Flags (bits from left to right) 0 = Terrain 1 = No color 2 = No alternate color 3 = Packed color 4 = Terrain culture cutout (footprint) 5 = Hidden, not drawn 6 = Roofline 7-31 = Spare
Unsigned Int	52	1	Light mode 0 = Use mesh color, not illuminated (Flat) 1 = Use vertex colors, not illuminated (Gouraud) 2 = Use mesh color and vertex normals (Lit) 3 = Use vertex colors and vertex normals (Lit Gouraud)
Char	53	7	Reserved
Unsigned Int	60	4	Packed color, primary (a, b, g, r) - only b, g, r used
Unsigned Int	64	4	Packed color, alternate (a, b, g, r) - only b, g, r used
Int	68	2	Texture mapping index, -1 if none
Int	70	2	Reserved
Unsigned Int	72	4	Primary color index, -1 if none
Unsigned Int	76	4	Alternate color index, -1 if none
Int	80	2	Reserved
Int	82	2	Shader index, -1 if none

Local Vertex Pool Record

This record defines a set of vertices that is referenced by the geometry (primitives) of the mesh.

Note: Currently the Local Vertex Pool is used exclusively in the context of mesh nodes, but it is designed in a general way so that it may appear in other contexts in future versions of the OpenFlight Scene Description.

Local Vertex Pool Record

Data Type	Offset	Length	Description
Int	0	2	Local Vertex Pool Opcode 85
Unsigned Int	2	2	Length - length of the record Note: Since the length of this record is represented by an unsigned short, the maximum length of the vertex pool is 2^{16} - 1 (or 65535 bytes). If the entire vertex pool cannot fit into this size, one or more continuation records will follow. (See "Continuation Record" on page 65.)
Unsigned Int	4	4	Number of vertices - number of vertices in the local vertex pool
Unsigned Int	8	4	Attribute mask - Bit mask indicating what kind of vertex information is specified for each vertex in the local vertex pool. Bits are ordered from left to right as follows: Bit # Description 0 Has Position - if set, data for each vertex in will include x, y, and z coordinates (3 doubles) 1 Has Color Index - if set, data for each vertex will include a color value that specifies a color table index as well as an alpha value 2 Has RGBA Color - if set, data for each vertex will include a color value that is a packed RGBA color value Note: Bits 1and 2 are mutually exclusive - a vertex can have either color index or RGB color value or neither, but not both. 3 Has Normal - if set, data for each vertex will include a normal (3 floats) 4 Has Base UV - if set, data for each vertex will include uv texture coordinates for the base texture (2 floats) 5 Has UV Layer 1 - if set, data for each vertex will include uv texture coordinates for layer 1 (2 floats) 6 Has UV Layer 2 - if set, data for each vertex will include uv texture coordinates for layer 2 (2 floats) 7 Has UV Layer 3 - if set, data for each vertex will include uv texture coordinates for layer 3 (2 floats) 8 Has UV Layer 4 - if set, data for each vertex will include uv texture coordinates for layer 4 (2 floats) 9 Has UV Layer 5 - if set, data for each vertex will include uv texture coordinates for layer 5 (2 floats) 10 Has UV Layer 6 - if set, data for each vertex will include uv texture coordinates for layer 6 (2 floats) 11 Has UV Layer 7 - if set, data for each vertex will include uv texture coordinates for layer 7 (2 floats) 12-31 Spare

Local Vertex Pool Record (Continued)

Then beginning at offset 12, the following fields are repeated for each vertex in the local vertex pool, depending on the bits set in the Attribute mask field above. In the fields listed below, N ranges from 0 to Number of vertices - 1.			
Double	Varies	8*3	$Coordinate_N$ - Coordinate of vertex N (x, y, z) - present if Attribute mask includes Has Position.
Unsigned Int	Varies	4	$color_N$ - Color for vertex N - present if Attribute mask includes Has Color Index or Has RGBA Color. If Has Color Index, lower 3 bytes specify color table index, upper 1 byte is Alpha. If Has RGBA Color, 4 bytes specify (a, b, g, r) values.
Float	Varies	4*3	$normal_N$ - Normal for vertex N (i, j, k) - present if Attribute mask includes Has Normal.
Float	Varies	4*2	$uvBase_N$ - Texture coordinates (u, v) for base texture layer of vertex N - present if Attribute mask includes Has Base UV.
Float	Varies	4*2	$uv1_N$ - Texture coordinates (u, v) for layer 1 of vertex N - present if Attribute mask includes Has UV Layer 1.
Float	Varies	4*2	$uv2_N$ - Texture coordinates (u, v) for layer 2 of vertex N - present if Attribute mask includes Has UV Layer 2.
Float	Varies	4*2	$uv3_N$ - Texture coordinates (u, v) for layer 3 of vertex N - present if Attribute mask includes Has UV Layer 3.
Float	Varies	4*2	$uv4_N$ - Texture coordinates (u, v) for layer 4 of vertex N - present if Attribute mask includes Has UV Layer 4.
Float	Varies	4*2	$uv5_N$ - Texture coordinates (u, v) for layer 5 of vertex N - present if Attribute mask includes Has UV Layer 5.
Float	Varies	4*2	$uv6_N$ - Texture coordinates (u, v) for layer 6 of vertex N - present if Attribute mask includes Has UV Layer 6.
Float	Varies	4*2	$uv7_N$ - Texture coordinates (u, v) for layer 7 of vertex N - present if Attribute mask includes Has UV Layer 7.

Mesh Primitive Record

This record defines a geometric primitive (triangle strip, triangle fan, quadrilateral strip, or indexed polygon) for a mesh.

Mesh Primitive Record

Data Type	Offset	Length	Description
Int	0	2	Mesh Primitive Opcode 86
Unsigned Int	2	2	Length - length of the record
Int	4	2	Primitive Type - specifies how the vertices of the primitive are interpreted 1 = Triangle Strip 2 = Triangle Fan 3 = Quadrilateral Strip 4 = Indexed Polygon
Unsigned Int	6	2	Index Size - specifies the length (in bytes) of each of the vertex indices that follow - will be either 1, 2, or 4
Unsigned Int	8	4	Vertex Count- number of vertices contained in this primitive.
The following field is repeated for each vertex referenced by the mesh primitive. These vertices are interpreted according to Primitive Type. In the field below, N ranges from 0 to Vertex Count - 1.			
Int	12+(N*Index Size)	Index Size	$Index_N$ - Index of vertex N of the mesh primitive.

Each mesh primitive is represented using the Mesh Primitive record above. The following descriptions explain how the vertices of each primitive type are interpreted as geometry:

- **Triangle Strip** - This mesh primitive defines a connected group of triangles in the context of the enclosing mesh. Each triangle shares the “polygon” attributes defined by the enclosing mesh. This primitive contains a sequence of indices that reference vertices from the local vertex pool. One triangle is defined for each vertex presented after the first two vertices. For odd n, vertices n, n+1, and n+2 define triangle n. For even n, vertices n+1, n, and n+2 define triangle n. The first triangle is n=1. The first vertex in the vertex pool is n=1. N vertices represent N-2 triangles.
- **Triangle Fan** - Like the Triangle Strip, this mesh primitive also defines a connected group of triangles in the context of the enclosing mesh. Each triangle shares the “polygon” attributes defined by the enclosing mesh. This primitive contains a sequence of indices that reference vertices from the local vertex pool. One triangle is defined for each vertex presented after the first two vertices. Vertices 1, n+1, and n+2 define triangle n. The first triangle is n=1. The first vertex in the vertex pool is n=1. N vertices represent N-2 triangles.
- **Quadrilateral Strip** - This mesh primitive defines a connected group of quadrilaterals in the context of the enclosing mesh. Each quadrilateral shares the “polygon” attributes defined by the enclosing mesh. This primitive contains a sequence of indices that reference vertices from the local vertex pool. One quadrilateral is defined for each pair of vertices presented after the first pair. Vertices 2n-1, 2n, 2n+2, and 2n+1 define quadrilateral n. The first quadrilateral is n=1. The first vertex in the vertex pool is n=1. N vertices represent (N/2)-1 quadrilaterals.
- **Indexed Polygon** -This mesh primitive defines a single polygon in the context of the enclosing mesh. This primitive is similar to the other mesh primitives in that it also shares the polygon attributes of the enclosing mesh. It is different from the other mesh primitive types in that while triangle strips/ fans and quadrilateral strips describe a set of connected triangles/quadrilaterals, the indexed polygon defines a single polygon. This primitive contains a sequence of indices that reference vertices from

the local vertex pool. One polygon is defined by the sequence of vertices in this record. N vertices represent 1 N-sided closed polygon or 1 (N-1)-sided unclosed polygon.

Light Point Nodes

The OpenFlight format supports two kinds of light point records, indexed and inline. In indexed light point records, the attributes are stored in two palettes; the light point appearance palette and the light point animation palette. The indexed light point record simply stores indices into these two palettes. In inline light point records, all the attributes are stored directly in the light point record itself. This section describes both of these records.

Indexed Light Point Record

The indexed light point record is one of the records that can represent a light point node.

The appearance index specifies an entry in the light point appearance palette that contains the visual attributes of the light point.

The animation index specifies an entry in the light point animation palette that contains the behavioral attributes of the light point.

The palette entries referenced by the indexed light point record describe the visual state of the light point's child vertices. Only vertex nodes may be children of light point nodes.

Indexed Light Point Record

Data type	Offset	Length	Description
Int	0	2	Indexed Light Point Record Opcode 130
Unsigned Int	2	2	Length - length of the record
Char	4	8	7 char ASCII ID; 0 terminates
Int	12	4	Appearance index
Int	16	20	Animation index
Int	24	4	Draw order (for calligraphic lights)
Int	28	4	Reserved

Light Point Record

The light point record is one of the records that can represent a light point node. The light point record contains attributes describing the visual state of its child vertices. Only vertex nodes may be children of light point nodes.

Light points are geometric points that represent real world light sources such as runway lights, vehicle lights, street lights, and rotating beacons. Light points differ from light sources in that they do not illuminate the scene around them. They are primarily used to model important visual cues without incurring the tremendous rendering overhead associated with light sources.

Most light point attributes are specific to these unique requirements. Light points can be displayed on special purpose calligraphic imaging systems, the more familiar raster variety, or even hybrid raster/calligraphic (RASCAL) systems.

Light Point Record

Data type	Offset	Length	Description
Int	0	2	Light Point Record Opcode 111
Unsigned Int	2	2	Length - length of the record
Char	4	8	7 char ASCII ID; 0 terminates
Int	12	2	Surface material code
Int	14	2	Feature ID
Unsigned Int	16	4	Back color for bidirectional points
Int	20	4	Display mode 0 = RASTER 1 = CALLIGRAPHIC 2 = EITHER
Float	24	4	Intensity - scalar for front colors
Float	28	4	Back intensity - scalar for back color
Float	32	4	Minimum defocus - (0.0 - 1.0) for calligraphic points
Float	36	4	Maximum defocus - (0.0 - 1.0) for calligraphic points
Int	40	4	Fading mode 0 = Enable perspective fading calculations 1 = Disable calculations
Int	44	4	Fog Punch mode 0 = Enable fog punch through calculations 1 = Disable calculations
Int	48	4	Directional mode 0 = Enable directional calculations 1 = Disable calculations
Int	52	4	Range mode 0 = Use depth (Z) buffer calculation 1 = Use slant range calculation
Float	56	4	Min pixel size - minimum diameter of points in pixels
Float	60	4	Max pixel size - maximum diameter of points in pixels
Float	64	4	Actual size - actual diameter of points in database units
Float	68	4	Transparent falloff pixel size - diameter in pixels when points become transparent
Float	72	4	Transparent falloff exponent >= 0 - falloff multiplier exponent 1.0 - linear falloff
Float	76	4	Transparent falloff scalar > 0 - falloff multiplier scale factor
Float	80	4	Transparent falloff clamp - minimum permissible falloff multiplier result
Float	84	4	Fog scalar >= 0 - adjusts range of points for punch threw effect.
Float	88	4	Reserved
Float	92	4	Size difference threshold - point size transition hint to renderer

Light Point Record (Continued)

Data type	Offset	Length	Description
Int	96	4	Directionality 0 = OMNIDIRECTIONAL 1 = UNIDIRECTIONAL 2 = BIDIRECTIONAL
Float	100	4	Horizontal lobe angle - total angle in degrees
Float	104	4	Vertical lobe angle - total angle in degrees
Float	108	4	Lobe roll angle - rotation of lobe about local Y axis in degrees
Float	112	4	Directional falloff exponent >= 0 - falloff multiplier exponent 1.0 - linear falloff
Float	116	4	Directional ambient intensity - of points viewed off axis
Float	120	4	Animation period in seconds
Float	124	4	Animation phase delay in seconds - from start of period
Float	128	4	Animation enabled period in seconds
Float	132	4	Significance - drop out priority for RASCAL lights (0.0 - 1.0)
Int	136	4	Calligraphic draw order - for rendering consistency
Int	140	4	Flags (bits, from left to right) 0 = reserved 1 = No back color TRUE = don't use back color for bidirectional points FALSE = use back color for bidirectional points 2 = reserved 3 = Calligraphic proximity occulting (Debunching) 4 = Reflective, non-emissive point 5-7 = Randomize intensity 0 = never 1 = low 2 = medium 3 = high 8 = Perspective mode 9 = Flashing 10 = Rotating 11 = Rotate Counter Clockwise Direction of rotation about local Z axis 12 = reserved 13-14 = Quality 0 = Low 1 = Medium 2 = High 3 = Undefined 15 = Visible during day 16 = Visible during dusk 17 = Visible during night 18-31 = Spare
Float	144	4*3	Axis of rotation for rotating animation (i, j, k)

Light Point System Record

The light point system record enables you to collect a set of light points and enable/disable or brighten/dim them as a group.

Light Point System Record

Data type	Offset	Length	Description
Int	0	2	Light Point System Record Opcode 130
Unsigned Int	2	2	Length - length of the record
Char	4	8	7 char ASCII ID; 0 terminates
Float	12	4	Intensity
Int	16	4	Animation state 0 = On 1 = Off 2 = Random
Int	20	4	Flags (bits, from left to right) 0 = Enabled 1-31 = Spare

Degree of Freedom Record

The degree of freedom (DOF) record is the primary record of the DOF node. The DOF node specifies a local coordinate system and the range allowed for translation, rotation, and scale with respect to that coordinate system.

The DOF record can be viewed as a series of applied transformations consisting of the following elements:

[PTTTRRRSSSP]

where “P” denotes “put,” “T” denotes “translate,” “R” denotes “rotate,” and “S” denotes “scale.”

It is important to understand the order in which these transformations are applied to the geometry. A pre-multiplication is assumed, so the sequence of transformations must be read from right to left, in order to describe its effect on the geometry contained below the DOF. In this manner, a DOF is interpreted as a Put followed by three Scales, three Rotates, three Translates, and a Put.

Taking the transformations in right to left order, they represent:

1. A Put (3 point to 3 point transformation). This matrix brings the DOF coordinate system to the world origin, with its x-axis aligned along the world x-axis and its y-axis in the world x-y plane. Testing against the DOF's constraints is performed in this standard position. This matrix is therefore the inverse of the last (See Step 11 below).
2. Scale in x.
3. Scale in y.
4. Scale in z.

5. Rotation about z (yaw).
6. Rotation about y (roll).
7. Rotation about x (pitch).
8. Translation in x.
9. Translation in y.
10. Translation in z.
11. A final Put. This matrix moves the DOF coordinate system back to its original position in the scene.

The DOF record specifies the minimum, maximum, and current values for each transformation. Only the current value affects the actual transformation applied to the geometry. The increment value specifies discrete allowable values within the range of legal values represented by the DOF.

Degree of Freedom Record

Data type	Offset	Length	Description
Int	0	2	Degree-of-Freedom Opcode 14
Unsigned Int	2	2	Length - length of the record
Char	4	8	7 char ASCII ID; 0 terminates
Int	12	4	Reserved
Double	16	8*3	Origin of DOF's local coordinate system (x, y, z)
Double	40	8*3	Point on x axis of DOF's local coordinate system (x, y, z)
Double	64	8*3	Point in xy plane of DOF's local coordinate system (x, y, z)
Double	88	8	Min z value with respect to local coordinate system
Double	96	8	Max z value with respect to local coordinate system
Double	104	8	Current z value with respect to local coordinate system
Double	112	8	Increment in z
Double	120	8	Min y value with respect to local coordinate system
Double	128	8	Max y value with respect to the local coordinate system
Double	136	8	Current y value with respect to local coordinate system
Double	144	8	Increment in y
Double	152	8	Min x value with respect to local coordinate system
Double	160	8	Max x value with respect to local coordinate system
Double	168	8	Current x value with respect to local coordinate system
Double	176	8	Increment in x
Double	184	8	Min pitch (rotation about the x axis)
Double	192	8	Max pitch
Double	200	8	Current pitch
Double	208	8	Increment in pitch
Double	216	8	Min roll (rotation about the y axis)
Double	224	8	Max roll
Double	232	8	Current roll
Double	240	8	Increment in roll
Double	248	8	Min yaw (rotation about the z axis)
Double	256	8	Max yaw
Double	264	8	Current yaw
Double	272	8	Increment in yaw
Double	280	8	Min z scale (about local origin)
Double	288	8	Max z scale (about local origin)

Degree of Freedom Record (Continued)

Data type	Offset	Length	Description
Double	296	8	Current z scale (about local origin)
Double	304	8	Increment for scale in z
Double	312	8	Min y scale (about local origin)
Double	320	8	Max y scale (about local origin)
Double	328	8	Current y scale (about local origin)
Double	336	8	Increment for scale in y
Double	344	8	Min x scale (about local origin)
Double	352	8	Max x scale (about local origin)
Double	360	8	Current x scale (about local origin)
Double	368	8	Increment for scale in x
Int	376	4	Flags (bits, from left to right) 0 = x translation is limited 1 = y translation is limited 2 = z translation is limited 3 = Pitch rotation is limited 4 = Roll rotation is limited 5 = Yaw rotation is limited 6 = x scale is limited 7 = y scale is limited 8 = z scale is limited 9 = Reserved 10 = Reserved 11-31 = Spare
Int	380	4	Reserved

Vertex List Record

A vertex list record is the primary record of a vertex node. Each record references one or more vertices in the vertex palette. See "Vertex Palette Records" on page 66. A vertex node is a leaf node in the database and therefore cannot have any children.

Vertex List Record

Data type	Offset	Length	Description
Int	0	2	Vertex List Opcode 72
Unsigned Int	2	2	Length - length of the record
The following field is repeated for each vertex contained in the vertex list record. In the field below, N ranges from 0 to Number of vertices - 1, where Number of vertices = (Length - 4) / 4			
Int	4+(N*4)	4	$Offset_N$ - Byte offset into vertex palette of the actual vertex for vertex N.

Morph Vertex List Record

A morph vertex list record is the primary record of a morph vertex node. Like the vertex list record, each morph vertex list record references one or more vertices in the vertex palette. See

"Vertex Palette Records" on page 66. A morph vertex node is a leaf node in the database and therefore cannot have any children.

Each record references one or more pairs of vertices (weights) in the vertex palette. One weight is the 0 percent morph attributes and the other weight is the 100 percent morph attributes. Since each weight references a vertex, all vertex attributes including color, normal, and texture coordinates may be morphed.

When the eyepoint approaches the switch-in distance, the vertex attributes displayed are 100 percent morphed. When the eyepoint reaches the distance computed by LOD switch-in distance minus LOD transition range, the vertex attributes displayed are 0 percent morphed. Within the LOD transition range, the vertex attributes displayed are interpolated between the two known vertex attributes.

Geometric morphing is controlled by the parent LOD node. Only morph vertex nodes are affected. Both morphing and static geometry (vertices) may exist within the same branch of the database hierarchy.

Morph Vertex List Record

Data type	Offset	Length	Description
Int	0	2	Morph Vertex List Opcode 89
Unsigned Int	2	2	Length - length of the record
The following fields are repeated for each vertex contained in the morph vertex list record. In the fields below, N ranges from 0 to Number of vertices - 1, where Number of vertices = (Length - 4) / 8			
Int	4+(N*8)	4	Offset 0_N - Offset into vertex palette of Nth 0% vertex.
Int	8+(N*8)	4	Offset 100_N - Offset into vertex palette of Nth 100% vertex.

Binary Separating Plane Record

The binary separating plane (BSP) record is the primary record of the BSP node. A BSP allows you to model 3D databases without depth (Z) buffer support.

An application uses this information to cull portions of the database according to which side of the plane the subtree is situated on with regard to eyepoint position and viewing direction.

This record contains an equation ax + by + cz + d = 0 that describes the separating plane.

Binary Separating Plane Record

Data type	Offset	Length	Description
Int	0	2	Binary Separating Plane (BSP) Opcode 55
Unsigned Int	2	2	Length - length of the record
Char	4	8	7 char ASCII ID; 0 terminates
Int	12	4	Reserved
Double	16	8*4	Plane equation coefficients (a, b, c, d)

External Reference Record

The external reference record is the primary record of the external reference node. External references allow one database to reference, or instance, a node in another database (or an entire database). At the point of reference, the referenced node/database is copied (or possibly shared) as a child of the current parent node.

The override flags allow the referencing (parent) database to control use of the referenced (child) node/database palettes. If an override flag (e.g., material) is set, the child node/database uses its own (material) palette. Otherwise, the child node/database uses the current (parent's) palette. The override flags are hierarchical and may affect references made by the child node/database.

The view as bounding box field is used by the MultiGen-Paradigm, Inc. modeling environment and is not expected to be used by runtime applications.

External Reference Record

Data type	Offset	Length	Description
Int	0	2	External Reference Opcode 63
Unsigned Int	2	2	Length - length of the record
Char	4	200	199-char ASCII path; 0 terminates Format of this string is: filename<node name> if <node name> absent, references entire file
Int	204	4	Reserved
Int	208	4	Flags (bits, from left to right) 0 = Color palette override 1 = Material palette override 2 = Texture and texture mapping palette override 3 = Line style palette override 4 = Sound palette override 5 = Light source palette override 6 = Light point palette override 7 = Shader palette override 8-31 = Spare
Int	212	2	View as bounding box 0 = View external reference normally 1 = View external reference as bounding box
Int	214	2	Reserved

Level of Detail Record

The level of detail (LOD) record is the primary record of the LOD node. LOD's are perhaps the most important hierarchical node present in the database tree. Proper use of level-of-detail modeling concepts can vastly improve real-time playback of large databases. Attributes within the LOD record provide switching and transition distances for real-time culling and load management mechanisms.

The center coordinate can be used by a real-time application to calculate the slant range distance from the eyepoint to the LOD. Based upon the result of this calculation, a real-time application can choose not to display the LOD's children and thus reduce system load. The center of the LOD is generally the transformed center of the geometry of the LOD's children. This should include the effects of instancing and (parent) group replication as well.

The use previous slant range flag indicates that the slant range for this LOD is the same as the previous (sibling) LOD, implying the center coordinate is also the same. The real-time application can reuse the previous slant range calculation when evaluating this LOD, thereby improving performance.

If the freeze center flag is not set, the MultiGen-Paradigm, Inc. modeling environment as well as OpenFlight API based applications will recalculate the center point of the LOD when the OpenFlight file is saved.

Transition range specifies the range over which real-time smoothing effects should be employed while switching from one LOD to another. Smoothing effects include geometric morphing and image blending. The smoothing effect is active between: switch-in distance minus transition range (near), and switch-in distance (far). The center distance of the effect is therefore switch-in distance minus one half the transition range.

Significant size is a value used to calculate switch in and out distances based on viewing parameters of your simulation display system. This value is used internally by MultiGen-Paradigm and will be enhanced in future versions of OpenFlight.

Level of Detail Record

Data type	Offset	Length	Description
Int	0	2	Level-of-Detail Opcode 73
Unsigned Int	2	2	Length - length of the record
Char	4	8	7 char ASCII ID; 0 terminates
Int	12	4	Reserved
Double	16	8	Switch-in distance
Double	24	8	Switch-out distance
Int	32	2	Special effect ID1 - application defined
Int	34	2	Special effect ID2 - application defined
Int	36	4	Flags (bits, from left to right) 0 = Use previous slant range 1 = Reserved 2 = Freeze center (don't recalculate) 3-31 = Spare
Double	40	8	Center coordinate x of LOD
Double	48	8	Center coordinate y of LOD
Double	56	8	Center coordinate z of LOD
Double	64	8	Transition range
Double	72	8	Significant size

Sound Record

The sound record is the primary record of the sound node. A sound node represents the position and orientation of a sound emitter in the database.

Amplitude and pitch blend are relative to the amplitude in the waveform file. Falloff defines how amplitude falls off when approaching the edge of the sound lobe, with maximum amplitude at the center of the lobe.

Priority determines which sounds are played when more emitters populate a scene than the sound system can play simultaneously.

Width defines the half angle of the sound lobe. Direction sets the type of sound lobe.

Doppler, absorption, and delay flags enable or disable the modeling of doppler, atmospheric absorption, and propagation delay in the sound environment.

Active indicates a sound is to be activated when read in to the modeling environment.

Sound Record

Data type	Offset	Length	Description
Int	0	2	Sound Node Opcode 91
Unsigned Int	2	2	Length - length of the record
Char	4	8	7 char ASCII ID; 0 terminates
Int	12	4	Reserved
Int	16	4	Index into sound palette
Int	20	4	Reserved
Double	24	8*3	Coordinate of offset from local origin (x, y, z)
Float	48	4*3	Sound direction (vector) wrt local coordinate axes (i, j, k)
Float	60	4	Amplitude of sound
Float	64	4	Pitch bend of sound
Float	68	4	Priority of sound
Float	72	4	Falloff of sound
Float	76	4	Width of sound lobe
Int	80	4	Flags (bits, from left to right) 0 = Doppler 1 = Atmospheric absorption 2 = Delay 3-4 = Direction: 0 = Omnidirectional 1 = Unidirectional 2 = Bidirectional 5 = Active 6-31 = Spare
Int	84	4	Reserved

Light Source Record

The light source record is the primary record of the light source node. Light sources illuminate the database. They contain position and rotation data (overriding any information stored in the light palette), an index into the light palette, and information on how the light behaves within the hierarchy.

The enabled flag indicates whether the light is turned on and, therefore, a factor of the lighting (rendering) model.

The global flag specifies whether the light shines on the entire database or only on its children (for example, the cabin light in a car).

Light Source Record

Data type	Offset	Length	Description
Int	0	2	Light Source Record Opcode 101
Unsigned Int	2	2	Length - length of the record
Char	4	8	7 char ASCII ID; 0 terminates
Int	12	4	Reserved
Int	16	4	Index into light palette
Int	20	4	Reserved
Int	24	4	Flags (bits, from left to right) 0 = Enabled 1 = Global 2 = Reserved 3 = Export 4 = Reserved 5-31 = Spare
Int	28	4	Reserved
Double	32	8*3	Position (for Local or Spot lights only) (x, y, z)
Float	56	4	Yaw (azimuth for Infinite or Spot lights only)
Float	60	4	Pitch (elevation for Infinite or Spot lights only)

Road Segment Record

A road segment record is the primary record of a road segment node. It stores the attributes used to create and modify a road segment. The children of the road node represent the geometry and paths of the road and should not be manually edited. Any modification invalidates the road segment.

Road Segment Record

Data type	Offset	Length	Description
Int	0	2	Road Segment Opcode 87
Unsigned Int	2	2	Length of record
Char	4	8	7 char ASCII ID; 0 terminates

Road Construction Record

A road construction record is the primary record of a road construction node. It supersedes the Road Segment Record described previously. It is created by the Pathfinder option of MultiGen II Pro v1.5 as well as the Road Tool option beginning with Creator v2.1. It stores the parameters defining the road path construction for one road section. In practice, the children of the road construction node usually represent the geometry and paths of the road section. Although every field in the road construction record may be modified, this data makes the most sense when it is kept in sync with the geometry that is created from it. Therefore, typical usage will be read-only access from applications able to analyze the road surface from this given data.

The Road type field dictates how the following fields define the current road section. For all road types, the Entry and Exit control points lie on the boundaries of the road section. The Alignment control point is only necessary for the Curve type as it defines a horizontal tangent with the other control points.

Other fields particular to the Curve type are the horizontal curve parameters. The horizontal components of the Curve type start and end with spiral transitions of specified lengths. An Arc Radius length is used to define the constant curve area. The Superelevation is specified in a rise over run slope measured laterally across the road for the maximum banking which is used throughout the constant curve component. The banking transitions along the spiral sections in one of three ways defined by the Spiral type field.

Both the Curve and Hill types may have a vertical curve component defined by the remaining fields. Slopes are given at both the entry and exit of the section. If the given slopes don't intersect within the road segment then two vertical parabolas are constructed instead of one, and the Additional vertical parabola flag is set. Note that this flag's value is only valid when the Road Tools version field is 3 or later. This flag may also be set when convergence of the slopes creates a vertical curve length less than Minimum curve length. Otherwise, Vertical curve length is used to define the horizontal distance covered by the single parabola vertical curve.

Road Construction Record

Data type	Offset	Length	Description
Int	0	2	Road Construction Opcode 127
Unsigned Int	2	2	Length of record
Char	4	8	7 char ASCII ID; 0 terminates
Char	12	4	Reserved
Int	16	4	Road type 0 = Curve 1 = Hill 2 = Straight
Int	20	4	Road Tools version
Double	24	8*3	Entry control point (x, y, z)
Double	48	8*3	Alignment control point (x, y, z)
Double	72	8*3	Exit control point (x, y, z)
Double	96	8	Arc radius
Double	104	8	Entry spiral length
Double	112	8	Exit spiral length

Road Construction Record (Continued)

Data type	Offset	Length	Description
Double	120	8	Superelevation
Int	128	4	Spiral type 0 = Linear with length 1 = Linear with angle 2 = Cosine with length
Int	132	4	Additional vertical parabola flag
Double	136	8	Vertical curve length
Double	144	8	Minimum curve length
Double	152	8	Entry slope
Double	160	8	Exit slope

Road Path Record

A road path record is the primary record of a road path node. A road path node is a child of a road segment node. It describes a lane of the parent road segment. The child of a road path node is a face node whose vertices provide the coordinates of the center of the lane.

Road path record attributes may also be written to an ASCII file for easy access by the application. The format of the file is described in "Road Path Files," page 101.

Road Path Record

Data type	Offset	Length	Description
Int	0	2	Road Path Opcode 92
Unsigned Int	2	2	Length of record
Char	4	8	7 char ASCII ID; 0 terminates
Int	12	4	Reserved
Char	16	120	Path name; 0 terminates
Double	136	8	Speed limit
Boolean	144	4	No passing
Int	148	4	Vertex normal type 0 = Up-vector 1 = Heading, Pitch, Roll
Int	152	480	Reserved

Clip Region Record

A clip region record is the primary record of a clip node. It defines those regions in 3D space in which drawing occurs. Clip regions only clip the geometry below the clip node in the hierarchy.

The coordinates create a four-sided face that defines the clip region in space. Planes are formed along the edges of the four-sided face normal to the face; a fifth plane clips the back side of the face.

Clip Region Record

Data type	Offset	Length	Description
Int	0	2	Clip Region Opcode 98
Unsigned Int	2	2	Length of record
Char	4	8	7 char ASCII ID; 0 terminates
Int	12	4	Reserved
Int	16	2	Reserved
Char	18	5	Flags for enabling the individual clip planes Char 0 is flag for edge defined by coordinate 0 and 1 Char 1 is flag for edge defined by coordinate 1 and 2 Char 2 is flag for edge defined by coordinate 2 and 3 Char 3 is flag for edge defined by coordinate 3 and 0 Char 5 is flag for plane that clips the half space behind the clip region
Char	23	1	Reserved
Double	24	8*3	1st coordinate defining the clip region (x, y, z)
Double	48	8*3	2nd coordinate defining the clip region (x, y, z)
Double	72	8*3	3rd coordinate defining the clip region (x, y, z)
Double	96	8*3	4th coordinate defining the clip region (x, y, z)
Double	120	8*20	Five plane equation coefficients (ax + by +cz + d) Coefficients are ordered: a_0, a_1, a_2, a_3, a_4 b_0, b_1, b_2, b_3, b_4 c_0, c_1, c_2, c_3, c_4 d_0, d_1, d_2, d_3, d_4

Text Record

The text record is the primary record of the text node. Text draws a string of data using a specified font. The record specifies the visual characteristics of the text and formatting information.

The actual string for the text is stored in the comment record immediately following. The format of the text record is:

Text Record

Data type	Offset	Length	Description
Int	0	2	Text Opcode 95
Unsigned Int	2	2	Length of record
Char	4	8	7 char ASCII ID; 0 terminates
Int	12	4	Reserved
Int	16	4	Reserved
Int	20	4	Type -1 = Static 0 = Text String 1 = Float 2 = Integer
Int	24	4	Draw type 0 = Solid 1 = Wireframe and close 2 = Wireframe 3 = Surround with wireframe in alternate color
Int	28	4	Justification 0 = Left 1 = Right 2 = Center
Double	32	8	Floating point value
Int	40	4	Integer value
Int	44	4*5	Reserved
Int	64	4	Flags (bits, from left to right) 0 = Boxable (Unused) 1-31 = Spare
Int	68	4	Color
Int	72	4	Color 2 (Unused)
Int	76	4	Material
Int	80	4	Reserved
Int	84	4	Maximum number of lines (Unused)
Int	88	4	Maximum number of characters
Int	92	4	Current length of text (Unused)
Int	96	4	Next line number available (Unused)
Int	100	4	Line number at top of display (Unused)
Int	104	4*2	Low/high values for integers
Double	112	8*2	Low/high values for floats
Double	128	8*3	Lower-left corner of rectangle around text (x, y, z)
Double	152	8*3	Upper-right corner of rectangle around text (x, y, z)
Char	176	120	Font name
Int	296	4	Draw vertical
Int	300	4	Draw italic
Int	304	4	Draw bold
Int	308	4	Draw underline
Int	312	4	Line style
Int	316	4	Reserved

Switch Record

A switch record is the primary record of a switch node. A switch represents a set of masks that control the display of the switch's children.

Each mask contains one bit for each child of the switch. Each mask bit indicates that the corresponding child is selected (1) or deselected (0). Each mask selects some, none, or all of the children for display according to the state of the mask bits.

Both the switch children and mask bits begin counting from 0. Therefore the selection state, for a particular switch child is derived from a given mask with the following calculation:

mask_bit = 1 << (child_num % 32)

mask_word = mask_words [mask_num * num_words + child_num / 32]

child_selected = mask_word & mask_bit

The current mask value is an index into the set of masks and indicates the selected mask.

The masks of a switch node can be named. These names are stored in the ancillary record, indexed string record. See "Indexed String Record" on page 53.

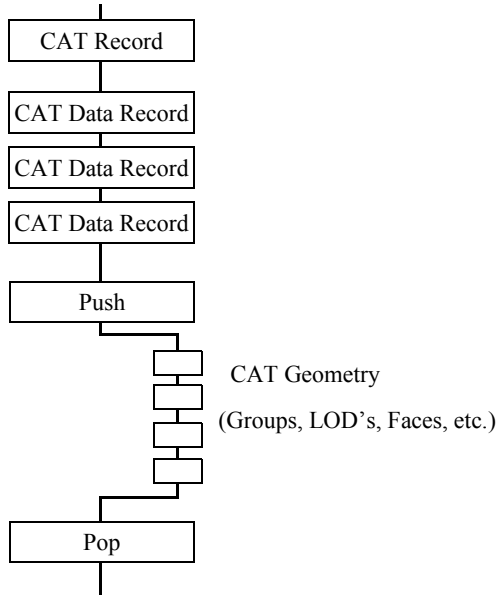
Switch Record

Data type	Offset	Length	Description
Int	0	2	Switch Opcode 96
Unsigned Int	2	2	Length of record
Char	4	8	7 char ASCII ID; 0 terminates
Int	12	4	Reserved
Int	16	4	Current mask
Int	20	4	Number of masks
Int	24	4	Number of words per mask - the number of 32 bit words required for each mask, calculated as follows: (number of children / 32) + X where X equals: 0 if (number of children modulo 32) is zero 1 if (number of children modulo 32) is nonzero
Unsigned Int	28	Variable	Mask words. The length (in bytes) can be calculated as follows: Number of words per mask * Number of masks * 4 bytes

CAT Record

A continuously adaptive terrain (CAT) record is the primary record of a CAT node. A continuously adaptive terrain skin is a hierarchical triangle mesh designed for high fidelity, real-time viewing.

A CAT skin is represented in OpenFlight by a record stream consisting of: a CAT record, a set of CAT data records, a push record, the CAT hierarchy and geometry, and a pop record. CAT hierarchy and geometry is represented by standard OpenFlight constructs of LOD's, groups, external references, faces, and vertices.



CAT Record

Data type	Offset	Length	Description
Int	0	2	CAT Opcode 115
Unsigned Int	2	2	Length - length of the record
Char	4	8	7 char ASCII ID; 0 terminates
Int	12	4	Reserved
Int	16	4	IR color code
Int	20	1	Draw type 0 = Hidden, don't draw 1 = Draw solid, no backface 2 = Draw wireframe
Int	21	1	Texture white = if TRUE, draw textured face white
Int	22	2	Reserved
Unsigned Int	24	2	Color name index
Unsigned Int	26	2	Alternate color name index
Int	28	2	Detail texture pattern index, -1 if none
Int	30	2	Texture pattern index, -1 if none
Int	32	2	Material index, -1 if none
Int	34	2	Surface material code (for DFAD)
Int	36	4	IR material code
Int	40	4*2	Reserved
Int	48	2	Texture mapping index
Int	50	2	Reserved
Unsigned Int	52	4	Primary color index
Unsigned Int	56	4	Alternate color index

CAT Record (Continued)

Data type	Offset	Length	Description
Int	60	4	Reserved
Double	64	8	Reserved
Int	72	4	Flags (bits, from left to right) 0 = No color 1 = No alternate color 2-31 = Spare
Int	76	4	Reserved

Extension Record

An extension node record is the primary record of an extension node. It introduces a user defined node type that is defined by an extension site that utilizes the extensibility of the OpenFlight format. It specifies the site information for a third party record which contains additional data that is not represented by the standard OpenFlight records. The content of the data itself is transparent to users other than the extension site. The data can be accessed by the combination of the OpenFlight API and the data dictionary defined by the extension site.

The relationship of an extension node relative to other hierarchical nodes is defined by the standard push and pop control records. For more information about extensions, please refer to the "OpenFlight API User's Guide, Level 3: Extensions".

The extension record (Opcode 100) may also introduce new attributes to existing nodes (See "Extension Attribute Record" on page 64.)

Extension Record

Data type	Offset	Length	Description
Int	0	2	Extension Opcode 100
Unsigned Int	2	2	Length of the total extension record
Char	4	8	7 char ASCII ID; 0 terminates
Char	12	8	Site ID - Unique site name. 7 char ASCII ID; 0 terminates
Int	20	1	Reserved
Int	21	1	Revision - site specific
Unsigned Int	22	2	Record code - site specific
Char	24	Varies	Extended data - site specific

Curve Record

A curve record is the primary record of a curve node. A curve node represents one or more curve segments joined together with at least G^0 continuity. Let a curve segment be defined by 4 geometric constraints. We will call these geometric constraints control points in the curve record. The way the control points are grouped and used will be discussed below.

Let each control point be a double precision 3D coordinate, P = (x, y, z).

Let the group of control points be (P_0, P_1,..., P_k).

The currently defined curve types are B-spline, Cardinal, and Bezier.

If the curve type is Bezier, P_0, P_1, P_2, and P_3 form the first curve segment. P_3, P_4, P_5, and P_6 form the next segment, and so on. Notice that the last control point in the first segment becomes the first control point in the second segment.

If the curve type is either B-spline or Cardinal, P_0, P_1, P_2, and P_3 form the first curve segment. P_1, P_2, P_3, and P_4 from the next segment, and so on. Notice that the second control point in the first segment becomes the first control point in the second segment.

Note that the smoothness of the curve depends on how many times your renderer samples the curve equation into piece-wise linear elements. In the MultiGen-Paradigm, Inc. modeling environment, each curve segment is evenly sampled 11 times to produce 10 lines per curve segment.

Curve Record

Data Type	Offset	Length	Description
Int	0	2	Curve Opcode 126
Unsigned Int	2	2	Length of the total curve record
Char	4	8	7 char ASCII ID; 0 terminates
Int	12	4	Reserved
Int	16	4	Curve type 4 = B-spline 5 = Cardinal 6 = Bezier
Int	20	4	Number of control points
Char	24	8	Reserved
Double	32	Variable	Coordinates of control points. Each coordinate is (x, y, z) Coordinates are ordered: cp_0x, cp_0y, cp_0z, cp_1x, cp_1y, cp_1z, ... cp_Nx, cp_Ny, cp_Nz where N is Number of control points - 1 (Length = Number of control points * 3 * 8 bytes.)

Ancillary Records

Ancillary records follow node primary records. They contain supplementary attribute data for the node they follow. Ancillary records are optional but must precede any control record, following the node primary record, when present, as shown in this example:

```
GROUP
COMMENT
LONG ID
PUSH
...
POP
```

In this example, the comment and long ID ancillary records apply to the group record. There is no order dependency between ancillary records. The comment could appear before or after the long ID record in the example above, but must appear before any control record.

Comment Record

A comment record is an ancillary record that contains text data that belongs to the preceding node primary record. The text description is a variable length ASCII string terminated by a <nil> character.

Comment Record

Data Type	Offset	Length	Description
Int	0	2	Comment Opcode 31
Unsigned Int	2	2	Length - length of the record
Char	4	Length - 4	Text description of node; 0 terminates

Long ID Record

A long ID record is an ancillary record that contains the full name of the preceding node. It is present only when the name exceeds eight characters (seven characters plus a terminating <nil> character).

Long ID Record

Data Type	Offset	Length	Description
Int	0	2	Long ID Opcode 33
Unsigned Int	2	2	Length - length of the record
Char	4	Length - 4	ASCII ID of node; 0 terminates

Indexed String Record

An indexed string record is an ancillary record that contains an integer index followed by a variable length character string. In this way, arbitrary strings can be associated to indices in a general way.

Currently, indexed string records are only used in the context of switch nodes, for which they represent the names of the masks contained in the switch node. The index specifies the mask

number for which the string specifies the name. Mask numbers start at 0. Not all masks are required to have names. For more information on switch nodes, see "Switch Record" on page 49.

Indexed String Record

Data Type	Offset	Length	Description
Int	0	2	Indexed string Opcode 132
Unsigned Int	2	2	Length - length of the record
Unsigned Int	4	4	Index
Char	8	Length - 8	ASCII string; 0 terminates

Multitexture

OpenFlight supports eight textures per polygon or mesh as well as eight uv values per vertex. The current texture information stored on the polygon is referred to as "the base texture" or "texture layer 0". Each additional texture is referred to as "texture layer N". Therefore, to support eight textures per polygon, a base texture is required as well as seven additional texture layers. Not all layers are required. Nor is any mandate set forth requiring that layers be contiguous after the base layer. The additional texture layers for each polygon, mesh, and vertex are represented in ancillary records at the face, mesh and vertex primary node level as shown in the following example:

FACE
MULTITEXTURE
PUSH
VERTEX LIST
UV LIST
POP

The records that are used to represent multitexture in the OpenFlight file are described in the following sections.

Multitexture Record

The multitexture record is an ancillary record of face and mesh nodes. It specifies the texture layer information for the face or mesh.

Multitexture Record

Data Type	Offset	Length	Description
Unsigned Int	0	2	Multitexture Opcode 52
Unsigned Int	2	2	Length - length of the record
Int	4	4	Attribute mask - Bit mask indicating what kind of multi-texture information is present in this record. Bits are ordered from left to right and have the following definitions: Bit # Description 0 Has Layer 1 - if set, multitexture information for texture layer 1 is present. 1 Has Layer 2 - if set, multitexture information for texture layer 2 is present. 2 Has Layer 3 - if set, multitexture information for texture layer 3 is present. 3 Has Layer 4 - if set, multitexture information for texture layer 4 is present. 4 Has Layer 5 - if set, multitexture information for texture layer 5 is present. 5 Has Layer 6 - if set, multitexture information for texture layer 6 is present. 6 Has Layer 7 - if set, multitexture information for texture layer 7 is present. 7-31 Spare
The following fields are repeated for each multitexture layer that is specified as present by the bits set in the Attribute mask field above. This mechanism allows for "sparse" multitexture layer information to be present and does not require that the information present be contiguous.			
Unsigned Int	Varies	2	$texture_N$ - Texture index for texture layer N
Unsigned Int	Varies	2	$effect_N$ - Multitexture effect for texture layer N 0 = Texture environment 1 = Bump map 2-100 = Reserved by MultiGen-Paradigm, Inc. >100 = user (runtime) defined
Unsigned Int	Varies	2	$mapping_N$ - Texture mapping index for texture layer N
Unsigned Int	Varies	2	$data_N$ - Texture data for layer N. This is user defined. For example, it may be used as a blend percentage or color or any other data needed by the runtime to describe texture layer N

UV List Record

The uv list record is an ancillary record of vertex nodes. This record (if present) always follows the vertex list or morph vertex list record and contains texture layer information for the vertices represented in the vertex list record it follows.

UV List Record

Data Type	Offset	Length	Description
Unsigned Int	0	2	UV List Opcode 53
Unsigned Int	2	2	Length - length of the record
Int	4	4	Attribute mask - Bit mask indicating what kind of multi-texture information is present in this record. Bits are ordered from left to right as follows: Bit # Description 0 Has Layer 1 - if set, uvs for layer 1 are present 1 Has Layer 2 - if set, uvs for layer 2 are present 2 Has Layer 3 - if set, uvs for layer 3 are present 3 Has Layer 4 - if set, uvs for layer 4 are present 4 Has Layer 5 - if set, uvs for layer 5 are present 5 Has Layer 6 - if set, uvs for layer 6 are present 6 Has Layer 7 - if set, uvs for layer 7 are present 7-31 Spare

The following fields are repeated for each vertex contained in the corresponding vertex list or morph vertex list record.

If this uv list record follows a vertex list record, the following fields are repeated for each layer present (as specified by the bits set in Attribute mask).

Data Type	Length	Description
Float	4	$u_{i, N}$ - Texture coordinate U for vertex i, layer N
Float	4	$v_{i, N}$ - Texture coordinate V for vertex i, layer N

The number of vertices represented in the uv list record that follows a vertex list record must be identical to the number of vertices contained in that vertex list record. This number can also be calculated as follows:

Number of vertices = (Length - 8) / (8 * X), where X is the number of bits set in Attribute mask.

If this uv list record follows a morph vertex list record, the following fields are repeated for each layer present (as specified by the bits set in Attribute mask).

Data Type	Length	Description
Float	4	$u0_{i, N}$ - Texture U for the 0% vertex i, layer N
Float	4	$v0_{i, N}$ - Texture V for the 0% vertex i, layer N
Float	4	$u100_{i, N}$ - Texture U for the 100% vertex i, layer N
Float	4	$v100_{i, N}$ - Texture V for the 100% vertex i, layer N

Again, the number of vertices represented in the uv list record that follows a morph vertex list record must be identical to the number of vertices contained in that morph vertex list record. This number can also be calculated as follows:

Number of vertices = (Length - 8) / (16 * X), where X is the number of bits set in Attribute mask.

Example

Consider a triangular face (3 vertices) that contains morph vertex information and has texture layers 1 and 3 defined. The following example shows the contents of the uv list record corresponding to the morph vertex list record representing this triangle:

Field	Data Type	Length	Description
opcode	Unsigned Int	2	53 (UV List opcode).
length	Unsigned Int	2	200 (Length of the record)
uvmask	Unsigned Int	4	1010 0000 0000 0000 (layers 1and 3 ON, others OFF)
u0 1,1	Float	8	Texture U for the 0% vertex 1, layer 1.
v0 1,1	Float	8	Texture V for the 0% vertex 1, layer 1.
u100 1,1	Float	8	Texture U for the 100% vertex 1, layer 1.
v100 1,1	Float	8	Texture V for the 100% vertex 1, layer 1.
u0 1,3	Float	8	Texture U for the 0% vertex 1, layer 3.
v0 1,3	Float	8	Texture V for the 0% vertex 1, layer 3.
u100 1,3	Float	8	Texture U for the 100% vertex 1, layer 3.
v100 1,3	Float	8	Texture V for the 100% vertex 1, layer 3.
u0 2,1	Float	8	Texture U for the 0% vertex 2, layer 1.
v0 2,1	Float	8	Texture V for the 0% vertex 2, layer 1.
u100 2,1	Float	8	Texture U for the 100% vertex 2, layer 1.
v100 2,1	Float	8	Texture V for the 100% vertex 2, layer 1.
u0 2,3	Float	8	Texture U for the 0% vertex 2, layer 3.
v0 2,3	Float	8	Texture V for the 0% vertex 2, layer 3.
u100 2,3	Float	8	Texture U for the 100% vertex 2, layer 3.
v100 2,3	Float	8	Texture V for the 100% vertex 2, layer 3.
u0 3,1	Float	8	Texture U for the 0% vertex 3, layer 1.
v0 3,1	Float	8	Texture V for the 0% vertex 3, layer 1.
u100 3,1	Float	8	Texture U for the 100% vertex 3, layer 1.
v100 3,1	Float	8	Texture V for the 100% vertex 3, layer 1.
u0 3,3	Float	8	Texture U for the 0% vertex 3, layer 3.
v0 3,3	Float	8	Texture V for the 0% vertex 3, layer 3.
u100 3,3	Float	8	Texture U for the 100% vertex 3, layer 3.
v100 3,3	Float	8	Texture V for the 100% vertex 3, layer 3

Replicate Record

A replicate record is an ancillary record of group, face, and light (string) point nodes. It indicates the number of times the group, face, or light (string) point is instantiated. An ancillary transformation record must also be present. The transformation is iteratively applied to each instance to uniquely place it in the database.

Replicate Record

Data Type	Offset	Length	Description
Int	0	2	Replicate Opcode 60
Unsigned Int	2	2	Length - length of the record
Int	4	2	Number of replications
Int	6	2	Reserved

Road Zone Record

The road zone record is an ancillary record of the header node. It references a road zone file that contains gridded elevation data. The format of the file is described in "Road Zone Files," page 103.

Road Zone Record

Data type	Offset	Length	Description
Int	0	2	Road Path Opcode 88
Unsigned Int	2	2	Length - length of the record
Char	4	120	Zone file name; 0 terminates
Int	124	4	Reserved
Double	128	8	Lower-left x coordinate
Double	136	8	Lower-left y coordinate
Double	144	8	Upper-right x coordinate
Double	152	8	Upper-right y coordinate
Double	160	8	Grid interval
Int	168	4	Number of posts along x axis
Int	172	4	Number of posts along y axis

Transformation Records

Transformation records may be ancillary records of most nodes. All hierarchical nodes may be transformed except the header node. Some nodes may only be transformed implicitly, as part of some other operation, such as point replication within a light point string.

There are several distinct types of transformation records. For a transformation applied to any node, a matrix record is always present and represents the final (composite) transformation. Following the matrix record is zero or more other transformation records. When present, the transformation records that follow a matrix record represent the individual transformations applied to the node. If an application only needs the final transformation, the matrix record is sufficient and the transformation records that follow the matrix record can be ignored. The records following the matrix record are only needed by the application if it needs to decompose the transformation. The MultiGen-Paradigm, Inc. modeling environment uses these records in order to allow the modeler to modify any of the discrete transformations applied to a node.

Again, each record that follows the matrix record represents a discrete transformation that has been concatenated to form the composite matrix. Concatenation is done in the order that the records are encountered, using premultiplication.

Note: The final and general matrices are only single-precision, while the discrete transformations are double-precision.

Matrix Record

Data type	Offset	Length	Description
Int	0	2	Matrix Opcode 49
Unsigned Int	2	2	Length - length of the record
Float	4	4*16	4x4 matrix, row major order

Rotate About Edge Record

Data type	Offset	Length	Description
Int	0	2	Rotate About Edge Opcode 76
Unsigned Int	2	2	Length - length of the record
Int	4	4	Reserved
Double	8	8*3	First point on edge (x, y, z)
Double	32	8*3	Second point on edge (x, y, z)
Float	56	4	Angle by which to rotate
Int	60	4	Reserved

Translate Record

Data type	Offset	Length	Description
Int	0	2	Translate Opcode 78
Unsigned Int	2	2	Length - length of the record
Int	4	4	Reserved
Double	8	8*3	From point (x, y, z)
Double	32	8*3	Delta to translate (x, y, z)

Scale Record

Data type	Offset	Length	Description
Int	0	2	Scale Opcode 79
Unsigned Int	2	2	Length - length of the record
Int	4	4	Reserved
Double	8	8*3	Scale center (x, y, z)
Float	32	4	x scale factor
Float	36	4	y scale factor
Float	40	4	z scale factor
Int	44	4	Reserved

Rotate About Point Record

Data type	Offset	Length	Description
Int	0	2	Rotate About Point Opcode 80
Unsigned Int	2	2	Length - length of the record
Int	4	4	Reserved
Double	8	8*3	Rotation center point (x, y, z)
Float	32	4	i, axis of rotation
Float	36	4	j, axis of rotation
Float	40	4	k, axis of rotation
Float	44	4	Angle by which to rotate

Rotate and/or Scale to Point Record

Data type	Offset	Length	Description
Int	0	2	Rotate and/or Scale Opcode 81
Unsigned Int	2	2	Length - length of the record
Int	4	4	Reserved
Double	8	8*3	Scale center (x, y, z)
Double	32	8*3	Reference point (x, y, z)
Double	56	8*3	To point (x, y, z)
Float	80	4	Overall scale factor
Float	84	4	Scale factor in direction of axis
Float	88	4	Angle by which to rotate
Int	92	4	Reserved

Put Record

Data type	Offset	Length	Description
Int	0	2	Put Opcode 82
Unsigned Int	2	2	Length - length of the record
Int	4	4	Reserved
Double	8	8*3	From point origin (x, y, z)
Double	32	8*3	From point align (x, y, z)
Double	56	8*3	From point track (x, y, z)
Double	80	8*3	To point origin (x, y, z)
Double	104	8*3	To point align (x, y, z)
Double	128	8*3	To point track (x, y, z)

General Matrix Record

Data type	Offset	Length	Description
Int	0	2	General Matrix Opcode 94
Unsigned Int	2	2	Length - length of the record
Float	4	4*16	4x4 matrix, row major order

Vector Record

A vector record is an ancillary record of the (pre v15.4) face node. Its only use is to provide the direction vector for old-style unidirectional and bidirectional light point faces.

Vector Record

Data type	Offset	Length	Description
Int	0	2	Vector Opcode 50
Unsigned Int	2	2	Length - length of the record
Float	4	4	i component
Float	8	4	j component
Float	12	4	k component

Bounding Volume Records

Bounding volumes are ancillary records for group nodes only. They generally encompass all the geometry of a group's children. A bounding volume may describe a box, sphere, cylinder, convex hull or histogram.

The center coordinate of a bounding volume is stored as a separate record. The orientation of a bounding volume is also stored as a separate record. The convex hull data is represented by a sequence of triangles forming the convex hull around the group geometry.

Applications may use the bounding volume information with culling and collision detection algorithms.

Bounding Box Record

Data type	Offset	Length	Description
Int	0	2	Bounding Box Opcode 74
Unsigned Int	2	2	Length - length of the record
Int	4	4	Reserved
Double	8	8	x coordinate of lowest corner
Double	16	8	y coordinate of lowest corner
Double	24	8	z coordinate of lowest corner
Double	32	8	x coordinate of highest corner
Double	40	8	y coordinate of highest corner
Double	48	8	z coordinate of highest corner

Bounding Sphere Record

Data type	Offset	Length	Description
Int	0	2	Bounding Sphere Opcode 105
Unsigned Int	2	2	Length - length of the record
Int	4	4	Reserved
Double	8	8	Radius of the sphere

Bounding Cylinder Record

Data type	Offset	Length	Description
Int	0	2	Bounding Cylinder Opcode 106
Unsigned Int	2	2	Length - length of the record
Int	4	4	Reserved
Double	8	8	Radius of the cylinder base
Double	16	8	Height of the cylinder

Bounding Convex Hull Record

Data type	Offset	Length	Description
Int	0	2	Bounding Convex Hull Opcode 107
Unsigned Int	2	2	Length - length of the record
Int	4	4	Number of triangles
The following fields are repeated for each triangle represented in the convex hull data. In the fields listed below, N ranges from 0 to Number of triangles-1.			
Double	8+(N*72)	8	x coordinate of vertex 1 of $triangle_N$
Double	16+(N*72)	8	y coordinate of vertex 1 of $triangle_N$
Double	24+(N*72)	8	z coordinate of vertex 1 of $triangle_N$
Double	32+(N*72)	8	x coordinate of vertex 2 of $triangle_N$
Double	40+(N*72)	8	y coordinate of vertex 2 of $triangle_N$
Double	48+(N*72)	8	z coordinate of vertex 2 of $triangle_N$
Double	56+(N*72)	8	x coordinate of vertex 3 of $triangle_N$
Double	64+(N*72)	8	y coordinate of vertex 3 of $triangle_N$
Double	72+(N*72)	8	z coordinate of vertex 3 of $triangle_N$

Bounding Histogram Record

Data type	Offset	Length	Description
Int	0	2	Bounding Histogram Opcode 119
Unsigned Int	2	2	Length - length of the record
Char	4	Variable	The contents of this record is reserved for use by Multi-Gen-Paradigm.

Bounding Volume Center Record

Data type	Offset	Length	Description
Int	0	2	Bounding Volume Center Opcode 108
Unsigned Int	2	2	Length - length of the record
Int	4	4	Reserved
Double	8	8	x coordinate of center
Double	16	8	y coordinate of center
Double	24	8	z coordinate of center

Bounding Volume Orientation Record

Data type	Offset	Length	Description
Int	0	2	Bounding Volume Orientation Opcode 109
Unsigned Int	2	2	Length - length of the record
Int	4	4	Reserved
Double	8	8	Yaw angle
Double	16	8	Pitch angle
Double	24	8	Roll angle

CAT Data Record

The CAT data records contain the information needed to reconstruct a Continuously Adaptive Terrain skin from its OpenFlight representation. They provide the information which links faces between levels of detail within a CAT skin. CAT data is stored as a key table with an opcode of 116. For specific detail please refer to "Key Table Records" on page 76.

Each CAT data record describes how a face within a CAT skin is related to faces at the next finer level of detail. The coarsest level of detail is level zero. The next finer level of detail is one, and so forth. Each data record is stored in the key table using an ordinal key, counting up from zero. The face node ID is stored in the data record, thereby providing the cross reference to the OpenFlight face node that represents it.

In OpenFlight, each CAT level of detail is parented by a LOD node. Each CAT triangle strip is parented by a group node.

CAT Data Header Record

Data type	Offset	Length	Description
Int	0	2	CAT Data Opcode 116
Unsigned Int	2	2	Length - length of the record
Int	4	4	Subtype 1 = indicates this record is a key table header
Int	8	4	Max number - maximum number of face keys
Int	12	4	Actual number - actual number of face keys

CAT Data Header Record (Continued)

Data type	Offset	Length	Description
Int	16	4	Total length of packed face data
Int	20	4	Reserved
Int	24	4	Reserved
Int	28	4	Reserved
The following fields are repeated for each face record represented in the CAT data. In the fields listed below, N ranges from 0 to Actual number - 1.			
Int	32+(N*12)	4	Face $index_N$ - index of face N
Int	36+(N*12)	4	$Reserved_N$ - reserved space for face N
Int	40+(N*12)	4	Face data $offset_N$ - offset for face data record N in the CAT data. Note: This offset is measured relative to the Packed face data field in the CAT data face record described below.

CAT Data Face Record

Data type	Offset	Length	Description
Int	0	2	CAT Data Opcode 116
Unsigned Int	2	2	Length - length of the record
Int	4	4	Subtype 2 = indicates this record is a key data record
Int	8	4	Total length of all packed face records
The following fields constitute one face record and are repeated for each face record represented in the CAT data. In the fields listed below, N ranges from 0 to Actual number - 1. Actual number is from the CAT data header record.			
Int	Varies	4	LOD_N - Level of detail to which this face N belongs.
Int	Varies	4	Child index 1_N - The 1st child (within this table) of face N, or -1 for no face.
Int	Varies	4	Child index 2_N - The 2nd child (within this table) of face N, or -1 for no face.
Int	Varies	4	Child index 3_N - The 3rd child index (within this table) of face N, or -1 for no face.
Int	Varies	4	Child index 4_N - The 4th child index (within this table) of face N, or -1 for no face.
Int	Varies	4	ID $Length_N$ - length of face node ID string which follows
Char	Varies	Varies	ID_N - ASCII ID of the face to which this record applies.

Extension Attribute Record

The extension attribute record is an ancillary record defined by an extension site that utilizes the extensibility of the OpenFlight format. It specifies the site information of a third party extended record which describes additional data that is not represented by the standard OpenFlight records. The data itself is transparent to users other than the extension site. The data can be accessed by the combination of the OpenFlight API and the data dictionary defined by the extension site.

Any hierarchical node can contain extension attribute records. Extension attributes are introduced by an push extension control record and concluded by a pop extension control record.

The extension record (Opcode 100) may also introduce a new node type (See "Extension Record" on page 51.)

Extension Attribute Record

Data type	Offset	Length	Description
Int	0	2	Extension Opcode 100
Unsigned Int	2	2	Length of the total extension record
Char	4	8	7 char ASCII ID; 0 terminates
Char	12	8	Site ID - Unique site name
Int	20	1	Reserved
Int	21	1	Revision - site specific
Unsigned Int	22	2	Record code - site specific
Char	24	Variable	Extended data - site specific

Continuation Record

All OpenFlight records begin with a 4 byte sequence. The first two bytes identify the record (opcode) and the second two bytes specify the length of the record. Given this regular record structure, the length of all OpenFlight records is limited to the largest value that can be encoded with 2 bytes or 16 bits (65535). For fixed-size records, this maximum size is sufficient. For variable-size records, this limitation is addressed with the continuation record which is described in this section.

The continuation record accommodates variable size records in the OpenFlight Scene Description. The continuation record is used to "continue" a record in the OpenFlight file stream. It appears in the stream immediately following the record that it "continues" (the record that is being continued will be referred to as the "original" record). In this way, the continuation record is an ancillary record to any other record type. The data contained in the continuation record is defined by the original record and is assumed to be directly appended onto the content of the original record.

Note: Multiple continuation records may follow a record, in which case all continuation records would be appended (in sequence) to the original record.

Continuation Record

Data type	Offset	Length	Description
Unsigned Int	0	2	Continuation Record Opcode 23
Unsigned Int	2	2	Length - length of the record
Varies	4	Length-4	Depends on the original record. The contents of this field are to be appended directly to the end of the original record contents (before the original record contents are parsed)

In theory, any OpenFlight record may be "continued", but in practice only variable length records, whose length is likely to exceed 65535 bytes, are. Following is a list of the variable length OpenFlight record types to which the continuation record is likely to apply:

- "Extension Record" on page 51
- "Name Table Record" on page 71
- "Local Vertex Pool Record" on page 30
- "Mesh Primitive Record" on page 32

Example: In the following example, the color name table is "too" big to fit in 65535 bytes so the primary palette record, `NAME TABLE`, is followed by one (or more) `CONTINUATION` records. The contents of each of the continuation records is appended to the contents of the name table record before the name table data is parsed.

```
NAME TABLE
CONTINUATION
CONTINUATION
```

Palette Records

Palette records are ancillary records of the header node. They contain attribute data globally shared by other nodes in the database. Other nodes, such as face nodes, reference the palette data by index.

Individual palettes contain resources such as vertex, material, light source, texture pattern, and line style definitions.

Vertex Palette Records

Double precision vertex records are stored in a vertex palette for the entire database. Vertices shared by one or more geometric entities are written only one time in the vertex palette. This reduces the overall size of the OpenFlight file by writing only "unique" vertices. Vertex palette records are referenced by faces and light points via vertex list and morph vertex list records. See

"Vertex List Record" on page 39 and "Morph Vertex List Record" on page 39 for more information.

Note: The vertices referenced by mesh nodes are not contained in vertex palette records. Instead, they are contained in local vertex pool records. See "Local Vertex Pool Record" on page 30.

The vertex palette record signifies the start of the vertex palette. It contains a one word entry specifying the total length of the vertex palette, which is equal to the length of this header record plus the length of the following vertex records. The individual vertex records follow this header, each starting with its own opcode. The length field in the vertex palette record makes it possible to skip over vertex records until the data is actually needed.

As stated above, vertices may be shared, and are accessed through the vertex and morph vertex list records following each face record. A face may contain all morph vertices, all non-morph vertices, or a mixture of both. Thus there can be one or more list records following each face. Consecutive vertices with the same type are grouped together within a list record. The length of each list record is determined by the number of consecutive vertices of each type. For each vertex, there is a one word field pointing to its vertex record in the vertex palette. Since this offset includes the length of the vertex palette record, the value of the first pointer is 8.

Vertex Palette Record

Data type	Offset	Length	Description
Int	0	2	Vertex Palette Opcode 67
Unsigned Int	2	2	Length - length of the record
Int	4	4	Length of this record plus length of the vertex palette

The vertex palette record is immediately followed by vertex records. Each vertex record contains all the attributes of a vertex that has been referenced one or more times in the database.

The Color name index references a name in the color name palette.

The Hard edge flag indicates this vertex starts an edge that is to be preserved by polygon reduction or decimation algorithms.

The Normal frozen flag indicates the normal is not to be updated by shading or lighting algorithms.

The No color flag indicates the vertex does not have a color. If set, neither the Packed color or Vertex color index fields are defined.

When a vertex has a color (the No color flag is not set), the Packed color field is always specified (regardless of the value of the Packed color flag) and contains the red, green, blue and alpha color components. For alpha, 0 represents fully transparent, 255 fully opaque. If the Packed color flag is set, the Vertex color index field will be undefined.

Here are some examples that show how vertex palette records can represent vertex colors:

Packed Color Flag	Packed Color	Vertex Color Index	Result
0	a, g, b, r	N	Vertex color index and Packed color attributes are both specified. a, b, g, r specify the vertex color components. g, b, r components match those of color index N in palette.
1	a, g, b, r	Not defined	Vertex color index attribute is not specified, only packed color. a, b, g, r specify the vertex color components.

Vertex with Color Record

Data type	Offset	Length	Description
Int	0	2	Vertex with Color Opcode 68
Unsigned Int	2	2	Length - length of the record
Unsigned Int	4	2	Color name index
Int	6	2	Flags (bits, from left to right) 0 = Start hard edge 1 = Normal frozen 2 = No color 3 = Packed color 4-15 = Spare
Double	8	8*3	Vertex coordinate (x, y, z)
Int	32	4	Packed color (a, b, g, r) - always specified when the vertex has color
Unsigned Int	36	4	Vertex color index - valid only if vertex has color and Packed color flag is not set

Vertex with Color and Normal Record

Data type	Offset	Length	Description
Int	0	2	Vertex with Color and Normal Opcode 69
Unsigned Int	2	2	Length - length of the record
Unsigned Int	4	2	Color name index
Int	6	2	Flags (bits, from left to right) 0 = Start hard edge 1 = Normal frozen 2 = No color 3 = Packed color 4-15 = Spare
Double	8	8*3	Vertex coordinate (x, y, z)
Float	32	4*3	Vertex normal (i, j, k)
Int	44	4	Packed color (a, b, g, r) - always specified when the vertex has color
Unsigned Int	48	4	Vertex color index - valid only if vertex has color and Packed color flag is not set
Int	52	4	Reserved

Vertex with Color and UV Record

Data type	Offset	Length	Description
Int	0	2	Vertex with Color and UV Opcode 71
Unsigned Int	2	2	Length - length of the record
Unsigned Int	4	2	Color name index
Int	6	2	Flags (bits, from left to right) 0 = Start hard edge 1 = Normal frozen 2 = No color 3 = Packed color 4-15 = Spare
Double	8	8*3	Vertex coordinate (x, y, z)
Float	32	4*2	Texture coordinate (u, v)
Int	40	4	Packed color (a, b, g, r) - always specified when the vertex has color
Unsigned Int	44	4	Vertex color index - valid only if vertex has color and Packed color flag is not set

Vertex with Color, Normal and UV Record

Data type	Offset	Length	Description
Int	0	2	Vertex with Color, Normal and UV Opcode 70
Unsigned Int	2	2	Length - length of the record
Unsigned Int	4	2	Color name index
Int	6	2	Flags (bits, from left to right) 0 = Start hard edge 1 = Normal frozen 2 = No color 3 = Packed color 4-15 = Spare
Double	8	8*3	Vertex coordinate (x, y, z)
Float	32	4*3	Vertex normal (i, j, k)
Float	44	4*2	Texture coordinate (u, v)
Int	52	4	Packed color (a, b, g, r) - always specified when the vertex has color
Unsigned Int	56	4	Vertex color index - valid only if vertex has color and Packed color flag is not set
Int	60	4	Reserved

Color Palette Record

The color palette record contains all colors indexed by face and vertex nodes in the database.

The color record is divided into two sections: one for color entries and one for color names. All color entries are in 32-bit packed format (a, b, g, r). Each color consists of red, green, and blue components of 8 bits each, plus 8 bits reserved for alpha (future). Currently alpha is always 0xff (fully opaque). The color entry section consists of 1024 ramped colors of 128 intensities each.

The color name section may or may not be included. If the length of the color palette record is greater than 4228, then you can assume that the color name section is included. When it is present, the color name section consists of a header followed by 0 or more color name entries. The header contains the number of names in the palette. If this value is 0, there are no names following in the palette. Each color name entry contains the name string, pointer to the associated color entry, and other reserved information. The name field is a variable-length, null-terminated ASCII string, with a maximum of 80 bytes.

Color Palette Record

Data type	Offset	Length	Description
Int	0	2	Color Palette Opcode 32
Unsigned Int	2	2	Length - length of the record
Char	4	128	Reserved
Int	132	4	Brightest RGB of color 0, intensity 127 (a, b, g, r)
Int	136	4	Brightest RGB of color 1, intensity 127 (a, b, g, r)
etc.	...	...	
Int	4224	4	Brightest RGB of color 1023, intensity 127 (a, b, g, r)
As stated above, if the length of the color palette record is greater than 4228, then it also contains a color name section as shown below:			
Int	4228	4	Number of color names
The following fields are repeated for each color name entry present in the color palette record. In the fields listed below, N ranges from 0 to Number of color names - 1.			
Unsigned Int	Varies	2	$Length_N$ - length of color name subrecord N. This length is the total length of this field plus the length of the next 3 fields plus the length of the Color $name_N$ field.
Int	Varies	2	$Reserved_N$ - reserved space for color name N
Int	Varies	2	Color $index_N$ - index of color in palette corresponding to color name N
Int	Varies	2	$Reserved_N$ - reserved space for color name N
Char	Varies	$Length_N$-8	Color $name_N$ - color name N; 0 terminates, max 80 bytes

Name Table Record

The name table contains a lookup table of names referenced within the database. These names are typically used as attributes (e.g., color name index in the face record). The primary benefit of the name table is to allow name referencing, so each name string is only stored once. Each name entry in the name table contains fields for the its length, index, and string. The name index is used by the database to reference names within the table. The name string is a variable-length, null-terminated ASCII string, with a maximum of 80 bytes.

Name Table Record

Data type	Offset	Length	Description
Int	0	2	Name Table Opcode 114
Unsigned Int	2	2	Length - length of the record
Int	4	4	Number of names
Unsigned Int	8	2	Next available name index
Name Table Entry 0			
Int	10	4	$Length_0$ - length of entry 0
Unsigned Int	14	2	Name $index_0$ - index corresponding to entry 0
Char	16	Varies	Name $string_0$ - name for entry 0; 0 terminates. Variable length, maximum of 80 chars
Name Table Entry 1			
Int	Varies	4	$Length_1$ - length of entry 1
Unsigned Int	Varies	2	Name $index_1$ - index corresponding to entry 1
Char	Varies	Varies	Name $string_1$ - name for entry 1; 0 terminates. Variable length, maximum of 80 chars
...	...	...	...
Name Table Entry N, where N is Number of names - 1			
Int	Varies	4	$Length_N$ - length of entry N
Unsigned Int	Varies	2	Name $index_N$ - index corresponding to entry N
Char	Varies	Varies	Name $string_N$ - name for entry N; 0 terminates. Variable length, maximum of 80 chars

Material Palette Record

The material palette contains descriptions of materials used while drawing geometry. It is composed of an arbitrary number of material palette records. The material palette records must follow the header record and precede the first push.

The appearance of a face or mesh in OpenFlight is a combination of the geometry (face or mesh) color and the material properties. The geometry color is factored into the material properties as follows:

Ambient:
The displayed material's ambient component is the product of the ambient component of the material and the geometry color:

Displayed ambient (red) = Material ambient (red)* geometry color (red)
Displayed ambient (green) = Material ambient (green)* geometry color (green)
Displayed ambient (blue) = Material ambient (blue)* geometry color (blue)

For example, suppose the material has an ambient component of {1.0,.5,.5} and the geometry color is {100, 100, 100}. The displayed material has as its ambient color {100, 50, 50}.

Diffuse:
As with the ambient component, the diffuse component is the product of the diffuse component of the material and the geometry color:

Displayed diffuse (red) = Material diffuse (red)* geometry color (red)
Displayed diffuse (green) = Material diffuse (green)* geometry color (green)
Displayed diffuse (blue) = Material diffuse (blue)* geometry color (blue)

Specular:
Unlike ambient and diffuse components, the displayed specular component is taken directly from the material:

Displayed specular (red) = Material specular (red)
Displayed specular (green) = Material specular (green)
Displayed specular (blue) = Material specular (blue)

Emissive:
The displayed emissive component is taken directly from the material:

Displayed emissive (red) = Material emissive (red)
Displayed emissive (green) = Material emissive (green)
Displayed emissive (blue) = Material emissive (blue)

Shininess:
The MultiGen-Paradigm, Inc. modeling environment uses the shininess directly from the material. Specular highlights are tighter, with higher shininess values.

Alpha:
An alpha of 1.0 is fully opaque, while 0.0 is fully transparent. The final alpha applied is acombination of the transparency value of the geometry (face or mesh) with the alpha value of the material record. The final alpha value is a floating point number between 0.0 (transparent) and 1.0 (opaque), and is computed as follows:

Final alpha = material alpha * (1.0 - (geometry transparency / 65535))

Material Palette Record

Data type	Offset	Length	Description
Int	0	2	Material Palette Opcode 113
Int	2	2	Length - length of the record
Int	4	4	Material index
Char	8	12	Material name
Int	20	4	Flags 0 = Material is used 1-31 = Spare
Float	24	4*3	Ambient component of material (r, g, b) *
Float	36	4*3	Diffuse component of material (r, g, b) *
Float	48	4*3	Specular component of material (r, g, b) *
Float	60	4*3	Emissive component of material (r, g, b) *
Float	72	4	Shininess - (0.0-128.0)
Float	76	4	Alpha - (0.0-1.0) where 1.0 is opaque
Int	80	4	Reserved

* normalized values between 0.0 and 1.0, inclusive.

Texture Palette Record

There is one record for each texture pattern referenced in the database. These records must follow the header record and precede the first push.

A palette and pattern system can be used to reference the texture patterns. A texture palette is made up of 256 patterns. The pattern index for the first palette is 0 - 255, for the second palette 256 - 511, etc. Note: If less than 256 patterns exist on a palette, several pattern indices are unused. The x and y palette locations are used to store offset locations in the palette for display.

Texture Palette Record

Data type	Offset	Length	Description
Int	0	2	Texture Palette Opcode 64
Unsigned Int	2	2	Length - length of the record
Char	4	200	File name of texture pattern
Int	204	4	Texture pattern index
Int	208	4*2	Location in the texture palette (x, y)

Eyepoint and Trackplane Palette Record

OpenFlight files can contain up to ten eyepoint and trackplane positions. The first eyepoint and trackplane in the file is reserved as the “last” one set during the modeling session. The other

nine are user-defined. Both the eyepoints and trackplanes are combined in the Eyepoint and Trackplane palette record which is described in this section.

Eyepoint and Trackplane Palette Record

Data type	Offset	Length	Description
Int	0	2	Eyepoint and Trackplane Palette Opcode 83
Unsigned Int	2	2	Length - length of the record
Int	4	4	Reserved
The following fields are repeated for 10 eyepoints			
Eyepoint 0 - 272 bytes			
Double	8	8*3	Rotation center (x, y, z)
Float	32	4*3	Yaw, pitch, and roll angles
Float	44	16*4	4x4 rotation matrix, row major order
Float	108	4	Field of view
Float	112	4	Scale
Float	116	4	Near clipping plane
Float	120	4	Far clipping plane
Float	124	16*4	4x4 fly-through matrix, row major order
Float	188	3*4	Eyepoint position (x, y, z)
Float	200	4	Yaw of fly-through
Float	204	4	Pitch of fly-through
Float	208	3*4	Eyepoint direction vector (i, j, k)
Int	220	4	No fly through - 1 if no fly-through
Int	224	4	Ortho view - 1 if ortho drawing mode
Int	228	4	Valid eyepoint - 1 if this is a valid eyepoint
Int	232	4	Image offset x
Int	236	4	Image offset y
Int	240	4	Image zoom
Int	244	4*8	Reserved
Int	276	4	Reserved
Eyepoint 1	280	272	Eyepoint 1 - the fields listed above are repeated here.
Eyepoint 2	552	272	Eyepoint 2 - the fields listed above are repeated here.
Eyepoint 3	824	272	Eyepoint 3 - the fields listed above are repeated here.
Eyepoint 4	1096	272	Eyepoint 4 - the fields listed above are repeated here.
Eyepoint 5	1368	272	Eyepoint 5 - the fields listed above are repeated here.
Eyepoint 6	1640	272	Eyepoint 6 - the fields listed above are repeated here.
Eyepoint 7	1912	272	Eyepoint 7 - the fields listed above are repeated here.
Eyepoint 8	2184	272	Eyepoint 8 - the fields listed above are repeated here.
Eyepoint 9	2456	272	Eyepoint 9 - the fields listed above are repeated here.

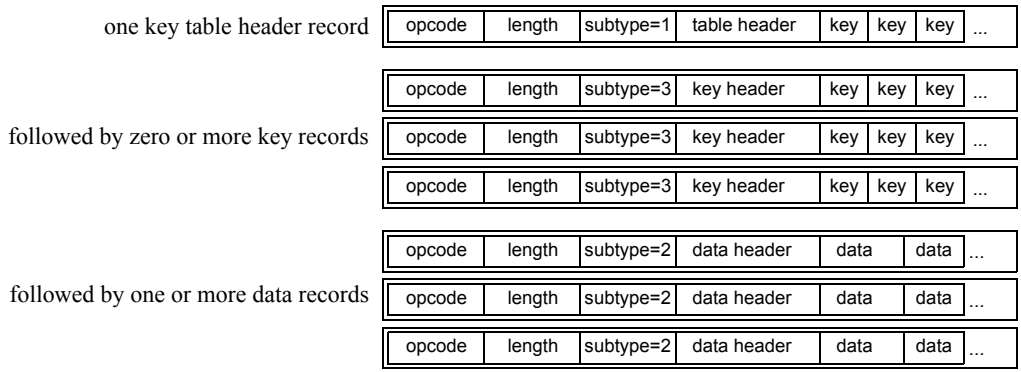
Eyepoint and Trackplane Palette Record (Continued)

Data type	Offset	Length	Description
The following fields are repeated for 10 trackplanes			
Trackplane 0 - 128 bytes			
Int	2728	4	Valid trackplane - 1 if this is a valid trackplane
Int	2732	4	Reserved
Double	2736	8*3	Trackplane origin coordinate (x, y, z)
Double	2760	8*3	Trackplane alignment coordinate (x, y, z)
Double	2784	8*3	Trackplane plane coordinate (x, y, z)
Boolean	2808	1	Grid visible - 1 if grid is visible
Int	2809	1	Grid type flag 0 = rectangular grid 1 = radial grid
Int	2810	1	Grid under flag 0 = draw grid over scene 1 = draw grid under scene 2 = draw grid depth buffered
Int	2811	1	Reserved
Float	2812	4	Grid angle for radial grid
Double	2816	8	Grid spacing in X. Radius if radial grid.
Double	2824	8	Grid spacing in Y
Int	2832	1	Radial grid spacing direction control
Int	2833	1	Rectangular grid spacing direction control
Boolean	2834	1	Snap cursor to grid - 1 if snap cursor to grid is on
Int	2835	1	Reserved
Int	2836	4	Reserved
Double	2840	8	Grid size (a power of 2)
Boolean	2848	4	Mask of visible grid quadrants
Int	2852	4	Reserved
Trackplane 1	2856	128	Trackplane 1 - the fields listed above are repeated here.
Trackplane 2	2984	128	Trackplane 2 - the fields listed above are repeated here.
Trackplane 3	3112	128	Trackplane 3 - the fields listed above are repeated here.
Trackplane 4	3240	128	Trackplane 4 - the fields listed above are repeated here.
Trackplane 5	3368	128	Trackplane 5 - the fields listed above are repeated here.
Trackplane 6	3496	128	Trackplane 6 - the fields listed above are repeated here.
Trackplane 7	3624	128	Trackplane 7 - the fields listed above are repeated here.
Trackplane 8	3752	128	Trackplane 8 - the fields listed above are repeated here.
Trackplane 9	3880	128	Trackplane 9 - the fields listed above are repeated here.

Key Table Records

Key table records store variable length data records and their identifiers. The linkage editor, sound palette, and CAT Data are stored as key table records. The first key table record contains the key table header and a set of keys. If all the keys cannot fit into the first record, additional key records are written. This is followed by one or more key table data records.

A key table consists of:.



For an example of the use of key table records, see "Sound Palette Record" on page 80.

Key Table Header Record

Data Type	Offset	Length	Description
Int	0	2	Opcode - opcode of record using key table for storage
Unsigned Int	2	2	Length - length of the record
Int	4	4	Subtype 1 = indicates this record is a key table header
Int	8	4	Max number - maximum number of entries
Int	12	4	Actual number - actual number of entries
Int	16	4	Total length of packed data
Int	20	4*3	Reserved
The following fields are repeated for each key in the key table. In the fields listed below, N ranges from 0 to Actual number - 1.			
Int	32+(N*12)	4	Key value$_N$ - key value N
Int	36+(N*12)	4	Reserved$_N$ - reserved space for key N, defined by record using key table for storage
Int	40+(N*12)	4	Data offset$_N$ - offset for data corresponding to key N. Note: This offset is measured relative to the Packed data field in the key table data record described below.

Key Table Data

Data Type	Offset	Length	Description
Int	0	2	Opcode - opcode of record using key table for storage
Unsigned Int	2	2	Length - length of the record
Int	4	4	Subtype 2 = indicates this record is a key table data record
Int	8	4	Data length
Char	12	Data length	Packed data Data is always 4 byte aligned, with unused bytes set to 0. Data length can be calculated as follows: Length - 12

Linkage Palette Record

Database linkages use key table records. Linkage data consists of two different constructs: nodes and arcs. Nodes usually contain data pertaining to database entities such as DOFs. In addition, the nodes may represent modeling driver functions and code nodes. The arcs contain information on how all the nodes are connected to each other. For most nodes, the value of the node is contained in the following Entity name subrecord. For example, this node value can be a node name, when the node represents a database entity, or a math formula as a string, in the case of a formula node. Names are stored as null-terminated ASCII strings.

See "Linkage Editor Parameter IDs" on page 105 for parameter ID values and descriptions.

Linkage Palette Header Record

Data Type	Offset	Length	Description
Int	0	2	Linkage Palette Opcode 90
Unsigned Int	2	2	Length - length of the record
Int	4	4	Subtype 1 = indicates this record is a key table header
Int	8	4	Max number - maximum number of entries. Each entry is either a node, arc, or entity name.
Int	12	4	Actual number - actual number of entries. Each entry is either a node, arc, or entity name.
Int	16	4	Total length of data
Int	20	4*3	Reserved
The following fields are repeated for each key in the key table. In the fields listed below, N ranges from 0 to Actual number - 1.			
Int	32+(N*12)	4	Key value$_N$ - key value N
Int	36+(N*12)	4	Data type$_N$ - data type for key N 0x12120001 = Node data 0x12120002 = Arc data 0x12120004 = Database entity name
Int	40+(N*12)	4	Data offset$_N$ - offset for data corresponding to key N. Note: This offset is measured relative to the Packed data field in the linkage palette data record described below.

Linkage Palette Data Record

Data Type	Offset	Length	Description
Int	0	2	Linkage Palette Opcode 90
Unsigned Int	2	2	Length - length of the record
Int	4	4	Subtype 2 = indicates this record is a key data record
Int	8	4	Data length
Char	12	Data length	Packed data. Each packed data item is either a node data subrecord, arc data subrecord or entity name subrecord. Node data subrecords can be either general nodes, formula nodes, or driver nodes. All these subrecords are described in the following sections. Data length can be calculated as follows: Length - 12

The offsets listed in the following subrecords are measured from the start of the subrecord, not from the start of the linkage palette data record that contains this packed data.

General Node Data Subrecord

Data Type	Offset	Length	Description
Int	0	4	Identifier
Int	4	4	Reserved
Int	8	4	Node type 0x12120003 = Header node 0x12120005 = Database entity node
Int	12	4*4	Reserved
Int	28	4	Sinks
Int	32	4	Sources
Int	36	4	Next node identifier
Int	40	4	Previous node identifier
Int	44	4	Arc source identifier
Int	48	4	Arc sink identifier

Formula Node Data Subrecord

Data Type	Offset	Length	Description
Int	0	4	Identifier
Int	4	4	Reserved
Int	8	4	Data type 0x12150000 = Formula node
Int	12	4	Reserved
Int	16	4	Reserved
Int	20	4	Reserved
Int	24	4	Reserved
Int	28	4	Sinks
Int	32	4	Sources
Int	36	4	Next node identifier
Int	40	4	Previous node identifier
Int	44	4	Arc source identifier
Int	48	4	Arc sink identifier
Int	52	4	Reserved

Formula Node Data Subrecord (Continued)

Data Type	Offset	Length	Description
Int	56	4	Reserved
Int	60	4	Reserved
Int	64	4	Reserved
Int	68	4	Reserved
Int	72	4	Reserved
Int	76	4	Reserved
Int	80	4	Reserved

Driver Node Data Subrecord

Data Type	Offset	Length	Description
Int	0	4	Identifier
Int	4	4	Reserved
Int	8	4	Node type 0x12140001 = Ramp driver node 0x12140004 = Variable driver node 0x12140005 = External file driver node
Int	12	4	Reserved
Int	16	4	Reserved
Int	20	4	Reserved
Int	24	4	Reserved
Int	28	4	Sinks
Int	32	4	Sources
Int	36	4	Next node identifier
Int	40	4	Previous node identifier
Int	44	4	Arc source identifier
Int	48	4	Arc sink identifier
Float	52	4	Current value
Float	56	4	Min amplitude
Float	60	4	Max amplitude
Float	64	4	Wave offset
Float	68	4	Min time
Float	72	4	Max time
Float	76	4	Time steps
Int	80	4	Reserved
Int	84	4	Reserved
Int	88	4	Reserved
Int	92	4	Reserved

Arc Data Subrecord

Data Type	Offset	Length	Description
Int	0	4	Identifier
Int	4	4	Reserved
Int	8	4	Data type 0x12120002 = Arc data subrecord
Int	12	4	Reserved
Int	16	4	Reserved
Int	20	4	Priority

Arc Data Subrecord (Continued)

Data Type	Offset	Length	Description
Int	24	4	Source parameter - parameter ID if source node is a node
Int	28	4	Sink parameter - parameter ID if sink node is a node number (0...7) for variables (x1...x8) Only valid if sink node is a formula
Int	32	4	Reserved
Int	36	4	Next source identifier
Int	40	4	Next sink identifier
Int	44	4	Node source identifier
Int	48	4	Node sink identifier

Entity Name Subrecord

Data Type	Offset	Length	Description
Char	0	Variable	ASCII string; 0 terminates

Sound Palette Record

The sound palette uses key table records to store the sound index and file name. The index is the key value, and the file name is the data record, formatted as a null-terminated ASCII string. The sound palette header record indicates the number of sounds associated with the database.

Sound Palette Header Record

Data	Offset	Length	Description
Int	0	2	Sound Palette Opcode 93
Unsigned Int	2	2	Length - length of the record
Int	4	4	Subtype 1 = indicates this record is a key table header
Int	8	4	Max number - the maximum number of sounds in palette
Int	12	4	Actual number - the actual number of sounds in palette
Int	16	4	Total length - total length of the sound file names contained in the sound palette key data record, which follows this record and is described below
Int	20	4*3	Reserved
The following fields are repeated for each sound represented in the palette. In the fields listed below, N ranges from 0 to Actual number - 1.			
Int	32+(N*12)	4	Sound $index_N$ - index of sound N in the palette
Int	36+(N+12)	4	$Reserved_N$ - reserved space for sound N in the palette
Int	40+(N*12)	4	File name $offset_N$ - starting offset for file name of sound N in the palette. This offset is measured relative to the Packed file names field in the sound palette data record described below.

Sound Palette Data Record

Data Type	Offset	Length	Description
Int	0	2	Sound Palette Opcode 93
Unsigned Int	2	2	Length - length of the record
Int	4	4	Subtype 2 = indicates this record is a key data record
Int	8	4	Total length of all packed sound file names
Char	12	Data length	Packed file names. Use File name offsets contained in sound palette key table header to locate individual names in this data blocks. Data length can be calculated as follows: Length - 12

Light Source Palette Record

These records represent entries in the light source palette. Entries are referenced by light source nodes using the palette index. Lights can be flagged as modeling lights, which illuminate a scene without being stored as part of the hierarchy. A modeling light is always positioned at the eye; its direction is stored in the palette. A light referenced by a node obtains its position and direction from the node. In this case, the palette yaw and pitch components are ignored.

Light Source Palette Record

Data Type	Offset	Length	Description
Int	0	2	Light Source Palette Opcode 102
Unsigned Int	2	2	Length - length of the record
Int	4	4	Light source index
Int	8	2*4	Reserved
Char	16	20	Light source name; 0 terminates
Int	36	4	Reserved
Float	40	4*4	Ambient component of light source (r, g, b, a) - alpha unused
Float	56	4*4	Diffuse component of light source (r, g, b, a) - alpha unused
Float	72	4*4	Specular component of light source (r, g, b, a) - alpha unused
Int	88	4	Light type 0 = Infinite 1 = Local 2 = Spot
Int	92	4*10	Reserved
Float	132	4	Spot exponential dropoff term
Float	136	4	Spot cutoff angle (in degrees)
Float	140	4	Yaw
Float	144	4	Pitch
Float	148	4	Constant attenuation coefficient
Float	152	4	Linear attenuation coefficient
Float	156	4	Quadratic attenuation coefficient
Int	160	4	Modeling light 0 = Light source is not active during modeling 1 = Light source is active during modeling
Int	164	4*19	Reserved

Light Point Appearance Palette Record

The light point appearance palette record defines the visual attributes of light points.

Light Point Appearance Palette Record

Data Type	Offset	Length	Description
Int	0	2	Light Point Appearance Palette Opcode 128
Unsigned Int	2	2	Length - length of the record
Int	4	4	Reserved
Char	8	256	Appearance name; 0 terminates
Int	264	4	Appearance index
Int	268	2	Surface material code
Int	270	2	Feature ID
Unsigned Int	272	4	Back color for bidirectional points
Int	276	4	Display mode 0 = RASTER 1 = CALLIGRAPHIC 2 = EITHER
Float	280	4	Intensity - scalar for front colors
Float	284	4	Back intensity - scalar for back color
Float	288	4	Minimum defocus - (0.0 - 1.0) for calligraphic points
Float	292	4	Maximum defocus - (0.0 - 1.0) for calligraphic points
Int	296	4	Fading mode 0 = Enable perspective fading calculations 1 = Disable calculations
Int	300	4	Fog Punch mode 0 = Enable fog punch through calculations 1 = Disable calculations
Int	304	4	Directional mode 0 = Enable directional calculations 1 = Disable calculations
Int	308	4	Range mode 0 = Use depth (Z) buffer calculation 1 = Use slant range calculation
Float	312	4	Min pixel size - minimum diameter of points in pixels
Float	316	4	Max pixel size - maximum diameter of points in pixels
Float	320	4	Actual size - actual diameter of points in database units
Float	324	4	Transparent falloff pixel size - diameter in pixels when points become transparent
Float	328	4	Transparent falloff exponent >= 0 - falloff multiplier exponent 1.0 - linear falloff
Float	332	4	Transparent falloff scalar > 0 - falloff multiplier scale factor
Float	336	4	Transparent falloff clamp - minimum permissible falloff multiplier result
Float	340	4	Fog scalar >= 0 - adjusts range of points for punch threw effect.
Float	344	4	Fog intensity

Light Point Appearance Palette Record (Continued)

Data Type	Offset	Length	Description
Float	348	4	Size difference threshold - point size transition hint to renderer
Int	352	4	Directionality 0 = OMNIDIRECTIONAL 1 = UNIDIRECTIONAL 2 = BIDIRECTIONAL
Float	356	4	Horizontal lobe angle - total angle in degrees
Float	360	4	Vertical lobe angle - total angle in degrees
Float	364	4	Lobe roll angle - rotation of lobe about local Y axis in degrees
Float	368	4	Directional falloff exponent >= 0 - falloff multiplier exponent 1.0 - linear falloff
Float	372	4	Directional ambient intensity - of points viewed off axis
Float	376	4	Significance - drop out priority for RASCAL lights (0.0 - 1.0)
Int	380	4	Flags (bits, from left to right) 0 = reserved 1 = No back color TRUE = don't use back color for bidirectional points FALSE = use back color for bidirectional points 2 = reserved 3 = Calligraphic proximity occulting (Debunching) 4 = Reflective, non-emissive point 5-7 = Randomize intensity 0 = never 1 = low 2 = medium 3 = high 8 = Perspective mode 9 = Flashing 10 = Rotating 11 = Rotate Counter Clockwise Direction of rotation about local Z axis 12 = reserved 13-14 = Quality 0 = Low 1 = Medium 2 = High 3 = Undefined 15 = Visible during day 16 = Visible during dusk 17 = Visible during night 18-31 = Spare
Float	384	4	Visibility range (> 0.0)
Float	388	4	Fade range ratio - percentage of total range at which light points start to fade (0.0 - 1.0)

Light Point Appearance Palette Record (Continued)

Data Type	Offset	Length	Description
Float	392	4	Fade in duration - time it takes (seconds) light point to fade in when turned on
Float	396	4	Fade out duration - time it takes (seconds) light point to fade out when turned off
Float	400	4	LOD range ratio - percentage of total range at which light points LODs are active (0.0 - 1.0)
Float	404	4	LOD scale - size of light point LOD polygon relative to light point diameter
Int	408	2	Texture pattern index, -1 if none
Int	410	2	Reserved

Light Point Animation Palette Record

The light point animation palette record defines the behavioral attributes of light points.

Light Point Animation Palette Record

Data Type	Offset	Length	Description
Int	0	2	Light Point Animation Opcode 129
Unsigned Int	2	2	Length - length of the record
Int	4	4	Reserved
char	8	256	Animation name; 0 terminates
Int	264	4	Animation index
Float	268	4	Animation period in seconds. Note: Rate = 1/Period
Float	272	4	Animation phase delay in seconds - from start of period
Float	276	4	Animation enabled period (time on) in seconds
Float	280	4*3	Axis of rotation for rotating animation (i, j, k)
Int	292	4	Flags (bits, from left to right) 0 = Flashing 1 = Rotating 2 = Rotate counter clockwise 3-31 = Spare
Int	296	4	Animation type 0 = Flashing sequence 1 = Rotating 2 = Strobe 3 = Morse code
Int	300	4	Morse code timing 0 = Standard timing 1 = Farnsworth timing
Int	304	4	Word rate (for Farnsworth timing)
Int	308	4	Character rate (for Farnsworth timing)
char	312	1024	Morse code string
Int	1336	4	Number of sequences (for Flashing sequence)
The following fields are repeated for each sequence represented in the light point animation palette entry. In the fields listed below, N ranges from 0 to Number of sequences - 1.			
Unsigned Int	1340+(N*12)	4	Sequence $State_N$ - state of sequence N 0 = On 1 = Off 2 = Color change
Float	1344+(N*12)	4	Sequence $Duration_N$ - duration of sequence N in seconds
Unsigned Int	1348+(N*12)	4	Sequence $Color_N$ - color for sequence N. Defined if Sequence state is On or Color change

Line Style Palette Record

Line style records define the outline displayed around faces in wireframe or wireframe-over-solid mode. The Pattern field defines a mask to control the display of segments of the line. For example, if all the bits of the mask are set, the line is drawn as a solid line. If every other bit is on, the line is displayed as a dashed line. The Line Width field controls the width of the line in

pixels. Line style 0 is the default. Faces are assigned line styles in the Line Style field of the face record. One of these records appears for each line style defined in the OpenFlight file.

Line Style Palette Record

Data Type	Offset	Length	Description
Int	0	2	Line Style Palette Record Opcode 97
Int	2	2	Length of record
Int	4	2	Line style index
Int	6	2	Pattern mask
Int	8	4	Line width

Texture Mapping Palette Record

The texture mapping palette record defines methods and parameters used to map textures onto geometry. One record is created for each texture mapping reference in the palette. These records must follow the header record and precede the first push.

Texture Mapping Palette Record

Data Type	Offset	Length	Description
Int	0	2	Texture Mapping Palette Opcode 112
Int	2	2	Length - length of the record
Int	4	4	Reserved
Int	8	4	Texture mapping index
Char	12	20	Texture mapping name
Int	32	4	Texture mapping type 0 = None 1 = Put 2 = 4 Point Put 3 = Reserved 4 = Spherical Project 5 = Radial Project 6 = Reserved
Int	36	4	Warped flag; if TRUE, 8 point warp applied
Double	40	8*16	4x4 Transformation matrix (for types 1, 2, 4 & 5), row major
Depending on the Texture mapping type field, different parameter blocks follow. These blocks are described in the following sections.			

The parameters for put texture mapping will appear immediately following the texture mapping palette record if Texture mapping type is 1.

Parameters for Put Texture Mapping (Type 1)

Data Type	Offset	Length	Description
Int	168	4	State of Put Texture tool 0 = Start state - no points entered 1 = One point entered 2 = Two points entered 3 = Three points entered
Int	172	4	Active geometry point 1 = Origin point 2 = Alignment point 3 = Shear point
Double	176	8*3	Lower-left corner of bounding box for geometry using this mapping when mapping was created (x, y, z)
Double	200	8*3	Upper-right corner of bounding box for geometry using this mapping when mapping was created (x, y, z)
Int	224	4*3	Use real world size flags for each of the put points
Int	236	4	Reserved
Double	240	8*3	Texture origin point (x, y, z)
Double	264	8*3	Texture alignment point (x, y, z)
Double	288	8*3	Texture shear point (x, y, z)
Double	312	8*3	Geometry origin point (x, y, z)
Double	336	8*3	Geometry alignment point (x, y, z)
Double	360	8*3	Geometry shear point (x, y, z)
Int	384	4	Active texture point 1 = Origin point 2 = Alignment point 3 = Shear point
Int	388	4	UV display type 1 = XY 2 = UV
Float	392	4	U Repetition
Float	396	4	V Repetition

The parameters for 4 point put texture mapping will appear immediately following the texture mapping palette record if Texture mapping type is 2

Parameters for 4 Point Put Texture Mapping (Type 2)

Data Type	Offset	Length	Description
Int	168	4	State of 4 Point Put Texture tool 0 = Start state - no points entered 1 = One point entered 2 = Two points entered 3 = Three points entered 4 = Four points entered
Int	172	4	Active geometry point 1 = Origin point 2 = Alignment point 3 = Shear point 4 = Perspective point
Double	176	8*3	Lower-left corner of bounding box for geometry using this mapping when mapping was created (x, y, z)
Double	200	8*3	Upper-right corner of bounding box for geometry using this mapping when mapping was created (x, y, z)
Int	224	4*3	Use real world size flags for each of the put points
Int	236	4	Reserved
Double	240	8*3	Texture origin point (x, y, z)
Double	264	8*3	Texture alignment point (x, y, z)
Double	288	8*3	Texture shear point (x, y, z)
Double	312	8*3	Texture perspective point (x, y, z)
Double	336	8*3	Geometry origin point (x, y, z)
Double	360	8*3	Geometry alignment point (x, y, z)
Double	384	8*3	Geometry shear point (x, y, z)
Double	408	8*3	Geometry perspective point (x, y, z)
Int	432	4	Active texture point 1 = Origin point 2 = Alignment point 3 = Shear point 4 = Perspective point
Int	436	4	UV display type 1 = XY 2 = UV
Float	440	4	Depth scale factor
Int	444	4	Reserved
Double	448	8*16	4x4 Transformation matrix for the 4 point projection plane, row major order
Float	576	4	U Repetition
Float	580	4	V Repetition

The parameters for spherical project mapping will appear immediately following the texture mapping palette record if Texture mapping type is 4.

Parameters for Spherical Project Mapping (Type 4)

Data Type	Offset	Length	Description
Float	168	4	Scale
Int	172	4	Reserved
Double	176	8*3	Center of the projection sphere (x, y, z)
Float	200	4	Scale / (maximum dimension of the mapped geometry bounding box
Float	204	4	Maximum dimension of the mapped geometry bounding box when mapping was created

The parameters for radial project mapping will appear immediately following the texture mapping palette record if Texture mapping type is 5.

Parameters for Radial Project Mapping (Type 5)

Data	Offset	Length	Description
Int	168	4	Active geometry point 1 = End point 1 of cylinder center line 2 = End point 2 of cylinder center line
Int	172	4	Reserved
Float	176	4	Radial scale
Float	180	4	Scale along length of cylinder
Double	184	8*16	4x4 Trackplane to XY plane transformation matrix, row major order
Double	312	8*3	End point 1 of cylinder center line (x, y, z)
Double	336	8*3	End point 2 of cylinder center line (x, y, z)

The parameters for warped mapping will be included if the Warped flag is set in the texture mapping palette record. This parameter block will appear immediately following the texture mapping parameter block to which the warp applies. In the offset fields below, X is equal to the size of the texture mapping palette record plus the size of the texture mapping parameter block to which the warp applies.

Parameters for Warped Mapping (Warped Flag Set)

Data Type	Offset	Length	Description
Int	X+0	4	Active geometry point 0 = First warp FROM point 1 = Second warp FROM point 2 = Third warp FROM point 3 = Fourth warp FROM point 4 = Fifth warp FROM point 5 = Sixth warp FROM point 6 = Seventh warp FROM point 7 = Eighth warp FROM point 8 = First warp TO point 9 = Second warp TO point 10 = Third warp TO point 11 = Fourth warp TO point 12 = Fifth warp TO point 13 = Sixth warp TO point 14 = Seventh warp TO point 15 = Eighth warp TO point
Int	X+4	4	Warp tool state 0 = Start state - no points entered 1 = One FROM point entered 2 = Two FROM point entered 3 = Three FROM point entered 4 = Four FROM point entered 5 = Five FROM point entered 6 = Six FROM point entered 7 = Seven FROM point entered 8 = All FROM point entered
Int	X+8	8	Reserved
Double	X+16	8*8*2	FROM points transformed to XY plane by above matrix. 8 FROM points are ordered 1, 2, ... 8. Each point is (x, y)
Double	X+144	8*8*2	TO points transformed to XY plane by above matrix. 8 TO points are ordered 1, 2, ... 8. Each point is (x, y)

Shader Palette Record

The shader palette contains descriptions of shaders used while drawing geometry. It is composed of an arbitrary number of shader palette records. The shader palette records must follow the header record and precede the first push.

Shader Palette Record

Data Type	Offset	Length	Description
Int	0	2	Shader Opcode 133
Unsigned Int	2	2	Length - length of the record
Int	4	4	Shader index
Int	8	4	Shader type 0 = Cg 1 = CgFX 2 = OpenGL Shading Language
Char	12	1024	Shader name
Depending on the Shader type field, different parameter blocks follow. These blocks are described in the following sections.			

The parameters for Cg shader will appear immediately following the shader palette record if Shader type is 0.

Parameters for Cg Shader

Data Type	Offset	Length	Description
Char	1036	1024	Vertex program file name
Char	2060	1024	Fragment program file name
Int	3084	4	Vertex program profile
Int	3088	4	Fragment program profile
Char	3092	256	Vertex program entry point
Char	3348	256	Fragment program entry point

The parameters for OpenGL Shading Language shader will appear immediately following the shader palette record if Shader type is 2.

Parameters for OpenGL Shading Language Shader

Data Type	Offset	Length	Description
Int	1036	4	Number of vertex program files
Int	1040	4	Number of fragment programs files
The following field is repeated for each vertex program file in the shader record. In the field listed below, N ranges from 0 to Number of vertex program files.			
Char	Varies	1024	Vertex program file$_N$
The following field is repeated for each fragment program file in the shader record. In the field listed below, N ranges from 0 to Number of fragment program files.			
Char	Varies	1024	Fragment program file$_N$

3 Texture Files

Texture Pattern Files

OpenFlight does not have its own texture pattern format, but rather uses existing texture formats and references patterns by file name. See “Texture Palette Record” on page 73.

File formats currently supported include:

- AT&T® image 8 format (8-bit color lookup)
- AT&T image 8 template format
- SGI intensity modulation
- SGI intensity modulation with alpha
- SGI RGB
- SGI RGB with alpha
- GIF
- JPEG/JFIF
- TIFF
- IFF/ILBM
- BMP/DIB
- PCX
- PNG
- PPM
- Sun™ Raster
- Direct Draw Surface (DDS)
- Targa™
- Alias™ Pix
- SGI clip texture

The format of the file is determined by the file name extension, the magic numbers within the file, or the texture attribute file, as described in the following section.

Texture Attribute Files

A corresponding attribute file is created for each texture pattern, with the name of the attribute file the same as the texture file, followed by the extension “.attr”. These attribute files are used by the modeling software, and may not be necessary for the application using the database.

The attribute file contains information specifying how to parse the texture pattern file, set the texture hardware and software environment for the texture pattern, or position the image in a database.

The format of the texture attribute file is described in this section.

Texture Attribute File Format

Data Type	Offset	Length	Description
Int	0	4	Number of texels in u direction
Int	4	4	Number of texels in v direction
Int	8	4	Real world size u direction (obsolete - not used)
Int	12	4	Real world size v direction (obsolete - not used)
Int	16	4	x component of up vector
Int	20	4	y component of up vector
Int	24	4	File format type 0 = AT&T image 8 pattern 1 = AT&T image 8 template 2 = SGI intensity modulation 3 = SGI intensity w/alpha 4 = SGI RGB 5 = SGI RGB w/alpha
Int	28	4	Minification filter type 0 = Point 1 = Bilinear 2 = Mipmap (obsolete) 3 = Mipmap Point 4 = Mipmap linear 5 = Mipmap bilinear 6 = Mipmap trilinear 7 = None 8 = Bicubic 9 = Bilinear greater/equal 10 = Bilinear less/equal 11 = Bicubic greater/equal 12 = Bicubic less/equal
Int	32	4	Magnification filter type 0 = Point 1 = Bilinear 2 = None 3 = Bicubic 4 = Sharpen 5 = Add Detail 6 = Modulate Detail 7 = Bilinear greater/equal 8 = Bilinear less/equal 9 = Bicubic greater/equal 10 = Bicubic less/equal

Texture Attribute File Format (Continued)

Data Type	Offset	Length	Description
Int	36	4	Wrap method u,v - only used when either Wrap method u or Wrap method v is set to None 0 = Repeat 1 = Clamp 4 = Mirrored Repeat
Int	40	4	Wrap method u 0 = Repeat 1 = Clamp 3 = None - use Wrap method u,v 4 = Mirrored Repeat
Int	44	4	Wrap method v 0 = Repeat 1 = Clamp 3 = None - use Wrap method u,v 4 = Mirrored Repeat
Int	48	4	Modified flag - for internal use only
Int	52	4	x pivot point for rotating textures
Int	56	4	y pivot point for rotating textures
Int	60	4	Environment type 0 = Modulate 1 = Blend 2 = Decal 3 = Replace 4 = Add
Int	64	4	TRUE if intensity pattern to be loaded in alpha with white in color
Int	68	4*8	Reserved
Int	100	4	Reserved
Double	104	8	Real world size u direction
Double	112	8	Real world size v direction
Int	120	4	Code for origin of imported texture
Int	124	4	Kernel version number
Int	128	4	Internal format type 0 = Default 1 = TX_I_12A_4 2 = TX_IA_8 3 = TX_RGB_5 4 = TX_RGBA_4 5 = TX_IA_12 6 = TX_RGBA_8 7 = TX_RGBA_12 8 = TX_I_16 (shadow mode only) 9 = TX_RGB_12

Texture Attribute File Format (Continued)

Data Type	Offset	Length	Description
Int	132	4	External format type 0 = Default 1 = TX_PACK_8 2 = TX_PACK_16
Int	136	4	TRUE if using following 8 floats for MIPMAP kernel
Float	140	4*8	8 floats for kernel of separable symmetric filter
Int	172	4	if TRUE send:
Float	176	4	LOD0 for TX_CONTROL_POINT
Float	180	4	SCALE0 for TX_CONTROL_POINT
Float	184	4	LOD1 for TX_CONTROL_POINT
Float	188	4	SCALE1 for TX_CONTROL_POINT
Float	192	4	LOD2 for TX_CONTROL_POINT
Float	196	4	SCALE2 for TX_CONTROL_POINT
Float	200	4	LOD3 for TX_CONTROL_POINT
Float	204	4	SCALE3 for TX_CONTROL_POINT
Float	208	4	LOD4 for TX_CONTROL_POINT
Float	212	4	SCALE4 for TX_CONTROL_POINT
Float	216	4	LOD5 for TX_CONTROL_POINT
Float	220	4	SCALE5 for TX_CONTROL_POINT
Float	224	4	LOD6 for TX_CONTROL_POINT
Float	228	4	SCALE6 for TX_CONTROL_POINT
Float	232	4	LOD7 for TX_CONTROL_POINT
Float	236	4	SCALE7 for TX_CONTROL_POINT
Float	240	4	Control Clamp
Int	244	4	Magnification filter type for alpha 0 = Point 1 = Bilinear 2 = None 3 = Bicubic 4 = Sharpen 5 = Add Detail 6 = Modulate Detail 7 = Bilinear greater/equal 8 = Bilinear less/equal 9 = Bicubic greater/equal 10 = Bicubic less/equal

Texture Attribute File Format (Continued)

Data Type	Offset	Length	Description
Int	248	4	Magnification filter type for color 0 = Point 1 = Bilinear 2 = None 3 = Bicubic 4 = Sharpen 5 = Add Detail 6 = Modulate Detail 7 = Bilinear greater/equal 8 = Bilinear less/equal 9 = Bicubic greater/equal 10 = Bicubic less/equal
Float	252	4	Reserved
Float	256	4*8	Reserved
Double	288	8	Lambert conic projection central meridian
Double	296	8	Lambert conic projection upper latitude
Double	304	8	Lambert conic projection lower latitude
Double	312	8	Reserved
Float	320	4*5	Reserved
Int	340	4	TRUE if using next 5 integers for TX_DETAIL
Int	344	4	J argument for TX_DETAIL
Int	348	4	K argument for TX_DETAIL
Int	352	4	M argument for TX_DETAIL
Int	356	4	N argument for TX_DETAIL
Int	360	4	Scramble argument for TX_DETAIL
Int	364	4	TRUE if using next 4 floats for TX_TILE
Float	368	4	Lower-left u value for TX_TILE
Float	372	4	Lower-left v value for TX_TILE
Float	376	4	Upper-right u value for TX_TILE
Float	380	4	Upper-right v value for TX_TILE
Int	384	4	Projection 0 = Flat earth 3 = Lambert conic 4 = UTM 7 = Undefined projection
Int	388	4	Earth model 0 = WGS84 1 = WGS72 2 = Bessel 3 = Clark 1866 4 = NAD27
Int	392	4	Reserved
Int	396	4	UTM zone
Int	400	4	Image origin 0 = Lower left 1 = Upper left

Texture Attribute File Format (Continued)

Data Type	Offset	Length	Description
Int	404	4	Geospecific points units 0 = Degrees 1 = Meters 2 = Pixels
Int	408	4	Reserved
Int	412	4	Reserved
Int	416	4	Hemisphere for geospecific points units 0 = Southern 1 = Northern
Int	420	4	Reserved
Int	424	4	Reserved
Int	428	4	Reserved
Int	432	4	TRUE if texture is used for cubemap
Int	436	4*147	Reserved
Char	1024	512	Comments; 0 terminates
Int	1536	4*13*	Reserved
Int	1588	4	Reserved
Int	1592	4	Attribute file version number
Int	1596	4	Number of geospecific control points

If the value of the Number of geospecific control points field is greater than 0, the following fields are also contained in the attribute file:

Geospecific Control Point subrecord

Data Type	Length	Description
Int	4	Reserved
The following fields are repeated for each geospecific control point in the texture attribute file. **Note:** In the fields below, N ranges from 0 to Number of geospecific control points - 1 The earth coordinates depend on the projection, earth model, and geospecific points units.		
Double	8	Texel u_N - texel u of control point
Double	8	Texel v_N - texel v of control point
Double	8	Earth coordinate x_N - earth x coordinate of control point.
Double	8	Earth coordinate y_N - earth y coordinate of control point.

After all the geospecific control points are listed, the following subtexture information appears:

Data Type	Length	Description
Int	4	Number of subtextures

If the value of the Number of subtextures field is greater than 0, the following fields are repeated for each subtexture in the texture attribute file.

In the fields below, N ranges from 0 to Number of subtextures - 1.

The Left, Bottom, Right and Top fields are all measured in texels.

Subtexture subrecord

Data Type	Length	Description
Char	32	$Name_N$ - name of subtexture N; 0 terminates
Int	4	$Left_N$ - Coordinate of left edge of subtexture N
Int	4	$Bottom_N$ - Coordinate of bottom edge of subtexture N
Int	4	$Right_N$ - Coordinate of right edge of subtexture N
Int	4	Top_N - Coordinate of top edge of subtexture N

4 Road Path Files

A road path file contains the attributes of a road path node in ASCII format. The name of the file is user defined. Each attribute is denoted by a keyword, a literal colon, a space, and the value(s). Boolean values are denoted by the string literals “TRUE” and “FALSE”. For the “POINT” keyword its values consist of an XYZ coordinate and an orientation vector, separated by spaces. The orientation vector is specified as either a normal up-vector, or in degrees of heading, pitch, and roll. The “STORE_HPR” keyword specifies which method is used. For path nodes that define the road’s centerline path, construction information for the correlated road section is also stored with additional keywords. Here’s an example:

```
ROAD_ID: 2.0
ROAD_TYPE: Curve
ARC_RADIUS: 175.000000
SPIRAL_LEN1: 80.000000
SPIRAL_LEN2: 80.000000
SUPERELEVATION: 0.080000
CONTROL_POINT: 0.000000 300.000000 0.000000
VCURVE_LEN: 400.000000
VCURVE_MIN: 20.000000
SLOPE1: 0.000000
SLOPE2: 0.000000
WIDTH: 12.000000
CENTER2LEFT: 6.000000
NUM_LANES: 2
LANE_OFFSET: 1.825000
LANE_OFFSET: -1.825000
PROFILE_NAME: /usr/people/db/road/crown.flt
PROFILE_POINT: 12.000000 0.000000
PROFILE_POINT: 9.823453 0.300000
PROFILE_POINT: 6.000000 0.500000
PROFILE_POINT: 3.200000 0.300000
PROFILE_POINT: 0.000000 0.000000
SPEED: 70.000000
NO_PASSING: TRUE
STORE_HPR: TRUE
NUM_POINTS: 12
POINT: 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
POINT: 0.000000 83.548590 0.000000 0.000000 0.000000 0.000000
POINT: 2.906056 145.953096 0.000000 8.000000 0.000000 3.574879
POINT: 6.072530 163.131640 0.000000 13.096178 0.000000 4.573921
POINT: 13.249899 186.467582 0.000000 21.096178 0.000000 4.573921
POINT: 36.936741 229.031118 0.000000 37.096180 0.000000 4.573921
POINT: 71.438096 263.416837 0.000000 53.096180 0.000000 4.573921
POINT: 114.080915 286.960649 0.000000 69.096176 0.000000 4.573921
POINT: 136.868360 293.927470 0.000000 76.903824 0.000000 4.573921
POINT: 166.586342 298.521248 0.000000 84.903824 0.000000 2.853243
POINT: 216.451410 300.000000 0.000000 90.000000 0.000000 0.000000
POINT: 300.000000 300.000000 0.000000 90.000000 0.000000 0.000000
```

This is the first section (a curve) in Road #2 of the database. Section numbers start at zero. Road ID also appears on database node.

Horizontal and vertical curve control values

Road width and centerline placement

Lane information for the road section

Lofting information, including the database file that contains the lofting profile, and (X,Z) points for the lofted section. Lofting information is only printed for the first reference to the profile database.

Passing lane flag (path attribute page)

Heading, Pitch and Roll data will be stored and reported

Data for each point, in the following order:

X, Y, Z, H, P, R

5 Road Zone Files

Zone files are gridded posts files containing elevation and attribute data for a road.The zone data is followed immediately by a series of:

(Number of data points in x) * (Number of data points in y) elevation data points.

The elevation data points are followed immediately by a series of:

(Number of data points in x) * (Number of data points in y) surface types corresponding to each of the elevation data points above.

The elevation data points as well as the surface types begin at the lower-left corner. Values are ordered from bottom to top, then in columns from left to right.

Road Zone File Format

Data Type	Offset	Length	Description
Int	0	4	Version - road tools format version
Int	4	4	Reserved
Double	8	8*3	Lower left corner (x, y, z)
Double	32	8*3	Upper right corner (x, y, z)
Double	56	8	Grid interval - spacing between data points
Int	64	4	Number of data points in x
Int	68	4	Number of data points in y
Float	72	4	Low z elevation data point
Float	76	4	High z elevation data point
Char	80	440	Reserved

The following field is repeated for each data point in the road zone file.
In this field, N ranges from 0 to Number of data points - 1, where
Number of data points = Number of data points in x * Number of data points in y.

Elevation Data Point subrecord

Data Type	Offset	Length	Description
Float	520+(N*4)	4	Z_N - elevation value for data point N

The following field is repeated for each data point in the road zone file.

In this field, N ranges from 0 to Number of data points - 1, where
Number of data points = Number of data points in x * Number of data points in y and M is equal to Number of data points.

Surface Type subrecord

Data Type	Offset	Length	Description
Char	520+(M*4)+N	1	Surface type$_N$ - user defined surface type for data point N

6 Linkage Editor Parameter IDs

Vertex Node Parameters

ID	Description
258	X coordinate
259	Y coordinate
260	Z coordinate
261	Texture U coordinate
262	Texture V coordinate
265	Color
266	Hard edge flag
267	Freeze normal flag
269	Normal I component
270	Normal J component
271	Normal K component

Face Node Parameters

ID	Description
514	Color
515	Polygon drawing
516	Lighting mode
518	Relative priority
519	Draw both sides flag
520	Texture index
521	Template
522	Infrared
523	Terrain flag
525	Material index
526	Feature ID
527	Surface material code
529	Draw textured faces white
530	IR material
534	Detail texture index
535	Transparency
536	Alternate color
537	LOD control
538	Line style index
539	Light point directional mode
540	Texture mapping

Object Node Parameters

ID	Description
770	Relative priority
771	Inhibit during day flag
772	Inhibit during dusk flag
773	Inhibit during night flag
774	No illumination flag
775	Flat shading flag
776	Shadow flag
777	Transparency
778	Special #1
779	Special #2
782	Significance

LOD Node Parameters

ID	Description
1026	Switch-in distance
1027	Switch-out distance
1028	Special #1
1029	Special #2
1030	Use previous range flag
1031	Center X coordinate
1032	Center Y coordinate
1033	Freeze center flag
1034	Center Z coordinate
1036	Additive LOD's below flag
1037	Transition distance

Group Node Parameters

ID	Description
1282	Relative priority
1284	Animation type
1286	Bounding volume type
1287	Special #1
1288	Special #2
1289	Replication count
1290	Significance
1291	Layer

DOF Node Parameters

ID	Description
1538	Current Z
1539	Minimum Z
1540	Maximum Z
1542	Current Y
1543	Minimum Y
1544	Maximum Y
1546	Current X
1547	Minimum X
1548	Maximum X
1550	Current pitch
1551	Minimum pitch
1552	Maximum pitch
1554	Current roll
1555	Minimum roll
1556	Maximum roll
1558	Current yaw
1559	Minimum yaw
1560	Maximum yaw
1562	Current Z scale
1563	Minimum Z scale
1564	Maximum Z scale
1566	Current Y scale
1567	Minimum Y scale
1568	Maximum Y scale
1570	Current X scale
1571	Minimum X scale
1572	Maximum X scale
1574	X constrained motion flag
1575	Y constrained motion flag
1576	Z constrained motion flag
1577	Pitch constrained motion flag
1578	Roll constrained motion flag
1579	Yaw constrained motion flag
1580	X scale constrained motion flag
1581	Y scale constrained motion flag
1582	Z scale constrained motion flag
1583	Repeating texture flag
1584	Membrane mode flag

Sound Node Parameters

ID	Description
1796	Amplitude
1797	Pitch bend
1798	Priority
1799	Falloff
1800	Width
1801	Doppler
1802	Absorption
1803	Delay
1804	Directivity
1805	X coordinate
1806	Y coordinate
1807	Z coordinate
1808	Direction vector I component
1809	Direction vector J component
1810	Direction vector K component
1812	Active flag

Switch Node Parameters

ID	Description
2050	Current mask index

Text Node Parameters

ID	Description
2307	Text type
2308	Draw type
2310	Color
2311	Alternate color
2312	Material index
2315	Integer value minimum
2316	Integer value maximum
2317	Float value minimum
2318	Float value maximum
2325	Current integer value
2326	Current float value
2327	Decimal places for float value
2329	Line style index
2330	Justification type
2331	Vertical flag
2332	Bold flag
2333	Italic flag
2334	Underline flag

Light Source Node Parameters

ID	Description
2819	Enabled flag
2820	Global flag
2821	X coordinate
2822	Y coordinate
2823	Z coordinate
2824	Yaw
2825	Pitch

Clip Node Parameters

ID	Description
3074	Plane 0 enable
3075	Plane 1 enable
3076	Plane 2 enable
3077	Plane 3 enable
3078	Plane 4 enable

7 OpenFlight Opcodes

Valid Opcodes

Opcode	Record Type	For more information, see..
1	Header	"Header Record" on page 19
2	Group	"Group Record" on page 22
4	Object	"Object Record" on page 25
5	Face	"Face Record" on page 26
10	Push Level	"Push Level Record" on page 17
11	Pop Level	"Pop Level Record" on page 17
14	Degree of Freedom	"Degree of Freedom Record" on page 37
19	Push Subface	"Push Subface Record" on page 17
20	Pop Subface	"Pop Subface Record" on page 17
21	Push Extension	"Push Extension Record" on page 17
22	Pop Extension	"Pop Extension Record" on page 17
23	Continuation	"Continuation Record" on page 65
31	Comment	"Comment Record" on page 53
32	Color Palette	"Color Palette Record" on page 70
33	Long ID	"Long ID Record" on page 53
49	Matrix	"Matrix Record" on page 59
50	Vector	"Vector Record" on page 61
52	Multitexture	"Multitexture Record" on page 54
53	UV List	"UV List Record" on page 55
55	Binary Separating Plane	"Binary Separating Plane Record" on page 40
60	Replicate	"Replicate Record" on page 57
61	Instance Reference	"Instance Reference Record" on page 19
62	Instance Definition	"Instance Definition Record" on page 19
63	External Reference	"External Reference Record" on page 41
64	Texture Palette	"Texture Palette Record" on page 73
67	Vertex Palette	"Vertex Palette Record" on page 67
68	Vertex with Color	"Vertex with Color Record" on page 68
69	Vertex with Color and Normal	"Vertex with Color and Normal Record" on page 68
70	Vertex with Color, Normal and UV	"Vertex with Color, Normal and UV Record" on page 69
71	Vertex with Color and UV	"Vertex with Color and UV Record" on page 69
72	Vertex List	"Vertex List Record" on page 39
73	Level of Detail	"Level of Detail Record" on page 41
74	Bounding Box	"Bounding Box Record" on page 62
76	Rotate About Edge	"Rotate About Edge Record" on page 59
78	Translate	"Translate Record" on page 59
79	Scale	"Scale Record" on page 59
80	Rotate About Point	"Rotate About Point Record" on page 60

Opcode	Record Type	For more information, see..
81	Rotate and/or Scale to Point	"Rotate and/or Scale to Point Record" on page 60
82	Put	"Put Record" on page 60
83	Eyepoint and Trackplane Palette	"Eyepoint and Trackplane Palette Record" on page 73
84	Mesh	"Mesh Record" on page 29
85	Local Vertex Pool	"Local Vertex Pool Record" on page 30
86	Mesh Primitive	"Mesh Primitive Record" on page 32
87	Road Segment	"Road Segment Record" on page 44
88	Road Zone	"Road Zone Record" on page 58
89	Morph Vertex List	"Morph Vertex List Record" on page 39
90	Linkage Palette	"Linkage Palette Record" on page 77
91	Sound	"Sound Record" on page 43
92	Road Path	"Road Path Record" on page 46
93	Sound Palette	"Sound Palette Record" on page 80
94	General Matrix	"General Matrix Record" on page 60
95	Text	"Text Record" on page 47
96	Switch	"Switch Record" on page 49
97	Line Style Palette	"Line Style Palette Record" on page 85
98	Clip Region	"Clip Region Record" on page 47
100	Extension	"Extension Record" on page 51
101	Light Source	"Light Source Record" on page 44
102	Light Source Palette	"Light Source Palette Record" on page 81
103	Reserved	
104	Reserved	
105	Bounding Sphere	"Bounding Sphere Record" on page 62
106	Bounding Cylinder	"Bounding Cylinder Record" on page 62
107	Bounding Convex Hull	"Bounding Convex Hull Record" on page 62
108	Bounding Volume Center	"Bounding Volume Center Record" on page 63
109	Bounding Volume Orientation	"Bounding Volume Orientation Record" on page 63
110	Reserved	
111	Light Point	"Light Point Record" on page 34
112	Texture Mapping Palette	"Texture Mapping Palette Record" on page 86
113	Material Palette	"Material Palette Record" on page 71
114	Name Table	"Name Table Record" on page 71
115	Continuously Adaptive Terrain (CAT)	"CAT Record" on page 50
116	CAT Data	"CAT Data Record" on page 63
117	Reserved	
118	Reserved	
119	Bounding Histogram	"Bounding Histogram Record" on page 62
120	Reserved	
121	Reserved	
122	Push Attribute	"Push Attribute Record" on page 18
123	Pop Attribute	"Pop Attribute Record" on page 18
124	Reserved	

Opcode	Record Type	For more information, see..
125	Reserved	
126	Curve	"Curve Record" on page 51
127	Road Construction	"Road Construction Record" on page 45
128	Light Point Appearance Palette	"Light Point Appearance Palette Record" on page 82
129	Light Point Animation Palette	"Light Point Animation Palette Record" on page 85
130	Indexed Light Point	"Indexed Light Point Record" on page 34
131	Light Point System	"Light Point System Record" on page 37
132	Indexed String	"Indexed String Record" on page 53
133	Shader Palette	"Shader Palette Record" on page 91

Obsolete Opcodes

Opcode	Record Type
3	Level of Detail (single precision floating point, replaced by Opcode 73)
6	Vertex with ID (scaled integer coordinates, replaced by Opcodes 68-71)
7	Short Vertex w/o ID (scaled integer coordinates, replaced by Opcodes 68-71)
8	Vertex with Color (scaled integer coordinates, replaced by Opcodes 68-71)
9	Vertex with Color and Normal (scaled integer coordinates, replaced by Opcodes 68-71)
12	Translate (replaced by Opcode 78)
13	Degree of Freedom (scaled integer coordinates, replaced by Opcode 14)
16	Instance Reference (replaced by Opcode 61)
17	Instance Definition (replaced by Opcode 62)
40	Translate (replaced by Opcode 78)
41	Rotate about Point (replaced by Opcode 80)
42	Rotate about Edge (replaced by Opcode 76)
43	Scale (replaced by Opcode 79)
44	Translate (replaced by Opcode 78)
45	Scale nonuniform (replaced by Opcode 79)
46	Rotate about Point (replaced by Opcode 80)
47	Rotate and/or Scale to Point (replaced by Opcode 81)
48	Put (replaced by Opcode 82)
51	Bounding Box (replaced by Opcode 74)
65	Eyepoint Palette (only eyepoints, replaced by Opcode 83)
66	Material Palette (fixed size 64 entries, replaced by Opcode 80)
77	Scale (replaced by Opcode 79)

A Summary of Changes Version 15.7

Overview

This section describes the changes in the OpenFlight Scene Description between versions 15.6 and 15.7. OpenFlight version 15.7 coincides with MultiGen Creator versions 2.4 through 2.5.1 and the OpenFlight API versions 2.4 through 2.5.1. The changes made for this version are:

Format Changes

Continuation Record

All OpenFlight records begin with a 4 byte sequence. The first two bytes identify the record (opcode) and the second two bytes specify the length of the record. Given this regular record structure, the length of all OpenFlight records is limited to the largest value that can be encoded with 2 bytes or 16 bits (65535). In most cases, this maximum size is sufficient but there are cases where it is not. For fixed size records, this is not a problem. For variable size records, this limitation is being addressed with this version.

A new record, called the continuation record is introduced in this version to accommodate variable size records in the OpenFlight Scene Description. The continuation record is used to "continue" a record in the OpenFlight Scene Description file stream. It would appear in the stream immediately following the record that it "continues" (the record that is being continued will be referred to as the "original" record). The data contained in the continuation record is defined by the original record and is assumed to be directly appended onto the content of the original record.

Note: Multiple continuation records may follow a record, in which case all continuation records would be appended (in sequence) to the original record.

Continuation Record
New record for OpenFlight 15.7

Data type	Offset	Length	Description
Unsigned Int	0	2	Continuation Record Opcode 23
Unsigned Int	2	2	Length - length of the record
Varies	4	Length-4	Depends on the original record. The contents of this field are to be appended directly to the end of the original record contents (before the original record contents are parsed)

For a complete description of the continuation record, see "Continuation Record" on page 65.

Header Record

New attributes have been appended to the end of the existing header record (see "Header Record" on page 19). The following fields were added at the specified offsets in the header record.

Header Record changes for OpenFlight15.7
New Fields

Data Type	Offset	Length	Description
Double	284	8	Delta z to place database (used in conjunction with existing Delta x and Delta y values)
Double	292	8	Radius (distance from database origin to farthest corner)
Unsigned Int	300	2	Next Mesh node ID number
Unsigned Int	302	2	Reserved

Mesh Nodes

A mesh node defines a set of geometric primitives that share attributes and vertices. In previous versions of OpenFlight, the fundamental geometric construct was the polygon. Each polygon has a unique set of attributes and vertices. Meshes are used to represent "sets" of related polygons, each sharing common attributes and vertices. Using a mesh, related polygons can be represented in a much more compact format. Each mesh will share one set of "polygon" attributes (color, material, texture, etc.), a common "vertex pool" and one or more geometric primitives that use the shared attributes and vertices. Using a mesh you can represent triangle strips, triangle fans, quadrilateral strips and indexed face sets.

A mesh node is defined by three distinct record types:

- *Mesh Record* - defines the "polygon" attributes associated to all geometric primitives of the mesh.

- *Local Vertex Pool Record* - defines the set of vertices that are referenced by the geometric primitives of the mesh.
- *Mesh Primitive Record* - defines a geometric primitive (triangle-strip, triangle-fan, quadrilateral-strip or indexed face set) for the mesh.

A mesh node consists of one mesh record, one local vertex pool record, and one or more mesh primitive records. The mesh primitive records are delimited by push and pop control records as shown in the following example:

```
MESH
LOCAL VERTEX POOL
PUSH
MESH PRIMITIVE
MESH PRIMITIVE
...
MESH PRIMITIVE
POP
```

Mesh Record

The mesh record is the primary record of a mesh node and defines the common "face-like" attributes associated to all geometric primitives of the mesh. These attributes are identical to those of the face record. See "Face Record" on page 26.

Mesh Record
New record for OpenFlight 15.7

Data type	Offset	Length	Description
Int	0	2	Mesh Opcode 84
Unsigned Int	2	2	Length - length of the record
Char	4	8	7 char ASCII ID; 0 terminates
Int	12	4	IR color code
Int	16	2	Relative priority
Int	18	1	Draw type 0 = Draw solid with backface culling 1 = Draw solid, no backface culling 2 = Draw wireframe 3 = Draw wireframe and close 4 = Surround with wireframe in alternate color 8 = Omnidirectional light 9 = Unidirectional light 10 = Bidirectional light
Int	19	1	Texture white = if TRUE, draw textured face white
Unsigned Int	20	2	Color name index
Unsigned Int	22	2	Alternate color name index
Int	24	1	Reserved

Mesh Record
New record for OpenFlight 15.7 (Continued)

Data type	Offset	Length	Description
Int	25	1	Template (billboard) 0 = Fixed, no alpha blending 1 = Fixed, alpha blending 2 = Axial rotate with alpha blending 4 = Point rotate with alpha blending
Int	26	2	Detail texture pattern index, -1 if none
Int	28	2	Texture pattern index, -1 if none
Int	30	2	Material index, -1 if none
Int	32	2	Surface material code (for DFAD)
Int	34	2	Feature ID (for DFAD)
Int	36	4	IR material code
Unsigned Int	40	2	Transparency 0 = Opaque 65535 = Totally clear
Unsigned Int	42	1	LOD generation control
Unsigned Int	43	1	Line style index
Int	44	4	Flags (bits from left to right) 0 = Terrain 1 = No color 2 = No alternate color 3 = Packed color 4 = Terrain culture cutout (footprint) 5 = Hidden, not drawn 6-31 = Spare
Unsigned Int	48	1	Light mode 0 = Use mesh color, not illuminated 1 = Use vertex colors, not illuminated 2 = Use mesh color and vertex normals 3 = Use vertex colors and vertex normals
Char	49	7	Reserved
Unsigned Int	56	4	Packed color, primary (a, b, g, r)
Unsigned Int	60	4	Packed color, alternate (a, b, g, r)
Int	64	2	Texture mapping index
Int	66	2	Reserved
Unsigned Int	68	4	Primary color index
Unsigned Int	72	4	Alternate color index
Int	76	4	Reserved

Local Vertex Pool Record

This record defines a set of vertices that is referenced by the geometry (primitives) of the mesh.

Note: Currently the Local Vertex Pool is used exclusively in the context of mesh nodes, but it is designed in a general way so that it may appear in other contexts in future versions of the OpenFlight Scene Description.

Local Vertex Pool Record
New record for OpenFlight 15.7

Data Type	Offset	Length	Description
Int	0	2	Local Vertex Pool Opcode 85
Unsigned Int	2	2	Length - length of the record Note: Since the length of this record is represented by an unsigned short, the maximum length of the vertex pool is 2^{16} - 1 (or 65535 bytes). If the entire vertex pool cannot fit into this size, one or more continuation records will follow. (See "Continuation Record" on page 65.)
Unsigned Int	4	4	Number of vertices - number of vertices in the local vertex pool
Unsigned Int	8	4	Attribute mask - Bit mask indicating what kind of vertex information is specified for each vertex in the local vertex pool. Bits are ordered from left to right as follows: Bit # Description 0 Has Position - if set, data for each vertex in will include x, y, and z coordinates (3 doubles) 1 Has Color Index - if set, data for each vertex will include a color value that is a color table index (1 int) 2 Has RGB Color - if set, data for each vertex will include a color value that is a packed RGB color (1 int) Note: Bits 1and 2 are mutually exclusive - a vertex can have either color index or RGB color value or neither, but not both. 3 Has Normal - if set, data for each vertex will include a normal (3 floats) 4 Has Base UV - if set, data for each vertex will include uv texture coordinates for the base texture (2 floats) 5 Has UV Layer 1 - if set, data for each vertex will include uv texture coordinates for layer 1 (2 floats) 6 Has UV Layer 2 - if set, data for each vertex will include uv texture coordinates for layer 2 (2 floats) 7 Has UV Layer 3 - if set, data for each vertex will include uv texture coordinates for layer 3 (2 floats) 8 Has UV Layer 4 - if set, data for each vertex will include uv texture coordinates for layer 4 (2 floats) 9 Has UV Layer 5 - if set, data for each vertex will include uv texture coordinates for layer 5 (2 floats) 10 Has UV Layer 6 - if set, data for each vertex will include uv texture coordinates for layer 6 (2 floats) 11 Has UV Layer 7 - if set, data for each vertex will include uv texture coordinates for layer 7 (2 floats) 12-31 Spare

Local Vertex Pool Record
New record for OpenFlight 15.7 (Continued)

Then beginning at offset 12, the following fields are repeated for each vertex in the local vertex pool, depending on the bits set in the Attribute mask field above: In the fields listed below, N ranges from 0 to Number of vertices - 1.			
Double	Varies	8*3	$Coordinate_N$ - Coordinate of vertex N (x, y, z) - present if Attribute mask includes Has Position.
Unsigned Int	Varies	4	$color_N$ - Color for vertex N - present if Attribute mask includes Has Color Index or Has RGB Color. If Has Color Index, specifies color table index. If Has RGB Color, 4 bytes specify (a, b, g, r) values (alpha ignored).
Float	Varies	4*3	$normal_N$ - Normal for vertex N (i, j, k) - present if Attribute mask includes Has Normal.
Float	Varies	4*2	$uvBase_N$ - Texture coordinates (u, v) for base texture layer of vertex N - present if Attribute mask includes Has Base UV.
Float	Varies	4*2	$uv1_N$ - Texture coordinates (u, v) for layer 1 of vertex N - present if Attribute mask includes Has UV Layer 1.
Float	Varies	4*2	$uv2_N$ - Texture coordinates (u, v) for layer 2 of vertex N - present if Attribute mask includes Has UV Layer 2.
Float	Varies	4*2	$uv3_N$ - Texture coordinates (u, v) for layer 3 of vertex N - present if Attribute mask includes Has UV Layer 3.
Float	Varies	4*2	$uv4_N$ - Texture coordinates (u, v) for layer 4 of vertex N - present if Attribute mask includes Has UV Layer 4.
Float	Varies	4*2	$uv5_N$ - Texture coordinates (u, v) for layer 5 of vertex N - present if Attribute mask includes Has UV Layer 5.
Float	Varies	4*2	$uv6_N$ - Texture coordinates (u, v) for layer 6 of vertex N - present if Attribute mask includes Has UV Layer 6.
Float	Varies	4*2	$uv7_N$ - Texture coordinates (u, v) for layer 7 of vertex N - present if Attribute mask includes Has UV Layer 7.

Mesh Primitive Record

This record defines a geometric primitive (triangle strip, triangle fan, quadrilateral strip, or indexed polygon) for a mesh.

Mesh Primitive Record
New record for OpenFlight 15.7

Data Type	Offset	Length	Description
Int	0	2	Mesh Primitive Opcode 86
Unsigned Int	2	2	Length - length of the record
Int	4	2	Primitive Type - specifies how the vertices of the primitive are interpreted 1 = Triangle Strip 2 = Triangle Fan 3 = Quadrilateral Strip 4 = Indexed Polygon
Unsigned Int	6	2	Index Size - specifies the length (in bytes) of each of the vertex indices that follow - will be either 1, 2, or 4
Unsigned Int	8	4	Vertex Count - number of vertices in this primitive.
The following field is repeated for each vertex referenced by the mesh primitive. These vertices are interpreted according to Primitive Type. In the field below, N ranges from 0 to Vertex Count - 1.			
Int	12+(N*Index Size)	Index Size	$Index_N$ - Index of vertex N of the mesh primitive.

Each mesh primitive is represented using the Mesh Primitive record above. The following descriptions explain how the vertices of each primitive type are interpreted as geometry:

- **Triangle Strip** - This mesh primitive defines a connected group of triangles in the context of the enclosing mesh. Each triangle shares the “polygon” attributes defined by the enclosing mesh. This primitive contains a sequence of indices that reference vertices from the local vertex pool. One triangle is defined for each vertex presented after the first two vertices. For odd n, vertices n, n+1, and n+2 define triangle n. For even n, vertices n+1, n, and n+2 define triangle n. The first triangle is n=1. The first vertex in the vertex pool is n=1. N vertices represent N-2 triangles.

- **Triangle Fan** - Like the Triangle Strip, this mesh primitive also defines a connected group of triangles in the context of the enclosing mesh. Each triangle shares the “polygon” attributes defined by the enclosing mesh. This primitive contains a sequence of indices that reference vertices from the local vertex pool. One triangle is defined for each vertex presented after the first two vertices. Vertices 1, n+1, and n+2 define triangle n. The first triangle is n=1. The first vertex in the vertex pool is n=1. N vertices represent N-2 triangles.

- **Quadrilateral Strip** - This mesh primitive defines a connected group of quadrilaterals in the context of the enclosing mesh. Each quadrilateral shares the “polygon” attributes defined by the enclosing mesh. This primitive contains a sequence of indices that reference vertices from the local vertex pool. One quadrilateral is defined for each pair of vertices presented after the first pair. Vertices 2n-1, 2n, 2n+2, and 2n+1 define quadrilateral n. The first quadrilateral is n=1. The first vertex in the vertex pool is n=1. N vertices represent (N/2)-1 quadrilaterals.

- **Indexed Polygon** -This mesh primitive defines a single polygon in the context of the enclosing mesh. This primitive is similar to the other mesh primitives in that it also shares the polygon attributes of the enclosing mesh. It is different from the other mesh primitive types in that while triangle strips/ fans and quadrilateral strips describe a set of connected triangles/quadrilaterals, the indexed polygon

defines a single polygon. This primitive contains a sequence of indices that reference vertices from the local vertex pool. One polygon is defined by the sequence of vertices in this record. N vertices represent 1 N-sided closed polygon or 1 (N-1)-sided unclosed polygon.

Multitexture

OpenFlight supports 8 textures per polygon or mesh as well as 8 uv's per vertex. The current texture information stored on the polygon is referred to as “the base texture” or “texture layer 0". Each additional texture is referred to as “texture layer N”. Therefore, to support 8 textures per polygon, a base texture is required as well as 7 additional texture layers. The additional texture layers for each polygon, mesh, and vertex will be represented in ancillary records at the Face, Mesh, and Vertex primary node levels as shown in the following example:

```
FACE
MULTITEXTURE
PUSH
VERTEX LIST
UV LIST
POP
```

The records that are used to represent multitexture in the OpenFlight file are described in the following sections.

Multitexture Record

The multitexture record is an ancillary record of face and mesh nodes. It specifies the texture layer information for the face or mesh.

Multitexture Record
New record for OpenFlight 15.7

Data Type	Offset	Length	Description
Unsigned Int	0	2	Multitexture Opcode 52
Unsigned Int	2	2	Length - length of the record
Int	4	4	Attribute mask - Bit mask indicating what kind of multitexture information is present in this record. Bits are ordered from left to right as follows: Bit # Description 0 Has Layer 1 - if this bit is set, multitexture information for texture layer 1 is present. 1 Has Layer 2 - if this bit is set, multitexture information for texture layer 2 is present. 2 Has Layer 3 - if this bit is set, multitexture information for texture layer 3 is present. 3 Has Layer 4 - if this bit is set, multitexture information for texture layer 4 is present. 4 Has Layer 5 - if this bit is set, multitexture information for texture layer 5 is present. 5 Has Layer 6 - if this bit is set, multitexture information for texture layer 6 is present. 6 Has Layer 7 - if this bit is set, multitexture information for texture layer 7 is present. 7-31 Spare
The following fields are repeated for each multitexture layer that is specified as present by the bits set in the Attribute mask field above. This mechanism allows for "sparse" multitexture layer information to be present and does not require that the information present be contiguous.			
Unsigned Int	Varies	2	$texture_N$ - Texture index for texture layer N
Unsigned Int	Varies	2	$effect_N$ - Multitexture effect for texture layer N 0 = Texture environment 1 = Bump map 2-100 = Reserved by MultiGen-Paradigm >100 = user (runtime) defined
Unsigned Int	Varies	2	$mapping_N$ - Texture mapping index for texture layer N
Unsigned Int	Varies	2	$data_N$ - Texture data for layer N. This is user defined. For example, it may be used as a blend percentage or color or any other data needed by the runtime to describe texture layer N

UV List Record

The uv list record is an ancillary record of vertex nodes. This record (if present) always follows the vertex list or morph vertex list record and contains texture layer information for the vertices represented in the vertex list record it follows.

UV List Record
New record for OpenFlight 15.7

Data Type	Offset	Length	Description
Unsigned Int	0	2	UV List Opcode 53
Unsigned Int	2	2	Length - length of the record
Int	4	4	Attribute mask - Bit mask indicating what kind of multi-texture information is present in this record. Bits are ordered from left to right as follows: Bit # Description 0 Has Layer 1 - if set, uvs for layer 1 are present 1 Has Layer 2 - if set, uvs for layer 2 are present 2 Has Layer 3 - if set, uvs for layer 3 are present 3 Has Layer 4 - if set, uvs for layer 4 are present 4 Has Layer 5 - if set, uvs for layer 5 are present 5 Has Layer 6 - if set, uvs for layer 6 are present 6 Has Layer 7 - if set, uvs for layer 7 are present 7-31 Spare

The following fields are repeated for each vertex contained in the corresponding vertex list or morph vertex list record.

If this uv list record follows a vertex list record, the following fields are repeated for each layer present (as specified by the bits set in the Attribute mask field).

Data Type	Length	Description
Float	4	$u_{i, N}$ - Texture U for vertex i, layer N
Float	4	$v_{i, N}$ - Texture V for vertex i, layer N

If this uv list record follows a morph vertex list record, the following fields are repeated for each layer present (as specified by the bits set in the Attribute mask field).

Data Type	Length	Description
Float	4	$u0_{i, N}$ - Texture U for the 0% vertex i, layer N
Float	4	$v0_{i, N}$ - Texture V for the 0% vertex i, layer N
Float	4	$u100_{i, N}$ - Texture U for the 100% vertex i, layer N
Float	4	$v100_{i, N}$ - Texture V for the 100% vertex i, layer N

Texture Attribute File

Subtexture

Subtexture definitions have been added to the end of the Texture Attribute File (see "Texture Attribute Files" on page 93). After all the geospecific control points are listed, the following subtexture information now appears:

Texture Attribute File Format changes for OpenFlight 15.7
New Fields

Data Type	Length	Description
Int	4	Number of subtextures

If the value of the Number of subtextures field is greater than 0, the following fields are repeated for each subtexture in the texture attribute file.

In the fields below, N ranges from 0 to Number of subtextures - 1.

The Left, Bottom, Right and Top fields are all measured in texels.

Data Type	Length	Description
Char	32	$Name_N$ - name of subtexture N; 0 terminates
Int	4	$Left_N$ - Coordinate of left edge of subtexture N
Int	4	$Bottom_N$ - Coordinate of bottom edge of subtexture N
Int	4	$Right_N$ - Coordinate of right edge of subtexture N
Int	4	Top_N - Coordinate of top edge of subtexture N

B Summary of Changes Version 15.8

Overview

This section describes the changes in the OpenFlight Scene Description between versions 15.7 and 15.8 as well as the errors contained in previous versions of this document that have been corrected in this version.

OpenFlight version 15.8 coincides with MultiGen Creator version 2.6 and the OpenFlight API version 2.6. The changes made for this version are:

- "Header Record" on page 129
- "Group Record" on page 130
- "Level of Detail Record" on page 131
- "External Reference Record" on page 132
- "Indexed String Record" on page 132 (for Switch nodes)
- "Face Record" on page 133
- "Mesh Record" on page 133
- "Local Vertex Pool Record" on page 134
- "Vertex Palette Records" on page 135
- "Light Point Appearance Palette Record" on page 138
- "Light Point Animation Record" on page 141
- "Indexed Light Point Record" on page 142
- "Light Point System Record" on page 142
- "Texture Mapping Palette Record" on page 143

Also new in this version of the document is the addition of the "offset" column in the record format tables.

Document Corrections

The errors corrected in this version of the document are described in the sections that follow.

Text Record

The Reserved field, previously omitted in prior versions of this document, has been documented in the specification for OpenFlight 15.8. The offsets of fields following this field have been adjusted accordingly.

Text Record error corrected in OpenFlight 15.8 specification
Reserved field (documented)

Data Type	Offset	Length	Description
Int	16	4	Reserved

The Draw bold field, previously omitted in prior versions of this document, has been documented in the specification for OpenFlight 15.8. The offsets of fields following this field have been adjusted accordingly.

Text Record error corrected in OpenFlight 15.8 specification
Draw bold field (documented)

Data Type	Offset	Length	Description
Int	304	4	Draw bold

For a complete description of the text record, see "Text Record" on page 47.

CAT Record

The Relative priority field, included erroneously in the previous version of this document, has been removed from the specification for OpenFlight 15.8. The offsets of fields following this field have been adjusted accordingly.

CAT Record error corrected in OpenFlight 15.8 specification
Relative priority field (removed)

Data Type	Offset	Length	Description
Int	20	2	Relative priority

The Feature ID field, included erroneously in the previous version of this document, has been removed from the specification for OpenFlight 15.8. The offsets of fields following this field have been adjusted accordingly.

CAT Record error corrected in OpenFlight 15.8 specification
Feature ID field (removed)

Data Type	Offset	Length	Description
Int	38	2	Relative priority

The Reserved field, previously omitted in prior versions of this document, has been documented in the specification for OpenFlight 15.8. The offsets of fields following this field have been adjusted accordingly.

CAT Record error corrected in OpenFlight 15.8 specification
Reserved field (documented)

Data Type	Offset	Length	Description
Int	60	4	Reserved

For a complete description of the CAT record, see "CAT Record" on page 50.

Format Changes

Header Record

The header record has been modified to include additional projection attributes. New attributes have been appended to the end of the existing header record and some of the existing fields have new values possible.

The following fields were added to the end (at the specified offsets) of the header record.

Header Record changes for OpenFlight15.8
New Fields

Data Type	Offset	Length	Description
Unsigned Int	302	2	Next Light Point System ID number
Int	304	4	Reserved
Double	308	8	Earth major axis (for user defined ellipsoid) in meters
Double	316	8	Earth minor axis (for user defined ellipsoid) in meters

The Projection type field has been changed to include two new possible values, Geocentric and Geodetic as shown here. New values are shown in **bold font**:

Header Record changes for OpenFlight15.8
Projection type field

Data Type	Offset	Length	Description
Int	92	4	Projection type 0 = Flat earth 1 = Trapezoidal 2 = Round earth 3 = Lambert 4 = UTM **5 = Geocentric** **6 = Geodetic**

The Earth ellipsoid model field has been changed to include one new possible value, User defined ellipsoid as shown here. This new value is shown in **bold font**.

Header Record changes for OpenFlight15.8
Earth ellipsoid field

Data Type	Offset	Length	Description
Int	268	4	Earth ellipsoid model 0 = WGS 1984 1 = WGS 1972 2 = Bessel 3 = Clarke 1866 4 = NAD 1927 **5 = User defined ellipsoid**

A field, previously labeled "Reserved" in prior versions of this document, has been described. It is the UTM zone for UTM projections and is shown here.

Header Record changes for OpenFlight15.8
UTM zone field

Data Type	Offset	Length	Description
Int	276	2	UTM zone (for UTM projections - negative value means Southern hemisphere)

For a complete description of the header record, see "Header Record" on page 19.

Group Record

The group record has been modified to include additional animation attributes. New attributes have been appended to the end of the existing group record and some of the existing fields have new values possible.

The following fields were added to the end (at the specified offsets) of the group record.

Group Record changes for OpenFlight15.8
New Fields

Data Type	Offset	Length	Description
Int	32	4	Loop count
Float	36	4	Loop duration in seconds
Float	40	4	Last frame duration in seconds

The Flags field has been changed to include a new bit which can be used to specify backwards animations as shown here. The new bit is shown in **bold font**.

Group Record changes for OpenFlight15.8
Flags field

Data Type	Offset	Length	Description
Int	16	4	Flags (bits, from left to right) 0 = Reserved 1 = Forward animation 2 = Swing animation 3 = Bounding box follows 4 = Freeze bounding box 5 = Default parent **6 = Backward animation** 7-31 = Spare

For a complete description of the group record, see "Group Record" on page 22.

Level of Detail Record

The level of detail record has been modified to include an additional attribute, Significant size. This new value helps an application to calculate switch ranges for the geometry more effectively for different display settings (field of view, screen size and resolution).

The following field was added to the end (at the specified offset) of the level of detail record.

LOD Record changes for OpenFlight15.8
New Field

Data Type	Offset	Length	Description
Double	72	8	Significant size

For a complete description of the level of detail record, see "Level of Detail Record" on page 41.

External Reference Record

The Flags field of the external reference record has been modified to include a new bit, Light point palette override, which is used to specify that the light point appearance and animation palettes override those contained in the master file. The new bit is shown in **bold font**.

External Reference Record changes for OpenFlight15.8
Flags field

Data Type	Offset	Length	Description
Int	208	4	Flags (bits, from left to right) 0 = Color palette override 1 = Material palette override 2 = Texture and texture mapping palette override 3 = Line style palette override 4 = Sound palette override 5 = Light source palette override **6 = Light point palette override** 7-31 = Spare

For a complete description of the external reference record, see "External Reference Record" on page 41.

Indexed String Record

Switch nodes now allow individual masks to be named. These names are stored in a new ancillary record called the Indexed String record. While these new ancillary records are currently only applicable to Switch records, they are not limited to Switch records and may be useful in future versions of OpenFlight in other contexts.

The new Indexed String Record is an ancillary record that contains an integer index followed by a variable length character string. In this way, arbitrary strings can be associated to indices in a general way.

With respect to Switch mask names, the index specifies the mask number for which the string specifies a name. Mask numbers start at 0. Not all masks are required to have names.

Indexed String Record
New record for OpenFlight 15.8

Data type	Offset	Length	Description
Int	0	2	Indexed string Opcode 132
Unsigned Int	2	2	Length - length of the record
Unsigned Int	4	2	Index
Char	8	Length - 8	ASCII string; 0 terminates

For a complete description of the indexed string record, see "Indexed String Record" on page 53.

Face Record

The Flags field of the face record has been modified to include a new bit, Roofline, which is used to specify that a face is part of a building's roof as viewed from above. The new specification of the Flags field is shown here. The new bit is shown in **bold font**.

Face Record changes for OpenFlight15.8
Flags field

Data Type	Offset	Length	Description
Int	44	4	Flags (bits from left to right) 0 = Terrain 1 = No color 2 = No alternate color 3 = Packed color 4 = Terrain culture cutout (footprint) 5 = Hidden, not drawn **6 = Roofline** 7-31 = Spare

For a complete description of the face record, see "Face Record" on page 26.

Mesh Record

Similar to the Face record described above, the Flags field of the mesh record has been modified to include a new bit, Roofline, which is used to specify that a mesh is part of a building's roof as viewed from above. The new specification of the Flags field is shown here. The new bit is shown in **bold font**.

Mesh Record changes for OpenFlight15.8
Flags field

Data Type	Offset	Length	Description
Int	44	4	Flags (bits from left to right) 0 = Terrain 1 = No color 2 = No alternate color 3 = Packed color 4 = Terrain culture cutout (footprint) 5 = Hidden, not drawn **6 = Roofline** 7-31 = Spare

For a complete description of the mesh record, see "Mesh Record" on page 29.

Local Vertex Pool Record

The Local Vertex Pool record has been modified to include an alpha color component for those vertices in the pool that have color. The alpha color component is represented as a 1 byte integer value whose range is 0 (fully transparent) to 255 (fully opaque).

The definition of the Attribute mask field has been changed as shown here.

Note: The physical layout of this field has not changed, only its definition. The bits for which new definitions apply are shown in **bold font**:

Local Vertex Pool Record changes for OpenFlight15.8
Attribute mask field

Data Type	Offset	Length	Description
Unsigned Int	8	4	Attribute mask - Bit mask indicating what kind of vertex information is specified for each vertex in the local vertex pool. Bits are ordered from left to right as follows: Bit # Description 0 Has Position - if set, data for each vertex in will include x, y, and z coordinates (3 doubles) **1 Has Color Index - if set, data for each vertex will include a color value that specifies a color table index as well as an alpha value** **2 Has RGBA Color - if set, data for each vertex will include a color value that is a packed RGBA color value** Note: Bits 1and 2 are mutually exclusive - a vertex can have either color index or RGB color value or neither, but not both. 3 Has Normal - if set, data for each vertex will include a normal (3 floats) 4 Has Base UV - if set, data for each vertex will include uv texture coordinates for the base texture (2 floats) 5 Has UV Layer 1 - if set, data for each vertex will include uv texture coordinates for layer 1 (2 floats) 6 Has UV Layer 2 - if set, data for each vertex will include uv texture coordinates for layer 2 (2 floats) 7 Has UV Layer 3 - if set, data for each vertex will include uv texture coordinates for layer 3 (2 floats) 8 Has UV Layer 4 - if set, data for each vertex will include uv texture coordinates for layer 4 (2 floats) 9 Has UV Layer 5 - if set, data for each vertex will include uv texture coordinates for layer 5 (2 floats) 10 Has UV Layer 6 - if set, data for each vertex will include uv texture coordinates for layer 6 (2 floats) 11 Has UV Layer 7 - if set, data for each vertex will include uv texture coordinates for layer 7 (2 floats) 12-31 Spare

The color field of the vertex pool data (data for each vertex) has been modified to include an alpha color component as shown here. The affected field is shown in **bold font**.

Local Vertex Pool Record changes for OpenFlight15.8
Color field

Data Type	Length	Description
Unsigned Int	4	**$color_N$ - Color for vertex N - present if Attribute mask includes Has Color Index or Has RGBA Color.** **If Has Color Index, lower 3 bytes specify color table index, upper 1 byte is Alpha.** **If Has RGBA Color, 4 bytes specify (a, b, g, r) values.**

For a complete description of the local vertex pool record, see "Local Vertex Pool Record" on page 30.

Vertex Palette Records

Vertex Palette Records have been modified to include an alpha color component. The alpha color component is represented as a 1 byte integer value whose range is 0 (fully transparent) to 255 (opaque).

Prior to OpenFlight version 15.8, vertex colors were represented in vertex palette records in one of two ways: Packed Color or Color Index. Depending on the value of the Packed color flag, either the Packed color (a, b, g, r) attribute or the Vertex color index attribute was valid, but not both. For example, if the Packed color flag was TRUE, then the Packed color attribute contained the RGB components of the vertex color and the Vertex color index attribute was not specified. Conversely, if the Packed color flag was FALSE, then the Vertex color index attribute contained the index (in the Color Palette) of the vertex color and the Packed color attribute was not specified. Furthermore, the A (alpha) component of the Packed color attribute was not valid and was ignored.

In OpenFlight version 15.8, the A (alpha) component of the Packed color attribute is valid and all vertex records include the Packed color (a, b, g, r) attribute, even those that also include the Vertex color index attribute. For those vertices that include the Vertex color index attribute, the RGB components of the Packed color attribute will match those of the color specified by the Vertex color index attribute if it was looked up in the color palette. This implies that an application concerned only with the RGB components of a vertex color can simply reference the Packed color attribute and ignore the Vertex color index attribute in all cases.

All the updated vertex palette records are shown here. The Packed color is shown in **bold font** to emphasize that it is always specified (for both color index and packed color specifications).

Vertex with Color Record changes for OpenFlight 15.8
Packed color field

Data type	Offset	Length	Description
Int	0	2	Vertex with Color Opcode 68
Unsigned Int	2	2	Length - length of the record
Unsigned Int	4	2	Color name index
Int	6	2	Flags (bits, from left to right) 0 = Start hard edge 1 = Normal frozen 2 = No color 3 = Packed color 4-15 = Spare
Double	8	8*3	Vertex coordinate (x, y, z)
Int	32	4	**Packed color (a, b, g, r) - always specified when the vertex has color**
Unsigned Int	36	4	Vertex color index - valid only if vertex has color and Packed color flag is not set

Vertex with Color and Normal Record changes for OpenFlight 15.8
Packed color field

Data type	Offset	Length	Description
Int	0	2	Vertex with Color and Normal Opcode 69
Unsigned Int	2	2	Length - length of the record
Unsigned Int	4	2	Color name index
Int	6	2	Flags (bits, from left to right) 0 = Start hard edge 1 = Normal frozen 2 = No color 3 = Packed color 4-15 = Spare
Double	8	8*3	Vertex coordinate (x, y, z)
Float	32	4*3	Vertex normal (i, j, k)
Int	44	4	**Packed color (a, b, g, r) - always specified when the vertex has color**
Unsigned Int	48	4	Vertex color index - valid only if vertex has color and Packed color flag is not set
Int	52	4	Reserved

Vertex with Color and UV Record changes for OpenFlight 15.8 Packed color field

Data type	Offset	Length	Description
Int	0	2	Vertex with Color and UV Opcode 71
Unsigned Int	2	2	Length - length of the record
Unsigned Int	4	2	Color name index
Int	6	2	Flags (bits, from left to right) 0 = Start hard edge 1 = Normal frozen 2 = No color 3 = Packed color 4-15 = Spare
Double	8	8*3	Vertex coordinate (x, y, z)
Float	32	4*2	Texture coordinate (u, v)
Int	40	4	**Packed color (a, b, g, r) - always specified when the vertex has color**
Unsigned Int	44	4	Vertex color index - valid only if vertex has color and Packed color flag is not set

Vertex with Color, Normal and UV Record changes for OpenFlight 15.8 Packed color field

Data type	Offset	Length	Description
Int	0	2	Vertex with Color, Normal and UV Opcode 70
Unsigned Int	2	2	Length - length of the record
Unsigned Int	4	2	Color name index
Int	6	2	Flags (bits, from left to right) 0 = Start hard edge 1 = Normal frozen 2 = No color 3 = Packed color 4-15 = Spare
Double	8	8*3	Vertex coordinate (x, y, z)
Float	36	4*3	Vertex normal (i, j, k)
Float	44	4*2	Texture coordinate (u, v)
Int	52	4	**Packed color (a, b, g, r) - always specified when the vertex has color**
Unsigned Int	56	4	Vertex color index - valid only if vertex has color and Packed color flag is not set
Int	60	4	Reserved

For a complete description of the vertex palette records, see "Vertex Palette Records" on page 66.

Light Points

The representation of Light Points in OpenFlight version 15.8 is significantly different from prior versions. Previously, all light point attributes were described completely within the primary record of the light point node.

In OpenFlight version 15.8, light point attributes have been divided into two categories, appearance and behavioral. To accommodate this, two new palettes have been created, the Light Point Appearance Palette and the Light Point Animation palette. A new Indexed Light Point node record has been added that references entries from the Light Point Appearance and Animation palettes. In effect, this moves the light point attributes out of the node record itself into entries of the two palettes and makes it much easier to share common attributes between multiple light points.

Note that the Light Point Record (Opcode 111) used in previous versions of OpenFlight remains valid for applications that require the data in this other format. Creator and the OpenFlight API versions 2.6 support both light point formats.

Following is a description of the new records in OpenFlight version 15.8 used to describe Light Point Palettes and Indexed Light Points.

Light Point Appearance Palette Record

The light point appearance palette record defines the visual attributes of light points.

Light Point Appearance Palette Record
New record for OpenFlight 15.8

Data Type	Offset	Length	Description
Int	0	2	Light Point Appearance Palette Opcode 128
Unsigned Int	2	2	Length - length of the record
Int	4	4	Reserved
Char	8	256	Appearance name; 0 terminates
Int	264	4	Appearance index
Int	268	2	Surface material code
Int	270	2	Feature ID
Unsigned Int	272	4	Back color for bidirectional points
Int	276	4	Display mode 0 = RASTER 1 = CALLIGRAPHIC 2 = EITHER
Float	280	4	Intensity - scalar for front colors
Float	284	4	Back intensity - scalar for back color
Float	288	4	Minimum defocus - (0.0 - 1.0) for calligraphic points
Float	292	4	Maximum defocus - (0.0 - 1.0) for calligraphic points
Int	296	4	Fading mode 0 = Enable perspective fading calculations 1 = Disable calculations

Light Point Appearance Palette Record
New record for OpenFlight 15.8 (Continued)

Data Type	Offset	Length	Description
Int	300	4	Fog Punch mode 0 = Enable fog punch through calculations 1 = Disable calculations
Int	304	4	Directional mode 0 = Enable directional calculations 1 = Disable calculations
Int	308	4	Range mode 0 = Use depth (Z) buffer calculation 1 = Use slant range calculation
Float	312	4	Min pixel size - minimum diameter of points in pixels
Float	316	4	Max pixel size - maximum diameter of points in pixels
Float	320	4	Actual size - actual diameter of points in database units
Float	324	4	Transparent falloff pixel size - diameter in pixels when points become transparent
Float	328	4	Transparent falloff exponent >= 0 - falloff multiplier exponent 1.0 - linear falloff
Float	332	4	Transparent falloff scalar > 0 - falloff multiplier scale factor
Float	336	4	Transparent falloff clamp - minimum permissible falloff multiplier result
Float	340	4	Fog scalar >= 0 - adjusts range of points for punch threw effect.
Float	344	4	Fog intensity
Float	348	4	Size difference threshold - point size transition hint to renderer
Int	352	4	Directionality 0 = OMNIDIRECTIONAL 1 = UNIDIRECTIONAL 2 = BIDIRECTIONAL
Float	356	4	Horizontal lobe angle - total angle in degrees
Float	360	4	Vertical lobe angle - total angle in degrees
Float	364	4	Lobe roll angle - rotation of lobe about local Y axis in degrees
Float	368	4	Directional falloff exponent >= 0 - falloff multiplier exponent 1.0 - linear falloff
Float	372	4	Directional ambient intensity - of points viewed off axis
Float	376	4	Significance - drop out priority for RASCAL lights (0.0 - 1.0)

Light Point Appearance Palette Record
New record for OpenFlight 15.8 (Continued)

Data Type	Offset	Length	Description
Int	380	4	Flags (bits, from left to right) 0 = reserved 1 = No back color TRUE = don't use back color for bidirectional points FALSE = use back color for bidirectional points 2 = reserved 3 = Calligraphic proximity occulting (Debunching) 4 = Reflective, non-emissive point 5-7 = Randomize intensity 0 = never 1 = low 2 = medium 3 = high 8 = Perspective mode 9 = Flashing 10 = Rotating 11 = Rotate Counter Clockwise Direction of rotation about local Z axis 12 = reserved 13-14 = Quality 0 = Low 1 = Medium 2 = High 3 = Undefined 15 = Visible during day 16 = Visible during dusk 17 = Visible during night 18-31 = Spare
Float	384	4	Visibility range (> 0.0)
Float	388	4	Fade range ratio - percentage of total range at which light points start to fade (0.0 - 1.0)
Float	392	4	Fade in duration - time it takes (seconds) light point to fade in when turned on
Float	396	4	Fade out duration - time it takes (seconds) light point to fade out when turned off
Float	400	4	LOD range ratio - percentage of total range at which light points LODs are active (0.0 - 1.0)
Float	404	4	LOD scale - size of light point LOD polygon relative to light point diameter

For a complete description of the light point appearance palette record, see "Light Point Appearance Palette Record" on page 82.

Light Point Animation Record

The light point animation palette record defines the behavioral attributes of light points.

Light Point Animation Palette Record
New record for OpenFlight 15.8

Data Type	Offset	Length	Description
Int	0	2	Light Point Animation Opcode 129
Unsigned Int	2	2	Length - length of the record
Int	4	4	Reserved
char	8	256	Animation name; 0 terminates
Int	264	4	Animation index
Float	268	4	Animation period in seconds. Note: Rate = 1/Period
Float	272	4	Animation phase delay in seconds - from start of period
Float	276	4	Animation enabled period (time on) in seconds
Float	280	4	Axis of rotation for rotating animation, I
Float	284	4	Axis of rotation for rotating animation, J
Float	288	4	Axis of rotation for rotating animation, K
Int	292	4	Flags (bits, from left to right) 0 = Flashing 1 = Rotating 2 = Rotate counter clockwise 3-31 = Spare
Int	296	4	Animation type 0 = Flashing sequence 1 = Rotating 2 = Strobe 3 = Morse code
Int	300	4	Morse code timing 0 = Standard timing 1 = Farnsworth timing
Int	304	4	Word rate (for Farnsworth timing)
Int	308	4	Character rate (for Farnsworth timing)
char	312	1024	Morse code string
Int	1336	4	Number of sequences (for Flashing sequence)
The following fields are repeated for each sequence represented in the light point animation palette entry. In the fields listed below, N ranges from 0 to Number of sequences - 1.			
Unsigned Int	1340+(N*12)	4	Sequence $State_N$ - state of sequence N 0 = On 1 = Off 2 = Color change
Float	1344+(N*12)	4	Sequence $Duration_N$i - duration of sequence N in seconds
Unsigned Int	1348+(N*12)	4	Sequence $Color_N$ - color for sequence N. Defined if Sequence state is On or Color change

For a complete description of the light point animation palette record, see "Light Point Animation Palette Record" on page 85.

Indexed Light Point Record

The indexed light point record is one of the records that can represent a light point node.

The appearance index specifies an entry in the light point appearance palette that contains the visual attributes of the light point.

The animation index specifies an entry in the light point animation palette that contains the behavioral attributes of the light point.

The palette entries referenced by the indexed light point record describe the visual state of the light point's child vertices. Only vertex nodes may be children of light point nodes.

Indexed Light Point Record
New record for OpenFlight 15.8

Data type	Offset	Length	Description
Int	0	2	Indexed Light Point Record Opcode 130
Unsigned Int	2	2	Length - length of the record
Char	4	8	7 char ASCII ID; 0 terminates
Int	12	4	Appearance index
Int	16	4	Animation index
Int	20	4	Draw order (for calligraphic lights)
Int	24	4	Reserved

For a complete description of the indexed light point records, see "Indexed Light Point Record" on page 34.

Light Point System Record

The light point system record enables you to collect a set of light points and enable/disable or brighten/dim them as a group.

Light Point System Record
New record for OpenFlight 15.8

Data type	Offset	Length	Description
Int	0	2	Light Point System Record Opcode 130
Unsigned Int	2	2	Length - length of the record
Char	4	8	7 char ASCII ID; 0 terminates
Float	12	4	Intensity
Int	16	4	Animation state 0 = On 1 = Off 2 = Random
Int	20	4	Flags (bits, from left to right) 0 = Enabled 1-31 = Spare

For a complete description of the light point system record, see "Light Point System Record" on page 37.

Texture Mapping Palette Record

Parameters for 3 Point Put Texture Mapping (Type 1)

The UV display type field, previously labeled Reserved in prior versions of this document, has been re-labeled in the specification for OpenFlight 15.8. The physical layout of the record was not changed.

Parameters for 3 Point Put Texture Mapping (Type 2)
changes for OpenFlight15.8
UV display type field (re-labeled)

Data Type	Offset	Length	Description
Int	388	4	UV display type 1 = XY 2 = UV

Parameters for 4 Point Put Texture Mapping (Type 2)

The following fields were added to the end (at the specified offsets) of the parameter subrecord.

Parameters for 4 Point Put Texture Mapping (Type 2)
changes for OpenFlight15.8
New Fields

Data Type	Offset	Length	Description
Float	576	4	U Repetition
Float	580	4	V Repetition

The UV display type field, previously labeled Reserved in prior versions of this document, has been re-labeled in the specification for OpenFlight 15.8. The physical layout of the record was not changed.

Parameters for 4 Point Put Texture Mapping (Type 2)
changes for OpenFlight15.8
UV display type field (re-labeled)

Data Type	Offset	Length	Description
Int	436	4	UV display type 1 = XY 2 = UV

C Summary of Changes Version 16.0

Overview

This section describes the changes in the OpenFlight Scene Description between versions 15.8 and 16.0 as well as the errors contained in previous versions of this document that have been corrected in this version.

OpenFlight version 16.0 coincides with MultiGen Creator version 3.0 and the OpenFlight API version 3.0. The changes made for this version are:

- "External Reference Record" on page 149
- "Face Record" on page 150
- "Mesh Record" on page 150
- "Light Point Appearance Palette Record" on page 150
- "Shader Palette Record" on page 151
- "Texture Attribute File" on page 151
- "Texture Mapping Palette Record" on page 152

Document Corrections

The errors corrected in this version of the document are described in the sections that follow.

Header Record

The value corresponding to User defined ellipsoid for the Earth ellipsoid model field has been corrected. It was previously listed as having a value of 5. The correct value is -1. The corrected value is shown in **bold font**.

Header Record error corrected in OpenFlight 16.0 specification
Earth ellipsoid model field (corrected)

Data Type	Offset	Length	Description
Int	268	4	Earth ellipsoid model 0 = WGS 1984 1 = WGS 1972 2 = Bessel 3 = Clarke 1866 4 = NAD 1927 **-1 = User defined ellipsoid**

Face Record

The possible values listed for the Draw type field have been corrected. The affected values are shown in **bold font**.

Face Record error corrected in OpenFlight 16.0 specification
Draw type field (corrected)

Data Type	Offset	Length	Description
Int	18	1	Draw type 0 = Draw solid with backface culling 1 = Draw solid, no backface culling **2 = Draw wireframe and close** **3 = Draw wireframe** 4 = Surround with wireframe in alternate color 8 = Omnidirectional light 9 = Unidirectional light 10 = Bidirectional light

For a complete description of the face record, see "Face Record" on page 26.

Mesh Record

The Reserved field at offset 12, previously omitted in prior versions of this document, has been documented in the specification for OpenFlight 16.0. The offsets of fields following this field have been adjusted accordingly.

Mesh Record error corrected in OpenFlight 16.0 specification
Reserved field (documented)

Data Type	Offset	Length	Description
Int	12	4	Reserved

The possible values listed for the Draw type field have been corrected. The affected values are shown in **bold font**.

Mesh Record error corrected in OpenFlight 16.0 specification
Draw type field (corrected)

Data Type	Offset	Length	Description
Int	18	1	Draw type 0 = Draw solid with backface culling 1 = Draw solid, no backface culling **2 = Draw wireframe and close** **3 = Draw wireframe** 4 = Surround with wireframe in alternate color 8 = Omnidirectional light 9 = Unidirectional light 10 = Bidirectional light

For a complete description of the mesh record, see "Mesh Record" on page 29.

Switch Record

The order of the fields were corrected. The affected fields are shown here.

Switch Record error corrected in OpenFlight 16.0 specification field order (corrected)

Data Type	Offset	Length	Description
Int	20	4	Number of masks
Int	24	4	Number of words per mask - the number of 32 bit words required for each mask, calculated as follows: (number of children / 32) + X where X equals: 0 if (number of children modulo 32) is zero 1 if (number of children modulo 32) is nonzero

For a complete description of the switch record, see "Switch Record" on page 49.

Texture Mapping Palette Record

The parameters for warped mapping in the texture mapping palette record were corrected. The 128 byte 4x4 Trackplane to XY plane transformation matrix was erroneously listed where an 8

byte reserved field was located. The entire record is shown here. The corrected field and offsets are shown in **bold font**:

Parameters for Warped Mapping error corrected in OpenFlight 16.0 specification
Reserved field (corrected)

Data Type	Offset	Length	Description
Int	X+0	4	Active geometry point 0 = First warp FROM point 1 = Second warp FROM point 2 = Third warp FROM point 3 = Fourth warp FROM point 4 = Fifth warp FROM point 5 = Sixth warp FROM point 6 = Seventh warp FROM point 7 = Eighth warp FROM point 8 = First warp TO point 9 = Second warp TO point 10 = Third warp TO point 11 = Fourth warp TO point 12 = Fifth warp TO point 13 = Sixth warp TO point 14 = Seventh warp TO point 15 = Eighth warp TO point
Int	X+4	4	Warp tool state 0 = Start state - no points entered 1 = One FROM point entered 2 = Two FROM point entered 3 = Three FROM point entered 4 = Four FROM point entered 5 = Five FROM point entered 6 = Six FROM point entered 7 = Seven FROM point entered 8 = All FROM point entered
Int	X+8	8	**Reserved**
Double	**X+16**	8*8*2	FROM points transformed to XY plane by above matrix. 8 FROM points are ordered 1, 2, ... 8. Each point is (x, y)
Double	**X+144**	8*8*2	TO points transformed to XY plane by above matrix. 8 TO points are ordered 1, 2, ... 8. Each point is (x, y)

For a complete description of the texture mapping palette record, see "Texture Mapping Palette Record" on page 86.

Indexed String Record

The length of the Index field has been corrected. It was previously listed as 2 bytes. The correct length is 4 bytes. The corrected field and length are shown in **bold font**:

Indexed String Record

Data Type	Offset	Length	Description
Int	0	2	Indexed string Opcode 132
Unsigned Int	2	2	Length - length of the record
Unsigned Int	4	**4**	**Index**
Char	8	Length - 8	ASCII string; 0 terminates

Bounding Convex Hull Record

The description of this previously undocumented record has been added to the specification. For a complete description of this record, see "Bounding Convex Hull Record" on page 62.

Bounding Histogram Record

The description of this previously undocumented record has been added to the specification. For a complete description of this record, see "Bounding Histogram Record" on page 62.

Format Changes

External Reference Record

The Flags field of the external reference record has been modified to include a new bit, Shader palette override, which is used to specify that the shader palette override those contained in the master file. The new bit is shown in **bold font:**

External Reference Record changes for OpenFlight15.8
Flags field

Data Type	Offset	Length	Description
Int	208	4	Flags (bits, from left to right) 0 = Color palette override 1 = Material palette override 2 = Texture and texture mapping palette override 3 = Line style palette override 4 = Sound palette override 5 = Light source palette override 6 = Light point palette override **7 = Shader palette override** 8-31 = Spare

For a complete description of the external reference record, see "External Reference Record" on page 41.

Face Record

The face record has been modified to include a new attribute, Shader index, which is used to specify the shader (if any) that is applied to the face.

Face Record changes for OpenFlight 16.0
Flags field

Data Type	Offset	Length	Description
Int	78	2	Shader index, -1 if none

For a complete description of the face record, see "Face Record" on page 26.

Mesh Record

Similar to the Face record described above, the mesh record has been modified to include a new attribute, Shader index, which is used to specify the shader (if any) that is applied to the mesh.

Mesh Record changes for OpenFlight 16.0
Flags field

Data Type	Offset	Length	Description
Int	78	2	Shader index, -1 if none

For a complete description of the mesh record, see "Mesh Record" on page 29.

Light Point Appearance Palette Record

The light point appearance palette record has been modified to include a new attribute, Texture pattern index, which is used to specify the texture (if any) that is applied to the light point appearance. Note that the new Reserved field is necessary to insure proper length of record.

Light Point Appearance Record changes for OpenFlight 16.0
Texture pattern index field

Data Type	Offset	Length	Description
Int	408	2	Texture pattern index, -1 if none
Int	410	2	Reserved

For a complete description of the light point appearance palette record, see "Light Point Appearance Palette Record" on page 82.

Shader Palette Record

The shader palette contains descriptions of shaders used while drawing geometry. It is composed of an arbitrary number of shader palette records. The shader palette records must follow the header record and precede the first push.

Shader Palette Record
New record for OpenFlight 16.0

Data Type	Offset	Length	Description
Int	0	2	Shader Opcode 133
Unsigned Int	2	2	Length - length of the record
Int	4	4	Shader index
Int	8	4	Shader type 0 = Cg 1 = CgFX 2 = OpenGL Shading Language
char	12	1024	Shader name; 0 terminates
char	1036	1024	Vertex program file name; 0 terminates (Cg Shader type specific)
char	2060	1024	Fragment program file name; 0 terminates (Cg Shader type specific)
Int	3084	4	Vertex program profile (Cg Shader type specific)
Int	3088	4	Fragment program profile (Cg Shader type specific)
char	3092	256	Vertex program entry point (Cg Shader type specific)
char	3348	256	Fragment program entry point (Cg Shader type specific)

Texture Attribute File

The Wrap method fields (Wrap method u,v, Wrap method u and Wrap method v) have been changed to include a new possible value, Mirrored repeat as shown here. This new value is shown in **bold font**:

Texture Attribute File Format changes for OpenFlight 16.0
Wrap method fields

Data Type	Offset	Length	Description
Int	36	4	Wrap method u,v - only used when either Wrap method u or Wrap method v is set to None 0 = Repeat 1 = Clamp **4 = Mirrored Repeat**
Int	40	4	Wrap method u 0 = Repeat 1 = Clamp 3 = None - use Wrap method u,v **4 = Mirrored Repeat**

Texture Attribute File Format changes for OpenFlight 16.0
Wrap method fields

Data Type	Offset	Length	Description
Int	44	4	Wrap method v 0 = Repeat 1 = Clamp 3 = None - use Wrap method u,v **4 = Mirrored Repeat**

The Environment type field has been changed to include a new possible value, Add as shown here. This new value is shown in **bold font**:

Texture Attribute File Format changes for OpenFlight 16.0
Environment type field

Data Type	Offset	Length	Description
Int	60	4	Environment type 0 = Modulate 1 = Blend 2 = Decal 3 = Replace **4 = Add**

Texture Mapping Palette Record

Parameters for 3 Point Put Texture Mapping (Type 1)

The following fields were added to the end (at the specified offsets) of the parameter subrecord.

Parameters for 3 Point Put Texture Mapping (Type 1)
changes for OpenFlight 16.0
New Fields

Data Type	Offset	Length	Description
Float	392	4	U Repetition
Float	396	4	V Repetition

D Summary of Changes Version 16.1

Overview

This section describes the changes in the OpenFlight Scene Description between versions 16.0 and 16.1 as well as the errors contained in previous versions of this document that have been corrected in this version.

OpenFlight version 16.1 coincides with MultiGen Creator version 3.1 and the OpenFlight API version 3.1. The changes made for this version are:

- "Shader Palette Record" on page 151
- "Texture Attribute File" on page 151

Document Corrections

The errors corrected in this version of the document are described in the sections that follow.

Mesh Record

Theoffset for the first Reserved field has been corrected. It was previously listed as 4. The correct offset is 12. The corrected field and offset are shown in **bold font:**

Mesh Record error corrected in OpenFlight 16.1 specification
Reserved field (corrected)

Data Type	Offset	Length	Description
Int	**12**	4	Reserved

For a complete description of the mesh record, see "Mesh Record" on page 29.

General Matrix Record

The opcode for this record has been corrected. It was previously listed as 82. The correct opcode is 94. The corrected field and opcode are shown in **bold font:**

General Matrix Record error corrected in OpenFlight 16.1 specification
Opcode (corrected)

Data Type	Offset	Length	Description
Int	0	2	**General Matrix Opcode 94**

For a complete description of the general matrix record, see "General Matrix Record" on page 60.

Parameters for Spherical Project Mapping

The reserved field at offset 172, previously omitted in prior versions of this document, has been documented in the specification for OpenFlight 16.1. The offsets of fields following this field have been adjusted accordingly.

Parameters for Spherical Project Mapping error corrected in OpenFlight 16.1 specification
Reserved field (documented)

Data Type	Offset	Length	Description
Int	172	4	Reserved

For a complete description of the parameters for spherical project mapping, see "Texture Mapping Palette Record" on page 86.

Format Changes

Shader Palette Record

The Shader palette record has been modified to support OpenGL Shading Language shader program files. The following parameter block will appear in the Shader palette record when the Shader type is 2 (OpenGL Shading Language).

Parameters for OpenGL Shading Language Shader

Data Type	Offset	Length	Description
char	1036	4	Number of vertex program files
char	1040	4	Number of fragment programs files
The following field is repeated for each vertex program file in the shader record.			
Int	Varies	1024	Vertex program file N
The following field is repeated for each fragment program file in the shader record.			
Int	Varies	1024	Fragment program file N

For a complete description of the shader palette record, see "Shader Palette Record" on page 91.

Texture Attribute File

The previously reserved field at offset 432 is now in use.

Texture Attribute File Format changes for OpenFlight 16.1
Cubemap field

Data Type	Offset	Length	Description
Int	432	4	TRUE if texture is used for cubemap

For a complete description of texture attribute files, see "Texture Attribute Files" on page 93.

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