OpenGL|SC ®

Safety-Critical Profile Specification

Version 1.0.1 (Difference Specification) (Annotated)

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Chapter 1

Overview

This document outlines the OpenGL Safety-Critical (SC) profile. The profile pipeline is described in the same order as in the OpenGL specification. The specification lists supported commands and state, and calls out commands and state that are part of the full (desktop) OpenGL specification but not part of the profile definition. This specification is not a standalone document describing the detailed behavior of the rendering pipeline subset and API. Instead, it provides a concise description of the differences between a full OpenGL renderer and the Safety-Critical renderer. This document is defined relative to the OpenGL 1.3 specification.

This document specifies the OpenGL Safety-Critical renderer. At this moment, no standard bindings to window systems or OS platforms exist. It is assumed that in the future, a companion document will define one or more bindings to window system/OS platform combinations analogous to the GLX, WGL, and AGL specifications. If required, an additional companion document will describe the utility library functionality analogous to the GLU specification.

1.1 Conventions

This document describes commands in the identical order as the OpenGL 1.3 specification. Each section corresponds to a section in the full OpenGL specification and describes the disposition of each command relative to Safety-Critical profile definition. Where necessary, the profile specification provides additional clarification of the reduced command behavior.

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Each section of the specification includes tables summarizing the commands and parameters that are retained in the Safety-Critical profile. The character "`T`" is used in place of a data type for a parameter to indicate that a data type appropriate to the command should be used. For example, if the command uses the suffix "**f**", as in **glVertex4f**, "`T`" is understood to be "`float`" and if the command has a suffix of "**fv**", as in **glVertex4fv**, then "`T`" is understood to be "`float *`". Several symbols are used within the tables to indicate various special cases. The symbol ◊ indicates that the double-precision form of the command is replaced with its single-precision variant from the `OES_single_precision` extension. The superscript "‡" indicates that the command is supported subject to additional constraints described in the section body containing the table.

> ■ Additional material summarizing some of the reasoning behind certain decisions is included as an annotation at the end of each section, set in this typeface. □

Chapter 2

OpenGL Operation

The basic GL operation remains largely unchanged. A significant change in the Safety-Critical profile is that the first stage of the pipeline for approximating curve and surface geometry is eliminated. The remaining pipeline stages include: display list processing, per-vertex operations and primitive assembly, pixel operations, rasterization, per-fragment operations, and whole framebuffer operations.

This Safety-Critical profile makes use of OpenGL extensions. These extensions are divided into two categories: those that are fully integrated into the profile definition – *core additions*; and those that remain extensions – *profile extensions*. Core additions do not use extension suffixes, whereas profile extensions retain their extension suffixes. Chapter 7 summarizes each extension and how it relates to the profile definition. Complete extension specifications are included in Appendix B.

■ The OpenGL SC profile is part of a wider family of OpenGL-derived application programming interfaces. As such, the profiles share a similar processing pipeline, command structure, and the same OpenGL name space. Where necessary, extensions are created to augment the existing OpenGL 1.3 functionality. OpenGL SC-specific extensions play a role in the OpenGL SC profile similar to that played by OpenGL ARB extensions relative to the OpenGL specification. OpenGL SC-specific extensions are either precursors of functionality destined for inclusion in future core profile revisions, or formalization of important but non-mainstream functionality.

Extension specifications are written relative to the full OpenGL specification so that they can also be added as extensions to an OpenGL 1.3 implementation and so that they are easily adapted to profile functionality enhancements that are drawn from the full OpenGL specification. Extensions that are part of the core profile do not have extension suffixes, since they are not extensions to the profile, though they are extensions to OpenGL 1.3. □

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2.1   OpenGL Fundamentals

Commands and tokens continue to be prefixed by **gl** and **GL_** in all profiles. The wide range of support for differing data types (8-bit, 16-bit, 32-bit and 64-bit; integer and floating-point) is reduced wherever possible to eliminate non-essential command variants and to reduce the complexity of the processing pipeline. Double-precision floating-point parameters and data types are eliminated completely, while other command and data type variations are considered on a command-by-command basis and eliminated when appropriate.

2.2   GL State

The Safety-Critical profile retains a large subset of the client and server state described in the full OpenGL specification. The separation of client and server state persists. Section 6.2 summarizes the disposition of all state variables relative to the Safety-Critical profile.

2.3   GL Command Syntax

Commands using the suffixes for the types: `byte`, `short`, and `ushort` are not supported. The type `double` and all double-precision commands are eliminated. The result is that the Safety-Critical profile uses only the suffixes '**f**', '**i**','**ub**', '**iv**', and '**fv**'.

2.4   Basic GL Operation

The basic command operation remains identical to OpenGL 1.3. The major difference from the OpenGL 1.3 pipeline is that there is no polynomial function evaluation stage.

2.5   GL Errors

The full OpenGL error detection behavior is retained, including ignoring offending commands and setting the current error state. In all commands, parameter values that are not supported by the profile are treated like any other unrecognized parameter value and an error results, i.e., `INVALID_ENUM` or `INVALID_VALUE`. Table 2.1 lists the errors.

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Table 2.1 Error Disposition

OpenGL 1.3	Safety-Critical
NO_ERROR	✓
INVALID_ENUM	✓
INVALID_VALUE	✓
INVALID_OPERATION	✓
STACK_OVERFLOW	✓
STACK_UNDERFLOW	✓
OUT_OF_MEMORY	✓
TABLE_TOO_LARGE	—

The command **GetError** is retained to return the current error state. As in OpenGL 1.3, it may be necessary to call **GetError** multiple times to retrieve error state from all parts of the pipeline.

OpenGL 1.3	Safety-Critical
GetError(void)	✓

■ Well defined error behavior allows portable applications to be written. Retrievable error state allows application developers to debug commands with invalid parameters during development. This is an important feature during initial profile deployment. Implementation errors (e.g. the hardware does not respond) are outside the scope of OpenGL SC and must be handled at the level of the OS binding layer. □

2.6 Begin/End Paradigm

The Safety-Critical profile supports the concept of **Begin**/**End** and display lists.

The primitives POINTS, LINES, LINE_STRIP, LINE_LOOP, TRIANGLES, TRIANGLE_STRIP, and TRIANGLE_FAN are supported; the primitives QUADS, QUAD_STRIP, and POLYGON are not supported.

Color index rendering is not supported. Edge flags are not supported.

OpenGL 1.3	Safety-Critical

Begin(enum mode)
   mode = POINTS,LINES,LINE STRIP,LINE_LOOP
   mode = TRIANGLES,TRIANGLE_STRIP,TRIANGLE_FAN
   mode = QUADS,QUAD STRIP,POLYGON
	
	✓
	✓
	—

End(void)	✓
EdgeFlag[v](T flag)	—

■ The **Begin/End** paradigm is supported because there are a majority of 2D safety-critical certifiable/qualifiable applications and tools that rely on this mechanism. The **Begin/End**

paradigm enables a melding of program and data in such a way as to allow a certifying authority to more clearly understand an application.

Edge flags are not included, as they are only used when drawing polygons as outlines and support for **PolygonMode** has not been included. Quads and polygons are eliminated since they can be readily emulated with triangles and it reduces the ambiguity with respect to decomposition of these primitives into triangles, since it is entirely left to the application. `float` types are supported for all-around generality. □

2.7 Vertex Specification

Vertices can be specified between **Begin** and **End**, as well as with vertex arrays. Only `float` coordinate and component types are supported with the exception of `ubyte` rather than `short` color components. There is limited support for specifying the current color, normal, and texture coordinate using the commands **Color4**, **Normal3**, and **MultiTexCoord2**.

Multitexture texture coordinates are supported, though only a single texture unit needs to be supported.

OpenGL 1.3	Safety-Critical
Vertex{23}f[v](T coords)	✓
Vertex{234}{sid}[v](T coords)	–
Vertex4f[v](T coords)	–
Normal3f[v](T coords)	✓
Normal3{bsid}[v](T coords)	–
TexCoord{1234}{sifd}[v](T coords)	–
MultiTexCoord2f[v](enum texture, T coords)	✓
MultiTexCoord2{sid}[v](enum texture, T coords)	–
MultiTexCoord134{sifd}[v](enum texture, T coords)	–
Color4{f fv ub}(T components)	✓
Color4ubv(T components)	–
Color4{bsid us ui}[v](T components)	–
Color3{bsifd ub us ui}[v](T components)	–
Index{sifd ub}[v](T components)	–

■ The **Begin/End** paradigm commands that have been included are based on common usage in safety-critical applications and code-generation tools. These have been augmented with the aim of forming an orthogonal set, e.g. if a usage is available for a normal, then it is also available for coordinate data.

Only 2-d texture coordinates can be specified – only 2-d textures are available, and texture matrix operations are not supported – so only 2 coordinates are useful.

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The Safety-Critical profile supports only the RGBA rendering model. Color index rendering is not a requirement. □

2.8 Vertex Arrays

Vertex arrays are supported with the same set of primitives available to **Begin**/**End**. Color index and edge flags are not supported. Both indexed and non-indexed arrays are supported, but the **InterleavedArrays**, **ArrayElement** and **DrawRangeElements** commands are not supported. Also, only a stride of zero is allowed for the supported array pointer commands (e.g., **VertexPointer**). Support for non-zero strides increases the implementation and testing burdens.

OpenGL 1.3	Safety-Critical
VertexPointer(int size, enum type, sizei stride, const void *ptr)	
size = 2,3 type = FLOAT	✓
size = 4 type = FLOAT	—
size = * type = INT,SHORT,DOUBLE	—
stride = 0	✓
stride != 0	—
NormalPointer(enum type, sizei stride, const void *ptr)	
type = FLOAT	✓
type = BYTE,UNSIGNED_BYTE,SHORT,UNSIGNED_SHORT	—
type = INT,UNSIGNED_INT,DOUBLE	—
stride = 0	✓
stride != 0	—
ColorPointer(int size, enum type, sizei stride, const void *ptr)	
type = UNSIGNED_BYTE,FLOAT	✓
type = BYTE,SHORT,UNSIGNED_SHORT	—
type = INT,UNSIGNED_INT,DOUBLE	—
stride = 0	✓
stride != 0	—
TexCoordPointer(int size, enum type, sizei stride, const void *ptr)	
size = 2 type = FLOAT	✓
all other combinations of size and type	—
stride = 0	✓
stride != 0	—
EdgeFlagPointer(sizei stride, const void *ptr)	—
IndexPointer(enum type, sizei stride, const void *ptr)	—
ArrayElement(int i)	—
DrawArrays(enum mode, int first, sizei count)	
mode = POINTS,LINES,LINE_STRIP,LINE_LOOP	✓
mode = TRIANGLES,TRIANGLE_STRIP,TRIANGLE_FAN	✓
mode = QUADS,QUAD_STRIP,POLYGON	—

OpenGL 1.3	Safety-Critical
DrawElements(enum mode, sizei count, enum type, const void *indices)	
mode = POINTS,LINES,LINE_STRIP,LINE_LOOP	✓
mode = TRIANGLES,TRIANGLE_STRIP,TRIANGLE_FAN	✓
mode = QUADS,QUAD_STRIP,POLYGON	—
type = UNSIGNED_BYTE,UNSIGNED_INT	✓
type = UNSIGNED_SHORT	—
InterleavedArrays(enum format, sizei stride, const void *pointer)	—
DrawRangeElements(enum mode, uint start, uint end, sizei count, enum type, const void *indices)	—
ClientActiveTexture(enum texture)	✓
EnableClientState(enum cap)	✓
DisableClientState(enum cap)	✓

■ Vertex arrays offer a performance improvement over **Begin/End**, particularly when rendering many elements of the same primitive at a time, such as in terrain rendering applications.

To further improve performance, vertex buffer objects will be a candidate for 1.1. ☐

2.9 Rectangles

The commands for directly specifying rectangles are not supported.

OpenGL 1.3	Safety-Critical
Rectf(T x1, T y1, T x2, T y2)	—
Rect{sid}(T x1, T y1, T x2, T y2)	—
Rect{sifd}v(T v1[2], T v2[2])	—

■ Although rectangle commands are used by existing safety-critical applications, they can be readily emulated by rendering triangle strips. ☐

2.10 Coordinate Transformations

The full transformation pipeline is supported with the following exceptions: no support for specification of double-precision matrices and transformation parameters; no support for the transpose form of the **LoadMatrix** and **MultMatrix** commands; no support for COLOR matrix and TEXTURE matrix; and no support for texture coordinate generation. The double-precision only commands **DepthRange**, **Frustum**, and **Ortho** are replaced with single-precision variants from the OES_single_precision extension.

OpenGL 1.3	Safety-Critical
DepthRange(clampd n, clampd f)	◊

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OpenGL 1.3	Safety-Critical
Viewport(int x, int y, sizei w, sizei h)	✓

MatrixMode(enum mode)
   mode = MODELVIEW,PROJECTION
   mode = COLOR,TEXTURE
	
	✓
	−

LoadMatrixf(float m[16])	✓
LoadMatrixd(double m[16])	−
MultMatrixf(float m[16])	✓
MultMatrixd(double m[16])	−
LoadTransposeMatrix{fd}(T m[16])	−
MultTransposeMatrix{fd}(T m[16])	−
LoadIdentity(void)	✓
Rotatef(float angle, float x, float y, float z)	✓
Rotated(double angle, double x, double y, double z)	−
Scalef(float x, float y, float z)	✓
Scaled(double x, double y, double z)	−
Translatef(float x, float y, float z)	✓
Translated(double x, double y, double z)	−
Frustum(double l, double r, double b, double t, double n, double f)	◊
Ortho(double l, double r, double b, double t, double n, double f)	◊
ActiveTexture(enum texture)	✓

PushMatrix(void)
   PROJECTION (2 deep)
   MODELVIEW (16 deep)
   TEXTURE
	
	✓
	✓
	−

PopMatrix(void)	✓
Enable/**Disable**(RESCALE_NORMAL)	✓
Enable/**Disable**(NORMALIZE)	✓
TexGen{ifd}[v](enum coord, enum pname, T param)	−
GetTexGen{ifd}v(enum coord, enum pname, T *params)	−
Enable/**Disable**(TEXTURE_GEN_{STRQ})	−

■ The double-precision version of the transform commands are not necessary when there is a single precision version. The matrix stacks and convenience functions for computing rotations, scales, and translations, as well as projection matrices with the exception of texture matrices are kept since they are used by a large number of applications. Inclusion of the texture matrix stack will be considered for 1.1. The non-transpose form of the matrix load and multiply commands are retained over the transpose versions to maximize compatibility with existing programming practices.

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The viewport and depth range commands are supported since they provide necessary application control over where primitives are drawn. Texture transformation is not a requirement, and so it is not included. While the **TexGen** command is useful, it is considered too much of an implementation burden (applications can implement it to some extent themselves). Both normalization and rescaling of normals are supported since normalization is deemed necessary and rescaling can be implemented using normalization minimizing implementation burden. □

2.11   Clipping

Clipping against the viewing frustum is supported; however, separate user-specified clipping planes are not supported.

OpenGL 1.3	Safety-Critical
ClipPlane(enum plane, const double *equation)	−
GetClipPlane(enum plane, double *equation)	−
Enable/**Disable**(CLIP_PLANE{0-5})	−

■ User-specified clipping planes aren't required by current safety-critical applications. User-specified clipping planes will be a candidate for 1.1. □

2.12   Current Raster Position

The concept of the current raster position for positioning pixel rectangles and bitmaps is supported. Current raster state and commands for setting the raster position are supported.

OpenGL 1.3	Safety-Critical
RasterPos2{sifd}[v](T coords)	−
RasterPos3f(T coords)	✓
RasterPos3fv(T coords)	−
RasterPos3{sid}[v](T coords)	−
RasterPos4{sifd}[v](T coords)	−

■ Bitmaps and pixel image primitives are supported. These primitives are positioned using the raster position command. Similarly to the Color, Normal, etc. commands, the most general floating-point form is supported. □

2.13   Colors and Coloring

The OpenGL 1.3 lighting model is supported with the following exceptions: no support for color index lighting, secondary color, different front and back materials, local viewer, or color material mode other than AMBIENT_AND_DIFFUSE.

Only directional lights are supported. An implementation must support a minimum of 2 lights. The **Material** command cannot independently change the front and back face

properties, so the result is that materials always have the same front and back properties. Two-sided lighting is not supported. The **ColorMaterial** command is not supported, so the color material mode cannot be changed from the default `AMBIENT_AND_DIFFUSE` mode, though `COLOR_MATERIAL` can be enabled in this mode. Neither local viewing computations nor separate specular color computation can be enabled using the **LightModel** command, therefore only the OpenGL 1.3 default infinite viewer and single color computational models are supported. Smooth and flat shading are fully supported for all primitives.

OpenGL 1.3	Safety-Critical
FrontFace(enum mode)	✓
Enable/**Disable**(LIGHTING)	✓
Enable/**Disable**(LIGHT{0-1})	✓

Materialf[v](enum face, enum pname, T param)
   face = FRONT_AND_BACK
   face = FRONT,BACK
   pname = AMBIENT, DIFFUSE,
         SPECULAR, EMISSION, SHININESS
   pname = AMBIENT_AND_DIFFUSE
   pname = COLOR_INDEXES
	✓
	—
	
	✓
	✓
	—

Materiali[v](enum face, enum pname, T param)	—

GetMaterialfv(enum face, enum pname, T *params)
   pname = AMBIENT,DIFFUSE,
         SPECULAR,EMISSION,SHININESS
   pname = COLOR_INDEXES
	
	✓
	—

GetMateriali[v](enum face, enum pname, int *params)	—
GetMaterialf(enum face, enum pname, float *params)	—

Lightfv(enum light, enum pname, T param)
   pname = AMBIENT,DIFFUSE,SPECULAR
   pname = POSITION
   pname = SPOT_CUTOFF,SPOT_DIRECTION,SPOT_EXPONENT
   pname = CONSTANT_ATTENUATION
   pname = LINEAR_ATTENUATION
   pname = QUADRATIC_ATTENUATION
	
	✓
	✓
	—
	—
	—
	—

Lightf(enum light, enum pname, T param)	—
Lighti[v](enum light, enum pname, T param)	—

GetLightfv(enum light, enum pname, T *params)
   pname = AMBIENT,DIFFUSE,SPECULAR
   pname = POSITION
   pname = SPOT_CUTOFF,SPOT_DIRECTION,SPOT_EXPONENT
   pname = CONSTANT_ATTENUATION
   pname = LINEAR_ATTENUATION
   pname = QUADRATIC_ATTENUATION
	
	✓
	✓
	—
	—
	—
	—

GetLighti[v](enum light, enum pname, int *params)	—
GetLightf(enum light, enum pname, float *params)	—

OpenGL 1.3	Safety-Critical

LightModelfv(enum pname, const float *params)
   pname = LIGHT_MODEL_AMBIENT
   pname = LIGHT_MODEL_TWO_SIDE
   pname = LIGHT_MODEL_COLOR_CONTROL
   pname = LIGHT_MODEL_LOCAL_VIEWER
	
	✓
	—
	—
	—

LightModelf(enum pname, float param)	—
LightModeli[v](enum pname, T param)	—
Enable/**Disable**(COLOR_MATERIAL)	✓‡
ColorMaterial(enum face, enum mode)	—
ShadeModel(enum mode)	✓

■ Lighting is a desirable feature. In safety-critical applications it is not used for complex cosmetic effects, or to model "real-life" lighting. Rather, it might be used to add shading to a relief map, or to add a "3D" feel to an instrument. To support this usage, only non-local lights are required (e.g. directional lights) in the Safety-Critical profile. The minimum number of lights is reduced to 2, which greatly reduces the testing burden while allowing for multiple lighting effects. Extensive research has not shown any need for more than 2 light sources. Support for secondary color is not required so it is not included. Local viewer and spot lights are not widely used even in the workstation space, and are removed to reduce testing burden. Two-sided lighting is not required by safety-critical applications and removing this feature further simplifies certification tests. Scene ambient is retained since its default value is non-zero and there would be no method to disable its effect if it were not included.

The most common use for the **ColorMaterial** functionality is to change the ambient and diffuse coefficients of the material. Since this is the default mode of the command, the **ColorMaterial** command is not included, but the ability to enable and disable it is, so the net effect is that only the ambient and diffuse material parameters can be modified. □

Chapter 3

Rasterization

3.1 Invariance

The invariance rules are retained in full.

3.2 Antialiasing

Multisampling is not supported.

OpenGL 1.3	Safety-Critical
Enable/**Disable**(MULTISAMPLE)	−

■ There is no demand for multisampling by current safety-critical (2D) applications. Polygon smoothing or line smoothing along the edges is sufficient and more appropriate for current applications. Multisampling will be a candidate for 1.1. □

3.3 Points

Aliased and antialiased points are fully supported.

OpenGL 1.3	Safety-Critical
PointSize(float size)	✓
Enable/**Disable**(POINT_SMOOTH)	✓

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■ See the note concerning antialiasing in section 3.4 below. □

3.4   Line Segments

Aliased and antialiased lines are fully supported. Line stippling is also fully supported.

OpenGL 1.3	Safety-Critical
LineWidth(float width)	✓
Enable/**Disable**(LINE_SMOOTH)	✓
LineStipple(int factor, ushort pattern)	✓
Enable/**Disable**(LINE_STIPPLE)	✓

■ Antialiasing is important for visual quality, an important issue in many safety-critical applications. Some antialiasing can be implemented within the application using 2D textures, but antialiasing is used by enough applications that it should be in the profile rather than something left to the application. The OpenGL 1.3 point and line antialiasing requirements provide substantial implementation latitude. In particular, only size/width 1.0 is required to be supported and the coverage computation constraints are easily satisfied. Line stippling is also commonly used in safety-critical applications. □

3.5   Polygons

Polygonal geometry support is reduced to triangle strips, triangle fans and independent triangles. All rasterization modes are supported except for point and line **PolygonMode** and POLYGON_SMOOTH. Depth offset is supported in FILL mode only.

OpenGL 1.3	Safety-Critical
CullFace(enum mode)	✓
Enable/**Disable**(CULL_FACE)	✓
PolygonMode(enum face, enum mode)	−
Enable/**Disable**(POLYGON_SMOOTH)	−
PolygonStipple(const ubyte *mask)	✓
GetPolygonStipple(ubyte *mask)	✓
Enable/**Disable**(POLYGON_STIPPLE)	✓
PolygonOffset(float factor, float units)	✓

Enable/**Disable**(enum cap)
   cap = POLYGON_OFFSET_FILL
   cap = POLYGON_OFFSET_LINE, POLYGON_OFFSET_POINT
	✓
	−

■ Support for all triangle types (independents, strips, fans) is not overly burdensome and each type has some desirable utility: strips for general performance and applicability, independents for efficiently specifying unshared vertex attributes, and fans for representing "corner-turning" geometry. Polygon modes are mostly used for debugging purposes, and are therefore not supported. Polygon smooth is as desirable as antialiasing for other primitives.

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However, its usefulness without support for polygon primitives and edge flag is very limited; Polygon smooth is therefore not supported. Face culling is important for eliminating unnecessary rasterization. Polygon stippling is commonly used in safety-critical applications. Polygon offset for filled triangles is necessary for rendering coplanar and outline polygons and if not present requires either stencil buffers or application tricks. □

3.6   Pixel Rectangles

Support for drawing pixel rectangles is limited to the format RGBA and type UNSIGNED_BYTE. Limited **PixelStore** support is retained to allow different pack alignments for **ReadPixels** and unpack alignments for **Bitmap**, **DrawPixels** and **TexImage2D**. **PixelTransfer** modes and **PixelZoom** are not supported. The Imaging subset is not supported.

OpenGL 1.3	Safety-Critical

PixelStorei(enum pname, T param)
    pname = PACK_ALIGNMENT,UNPACK_ALIGNMENT
    pname = *all other values*
	✓
	−

PixelStoref(enum pname, T param)	−
PixelTransfer{if}(enum pname, T param)	−
PixelMap{ui us f}v(enum map, int size, T *values)	−
GetPixelMap{ui us f}v(enum map, T *values)	−
Enable/**Disable**(COLOR_TABLE)	−
ColorTable(enum target, enum internalformat, sizei width, enum format, enum type, const void *table)	−
ColorSubTable(enum target, sizei start, sizei count, enum format, enum type, const void *data)	−
ColorTableParameter{if}v(enum target, enum pname, T *params)	−
GetColorTableParameter{if}v(enum target, enum pname, T *params)	−
CopyColorTable(enum target, enum internalformat, int x, int y, sizei width)	−
CopyColorSubTable(enum target, sizei start, int x, int y, sizei width)	−
GetColorTable(enum target, enum format, enum type, void *table)	−
ConvolutionFilter1D(enum target, enum internalformat, sizei width, enum format, enum type, const void *image)	−
ConvolutionFilter2D(enum target, enum internalformat, sizei width, sizei height, enum format, enum type, const void *image)	−

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OpenGL 1.3	Safety-Critical
GetConvolutionFilter(enum target, enum format, enum type, void *image)	—
CopyConvolutionFilter1D(enum target, enum internalformat, int x, int y, sizei width)	—
CopyConvolutionFilter2D(enum target, enum internalformat, int x, int y, sizei width, sizei height)	—
SeparableFilter2D(enum target, enum internalformat, sizei width, sizei height, enum format, enum type, const void *row, const void *column)	—
GetSeparableFilter(enum target, enum format, enum type, void *row, void *column, void *span)	—
ConvolutionParameter{if}[v](enum target, enum pname, T param)	—
GetConvolutionParameterfv(enum target, enum pname, T *params)	—
Enable/**Disable**(POST_CONVOLUTION_COLOR_TABLE)	—
MatrixMode(COLOR)	—
Enable/**Disable**(POST_COLOR_MATRIX_COLOR_TABLE)	—
Enable/**Disable**(HISTOGRAM)	—
Histogram(enum target, sizei width, enum internalformat, boolean sink)	—
ResetHistogram(enum target)	—
GetHistogram(enum target, boolean reset, enum format, enum type, void *values)	—
GetHistogramParameter{if}v(enum target, enum pname, T *params)	—
Enable/**Disable**(MINMAX)	—
Minmax(enum target, enum internalformat, boolean sink)	—
ResetMinmax(enum target)	—
GetMinmax(enum target, boolean reset, enum format, enum types, void *values)	—
GetMinmaxParameter{if}v(enum target, enum pname, T *params)	—
DrawPixels(sizei width, sizei height, enum format, enum type, void *data) format = RGBA type = UNSIGNED_BYTE	✓
all other combinations	—

OpenGL 1.3	Safety-Critical
PixelZoom(float xfactor, float yfactor)	—

■ The OpenGL 1.3 specification includes substantial support for operating on pixel images. Safety-critical applications require the ability to draw images directly in window coordinates, but with the constraint of minimizing the certification burden. To that end, the set of supported image formats and types is limited to one general format: RGBA with 8-bit components. There is minimal support for operating on images. The one exception is limited pixel storage mode support to allow different alignment options (other than the 4-byte OpenGL 1.0 default). **PixelZoom** and **PixelTransfer** are not used by safety-critical applications.

The command **PixelStore** must be included to allow changing the pack alignment for **ReadPixels** and unpack alignment for **TexImage2D** to something other than the default value of 4 to support `ubyte` RGB image formats. The integer version of **PixelStore** is retained rather than the floating-point version since all parameters can be fully expressed using integer values. ☐

3.7   Bitmaps

Bitmap images are fully supported.

OpenGL 1.3	Safety-Critical
Bitmap(sizei width, sizei height, float xorig, float yorig, float xmove, float ymove, const ubyte *bitmap)	✓

■ The **Bitmap** command doesn't offer any functionality which is not covered by **DrawPixels**. It is supported because safety-critical applications are using it to save memory usage on the host. ☐

3.8   Texturing

1D textures, 3D textures, and cube maps are not supported. 2D textures are supported with the following exceptions: only the image type `UNSIGNED_BYTE` is supported, as shown in Table 3.1. The only internal formats supported are the base internal formats: `RGBA`, `RGB`, `LUMINANCE`, `ALPHA`, and `LUMINANCE_ALPHA`. The format must match the base internal format (no conversions from one format to another during texture image processing are supported) as shown in Table 3.1.

The first call to **TexImage2D** for a texture object will set the size of the texture object, and, once established, it cannot be changed. Once the size of a texture object has been set, subsequent calls to **TexImage2D** for that texture object will have the following restrictions:

o   `internalFormat` must be identical to the `internalFormat` used for the first call to **TexImage2D** for the texture object.

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- o `width` must be **max**(2^{k-n},1), where *n* is the mipmap level for the call and *k* is the log$_2$ of the width of the level zero mipmap as set by the first call to **TexImage2D** for the texture object.

- o `height` must be **max**(2^{k-n},1), where *n* is the mipmap level for the call and *k* is the log$_2$ of the height of the level zero mipmap as set by the first call to **TexImage2D** for the texture object.

If mipmapping is disabled, subsequent calls to **TexImage2D** (for level zero) must have the same `internalFormat`, `width`, and `height` as the first call to **TexImage2D** for the texture object. If these restrictions are violated, an `INVALID_OPERATION` is generated.

Texture borders are not supported. The `border` parameter must be zero, and an `INVALID_VALUE` error results if it is non-zero.

CopyTexture, **CopyTexSubImage** and compressed textures are not supported.

Table 3.1   Image Types

OpenGL 1.3	Safety-Critical
UNSIGNED_BYTE	✓
BITMAP	−
BYTE	−
UNSIGNED_SHORT	−
SHORT	−
UNSIGNED_INT	−
INT	−
FLOAT	−
UNSIGNED_BYTE_3_3_2	−
UNSIGNED_BYTE_3_3_2_REV	−
UNSIGNED_SHORT_5_6_5	−
UNSIGNED_SHORT_5_6_5_REV	−
UNSIGNED_SHORT_4_4_4_4	−
UNSIGNED_SHORT_4_4_4_4_REV	−
UNSIGNED_SHORT_5_5_5_1	−
UNSIGNED_SHORT_5_5_5_1_REV	−
UNSIGNED_INT_8_8_8_8	−
UNSIGNED_INT_8_8_8_8_REV	−
UNSIGNED_INT_10_10_10_2	−
UNSIGNED_INT_10_10_10_2_REV	−

Wrap modes `REPEAT` and `CLAMP_TO_EDGE` are supported, but not `CLAMP` and

CLAMP_TO_BORDER. Texture priorities, LOD clamps, and explicit base and maximum level specification are not supported. The remaining OpenGL 1.3 texture parameters are supported including all filtering modes. Texture objects are supported, but proxy textures are not supported. Multitexture is supported, but the COMBINE texture environment mode is not.

OpenGL 1.3	Safety-Critical
TexImage1D(enum target, int level, int internalFormat, sizei width, int border, enum format, enum type, const void *pixels)	−

TexImage2D(enum target, int level, int internalFormat, sizei width, sizei height, int border, enum format, enum type, const void *pixels)
   target = TEXTURE_2D, border = 0
   target = PROXY_TEXTURE_2D
   border > 0
	
	✓
	−
	−

TexImage3D(enum target, int level, enum internalFormat, sizei width, sizei height, sizei depth, int border, enum format, enum type, const void *pixels)	−
GetTexImage(enum target, int level, enum format, enum type, void *pixels)	−
TexSubImage1D(enum target, int level, int xoffset, sizei width, enum format, enum type, const void *pixels)	−
TexSubImage2D(enum target, int level, int xoffset, int yoffset, sizei width, sizei height, enum format, enum type, const void *pixels)	✓‡
TexSubImage3D(enum target, int level, int xoffset, int yoffset, int zoffset, sizei width, sizei height, sizei depth, enum format, enum type, const void *pixels)	−
CopyTexImage1D(enum target, int level, enum internalformat, int x, int y, sizei width, int border)	−
CopyTexImage2D(enum target, int level, enum internalformat, int x, int y, sizei width, sizei height, int border)	−
CopyTexSubImage1D(enum target, int level, int xoffset, int x, int y, sizei width)	−
CopyTexSubImage2D(enum target, int level, int xoffset, int yoffset, int x, int y, sizei width, sizei height)	−
CopyTexSubImage3D(enum target, int level, int xoffset, int yoffset, int zoffset, int x, int y, sizei width, sizei height)	−

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OpenGL 1.3	Safety-Critical
CompressedTexImage1D(enum target, int level, enum internalformat, sizei width, int border, sizei imageSize, const void *data)	—
CompressedTexImage2D(enum target, int level, enum internalformat, sizei width, sizei height, int border, sizei imageSize, const void *data)	—
CompressedTexImage3D(enum target, int level, enum internalformat, sizei width, sizei height, sizei depth, int border, sizei imageSize, const void *data)	—
CompressedTexSubImage1D(enum target, int level, int xoffset, sizei width, enum format, sizei imageSize, const void *data)	—
CompressedTexSubImage2D(enum target, int level, int xoffset, int yoffset, sizei width, sizei height, enum format, sizei imageSize, const void *data)	—
CompressedTexSubImage3D(enum target, int level, int xoffset, int yoffset, int zoffset, sizei width, sizei height, sizei depth, enum format, sizei imageSize, const void *data)	—
GetCompressedTexImage(enum target, int lod, void *img)	—

TexParameteri(enum target, enum pname, int param)
    target = TEXTURE_2D
    target = TEXTURE_1D,TEXTURE_3D,TEXTURE_CUBE_MAP
    pname = TEXTURE_MIN_FILTER,TEXTURE_MAG_FILTER
    pname = TEXTURE_WRAP_S,TEXTURE_WRAP_T
    pname = TEXTURE_BORDER_COLOR
    pname = TEXTURE_MIN_LOD,TEXTURE_MAX_LOD
    pname = TEXTURE_BASE_LEVEL,TEXTURE_MAX_LEVEL
    pname = TEXTURE_WRAP_R
    pname = TEXTURE_PRIORITY
	
	✓
	—
	✓
	✓
	—
	—
	—
	—
	—

TexParameter{iv f[v]}(enum target, enum pname, T param)	—
GetTexParameterfv(enum target, enum pname, float *params)	—

GetTexParameteriv(enum target, enum pname, int *params)
    target = TEXTURE_2D
    target = TEXTURE_1D,TEXTURE_3D,TEXTURE_CUBE_MAP
    pname = TEXTURE_MIN_FILTER,TEXTURE_MAG_FILTER
    pname = TEXTURE_WRAP_S,TEXTURE_WRAP_T
    pname = TEXTURE_BORDER_COLOR
    pname = TEXTURE_MIN_LOD,TEXTURE_MAX_LOD
    pname = TEXTURE_BASE_LEVEL,TEXTURE_MAX_LEVEL
    pname = TEXTURE_WRAP_R
    pname = TEXTURE_PRIORITY
	
	✓
	—
	✓
	✓
	—
	—
	—
	—
	—

GetTexLevelParameter{if}v(enum target, int level, enum pname, T *params)	—

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OpenGL 1.3	Safety-Critical
BindTexture(enum target, uint texture) 　　target = TEXTURE_2D 　　target = TEXTURE_1D,TEXTURE_3D,TEXTURE_CUBE_MAP	 ✓ —
DeleteTextures(sizei n, const uint *textures)	—
GenTextures(sizei n, uint *textures)	✓
IsTexture(uint texture)	—
AreTexturesResident(sizei n, uint *textures, boolean *residences)	—
PrioritizeTextures(sizei n, uint *textures, clampf *priorities)	—
Enable/**Disable**(enum cap) 　　cap = TEXTURE_2D 　　cap = TEXTURE_1D,TEXTURE_3D,TEXTURE_CUBE_MAP	 ✓ —
TexEnvfv(enum target, enum pname, float *params) 　　pname = TEXTURE_ENV_COLOR 　　pname = TEXTURE_ENV_MODE 　　pname = COMBINE_RGB,COMBINE_ALPHA 　　pname = SOURCE{012}_RGB,SOURCE{012}_ALPHA 　　pname = RGB_SCALE,ALPHA_SCALE	 ✓ — — — —
TexEnvi(enum target, enum pname, int param) 　　pname = TEXTURE_ENV_COLOR 　　pname = TEXTURE_ENV_MODE: 　　　param = MODULATE,REPLACE,DECAL 　　　param = BLEND,ADD 　　　param = COMBINE 　　pname = COMBINE_RGB,COMBINE_ALPHA 　　pname = SOURCE{012}_RGB,SOURCE{012}_ALPHA 　　pname = RGB_SCALE,ALPHA_SCALE	 — ✓ ✓ — — — —
TexEnv{iv f}(enum target, enum pname, T param)	—
GetTexEnvfv(enum target, enum pname, float *params) 　　pname = TEXTURE_ENV_COLOR 　　pname = TEXTURE_ENV_MODE 　　pname = COMBINE_RGB,COMBINE_ALPHA 　　pname = SOURCE{012}_RGB,SOURCE{012}_ALPHA 　　pname = RGB_SCALE,ALPHA_SCALE	 ✓ — — — —
GetTexEnviv(enum target, enum pname, int *params) 　　pname = TEXTURE_ENV_COLOR 　　pname = TEXTURE_ENV_MODE 　　pname = COMBINE_RGB,COMBINE_ALPHA 　　pname = SOURCE{012}_RGB,SOURCE{012}_ALPHA 　　pname = RGB_SCALE,ALPHA_SCALE	 — ✓ — — —

■ Texturing with 2D images is a critical feature for mapping operations, and in some cases, for drawing text with arbitrary position and orientation. 1D, 3D, and cube map textures are less important. Texture objects are required for managing multiple textures. In some applications packing multiple textures into a single large texture is necessary for performance, therefore subimage support is also included.

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Texture deletion is not supported, as it is difficult to handle fragmentation and to meet real-time constraints at the same time. A real-time friendly texture deletion mechanism will be considered for 1.1.

To further facilitate the texture memory manager to meet real-time constraints, possible modifications of texture have been limited. Once a texture level is loaded, it cannot be modified in size. **TexImage2D** is restricted to allow only modifications of a loaded texture level which do not affect its internal format, width, height or border.

A limited set of formats, types and internal formats is included, as shown in Table 3.2. The RGB component ordering is always RGBA rather than BGRA since there is no real perceived advantage to using BGRA. As Safety-critical devices are not generally memory constrained, there is no support for low-resolution types. Textures with 8-bits per component are typical.

Copying from the framebuffer into textures is not supported, since this feature has not been demanded. If this functionality were to be added, "render to texture" would be preferred for its efficiency.

Texture borders are not included, as the modern way is to use CLAMP_TO_EDGE. If proper transition/interpolation across tiled textures is necessary, a sub region of the texture (2^n-1) can be used. All filter modes are supported since they represent a useful set of quality and speed options. Edge clamp and repeat wrap modes are both supported since these are most commonly used.

Texture priorities are not supported since they are seldom used by applications. Similarly, the ability to control the LOD range and the base and maximum mipmap image levels is not included, since these features are used by a narrow set of applications. Since all of the supported texture parameters are scalar valued, the vector form of the parameter command is eliminated.

Table 3.2   Texture Image Formats and Types

Internal Format	External Format	Type	Bytes per Pixel
RGBA	RGBA	UNSIGNED_BYTE	4
RGB	RGB	UNSIGNED_BYTE	3
LUMINANCE_ALPHA	LUMINANCE_ALPHA	UNSIGNED_BYTE	2
LUMINANCE	LUMINANCE	UNSIGNED_BYTE	1
ALPHA	ALPHA	UNSIGNED_BYTE	1

All OpenGL 1.3 texture environments except for the combine mode are supported. Combine is not supported as it creates a substantial implementation burden and is expected to be replaced with pixel shaders in some future version.

Compressed textures are important for reducing space and bandwidth requirements. In the safety-critical space, texture compression is not an issue and is not included. In the safety-critical space, texture priority and "residence" are not relevant. In this space it is very important to have repeatable, consistent execution time, and so most implementations will choose only to maintain "resident" textures. □

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3.9   Fog

Fog is not supported.

OpenGL 1.3	Safety-Critical
Fog{if}[v](enum pname, T param)	–
Enable/**Disable**(FOG)	–

■ Current safety-critical (2D) applications are not using fog. Terrain rendering applications are expected to use this feature in the future. Fog is a candidate for 1.1. □

Chapter 4

Per-Fragment Operations and the Framebuffer

4.1 Per-Fragment Operations

Most per-fragment operation functionalities are reduced.

Color index related operations and the imaging subset additions (**BlendColor** and **BlendEquation**) are not supported. Alpha test is supported for LEQUAL and ALWAYS. **BlendFunc** is supported for the combinations shown in Table 4.1:

Table 4.1   Blend Factor Combinations

Source Factor	Destination Factor
SRC_ALPHA	ONE_MINUS_SRC_ALPHA
SRC_ALPHA_SATURATE	ONE
ONE	ZERO

Depth test is supported for LESS, LEQUAL, and ALWAYS. Depth masking is supported. All other masking operations are not supported. Dithering and logic op are not supported. Scissor and stencil operations are fully supported. An implementation is not required to include a depth or stencil buffer.

OpenGL 1.3	Safety-Critical
Enable/**Disable**(SCISSOR_TEST)	✓
Scissor(int x, int y, sizei width, sizei height)	✓
Enable/**Disable**(SAMPLE_COVERAGE)	−
Enable/**Disable**(SAMPLE_ALPHA_TO_COVERAGE)	−
Enable/**Disable**(SAMPLE_ALPHA_TO_ONE)	−
SampleCoverage(clampf value, boolean invert)	−
Enable/**Disable**(ALPHA_TEST)	✓

AlphaFunc(enum func, clampf ref)
    func = LEQUAL, ALWAYS
    func = *all other values*
	
	✓
	−

Enable/**Disable**(STENCIL_TEST)	✓
StencilFunc(enum func, int ref, uint mask)	✓
StencilMask(uint mask)	✓
StencilOp(enum fail, enum zfail, enum zpass)	✓
Enable/**Disable**(DEPTH_TEST)	✓

DepthFunc(enum func)
    func = LESS, LEQUAL, ALWAYS
    func = *all other values*
	
	✓
	−

DepthMask(boolean flag)	✓
Enable/**Disable**(BLEND)	✓

BlendFunc(enum sfactor, enum dfactor)
    sfactor = SRC_ALPHA,dfactor = ONE_MINUS_SRC_ALPHA
    sfactor = SRC_ALPHA_SATURATE, dfactor = ONE
    sfactor = ONE, dfactor = ZERO
    all other combinations
	
	✓
	✓
	✓
	−

BlendEquation(enum mode)	−
BlendColor(clampf red, clampf green, clampf blue, clampf alpha)	−
Enable/**Disable**(DITHER)	−
Enable/**Disable**(INDEX_LOGIC_OP)	−
Enable/**Disable**(COLOR_LOGIC_OP)	−
LogicOp(enum opcode)	−

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■ Scissor is useful for providing complete control over where pixels are drawn and some form of window/drawing-surface scissoring is typically present in most rasterizers so the cost is small. Alpha testing is useful for early rejection of transparent pixels and for some kinds of keying. Stenciling is useful for drawing with masks and for a number of presentation effects and an implementation is not required to support a stencil buffer (just the API and the correct behavior when not present). Depth buffering is essential for many 3D applications and the profile should require some form of depth buffer to be present. Blending is necessary for implementing transparency and smoothing, other combinations of blend factors are removed to simplify certification tests. Additive blending will be a candidate for 1.1. Dithering is not required since frame buffers usually offer a resolution of 8 bits per component or more. By removing dithering, no implementation algorithm needs to be defined which would have to be tested for. Logic op is not used in the safety-critical space. Its omission will simplify certification tests. Mask operations other than **DepthMask** are not supported to simplify certification. **DepthMask** allows depth test without updating the depth buffer, which is useful for rendering transparent objects. In many cases, such as depth test, alpha test, blending, the number of potential modes has been reduced in order to limit the certification burden. Many modes are included in OpenGL 1.3 for completeness, and are not useful to most applications. Depth test is not only useful for correct depth occlusion, but also for visibility control of objects according to assigned priorities. The depth comparison function LESS is default and is the most commonly used function. The depth comparison function LEQUAL is useful to render screen aligned anti-aliased lines and points correctly without requiring polygon offset. The depth comparison function ALWAYS is useful for depth buffer shaping. In safety-critical applications, it can be used to cut out complex instruments, and for filtering priority classes of objects. **DepthFunc**(ALWAYS) and **DepthMask** complement each other. □

4.2   Whole Framebuffer Operations

All whole framebuffer operations are supported except for color index related operations, drawing to different color buffers, and accumulation buffer.

OpenGL 1.3	Safety-Critical
DrawBuffer(enum mode)	−
IndexMask(uint mask)	−
ColorMask(boolean red, boolean green, boolean blue, boolean alpha)	✓
Clear(bitfield mask)	✓
ClearColor(clampf red, clampf green, clampf blue, clampf alpha)	✓
ClearIndex(float c)	−
ClearDepth(clampd depth)	◊
ClearStencil(int s)	✓
ClearAccum(float red, float green, float blue, float alpha)	−
Accum(enum op, float value)	−

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■ Multiple drawing buffers are not exposed; an application can only draw to the default buffer, so **DrawBuffer** is not necessary. The accumulation buffer is not used in many applications, though it is useful as a non-interactive antialiasing technique. ☐

4.3   Drawing, Reading, and Copying Pixels

ReadPixels is supported with the following exceptions: the depth and stencil buffers cannot be read from and the number of format and type combinations for **ReadPixels** is severely restricted (see **DrawPixels**). The only format/type combination which is supported is format RGBA and type UNSIGNED_BYTE. **CopyPixels** is supported for color buffer only. **ReadBuffer** is not supported. Read operations return data from the default color buffer.

OpenGL 1.3	Safety-Critical
ReadBuffer(enum mode)	—
ReadPixels(int x, int y,sizei width, sizei height, enum format, enum type, void *pixels)	✓‡

CopyPixels(int x, int y, sizei width, sizei height, enum type)
    type = COLOR
    type = DEPTH, STENCIL
	
	✓
	—

■ Reading the color buffer is useful for some applications and also provides a platform independent method for testing. Pixel copy performance is important some applications, and in addition, on those platforms that support offscreen PBuffers, it provides the fastest possible mechanism for copying prerendered portions of the screen into the current buffer. Drawing to and reading from the depth and stencil buffers is not used frequently in applications (though it would be convenient for testing), so it is not included. **CopyPixels** is supported to enable fast copy from a pbuffer. This allows the hardware to be run at reduced clock speed to economize power consumption. **ReadBuffer** is not required since the concept of multiple drawing buffers is not exposed. ☐

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Chapter 5

Special Functions

5.1 Evaluators

Evaluators are not supported.

OpenGL 1.3	Safety-Critical
Map1{fd}(enum target, T u1, T u2, int stride, int order, T points)	—
Map2{fd}(enum target, T u1, T u2, int ustride, int uorder, T v1, T v2, int vstride, int vorder, T *points)	—
GetMap{ifd}v(enum target, enum query, T *v)	—
EvalCoord{12}{fd}[v](T coord)	—
MapGrid1{fd}(int un, T u1, T u2)	—
MapGrid2{fd}(int un, T u1, T u2, T v1, T v2)	—
EvalMesh1(enum mode, int i1, int i2)	—
EvalMesh2(enum mode, int i1, int i2, int j1, int j2)	—
EvalPoint1(int i)	—
EvalPoint2(int i, int j)	—

■ Evaluators are not used by many applications other than sophisticated CAD applications. □

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5.2   Selection

Selection is not supported.

OpenGL 1.3	Safety-Critical
InitNames(`void`)	−
LoadName(`uint name`)	−
PushName(`uint name`)	−
PopName(`void`)	−
RenderMode(`enum mode`)	−
SelectBuffer(`sizei size, uint *buffer`)	−

> ■ Selection is not used by many applications. There are other methods that applications can use to implement picking operations. ☐

5.3   Feedback

Feedback is not supported.

OpenGL 1.3	Safety-Critical
FeedbackBuffer(`sizei size, enum type, float *buffer`)	−
PassThrough(`float token`)	−

> ■ Feedback is seldom used. ☐

5.4   Display Lists

Display lists are supported with the exception of **CallList**, **IsList** and **DeleteLists**. An implementation does not need to support recursive display list execution (`MAX_LIST_NESTING` is at least 1).

OpenGL 1.3	Safety-Critical

NewList(`uint list, enum mode`)
    `mode = COMPILE`
    `mode = COMPILE_AND_EXECUTE`
	
	✓
	−

EndList(`void`)	✓
CallList(`uint list`)	−

CallLists(`sizei n, enum type, const void *lists`)
    `type = UNSIGNED_BYTE, UNSIGNED_INT`
    `type = BYTE, SHORT, UNSIGNED_SHORT, INT`
	
	✓
	−

ListBase(`uint base`)	✓
GenLists(`sizei range`)	✓
IsList(`uint list`)	−

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OpenGL 1.3	Safety-Critical
DeleteLists(uint list, sizei range)	—

■ Safety-critical applications using the **Begin/End** paradigm also use display lists to improve performance. On a system with multiple applications running simultaneously, drivers are implemented in such a way that one application cannot damage another. The drivers are rendering in indirect mode, which has a penalty on bandwidth. Using display lists allows to reduce bandwidth requirements to gain back performance.

In **NewList**, COMPILE_AND_EXECUTE is not supported since the same effect can be achieved by calling **NewList** followed by **CallLists**.

CallList is not supported as the same functionality is already provided by **CallLists**. **IsList** is not supported as it is not useful for state preservation.

Desktop OpenGL includes **DeleteLists** to allow complex applications to reclaim display list memory at run-time. However, implementing **DeleteLists** requires "real" memory management for handling the display list names, adding a burden to the driver implementation. Also, it is difficult to implement compacting or garbage-collection while respecting real-time constraints. Current safety-critical applications rarely call **DeleteLists**, it is therefore feasible to omit **DeleteLists** and to push the memory management issues from the driver to the application. Inclusion of **DeleteLists** or a replacement with similar functionality will be considered for 1.1.

Nesting of display lists results in recursive execution of display lists. This is not desirable in safety-critical applications, as it makes the execution time of a display list less deterministic, failing to meet a real-time constraint. The minimal maximum nesting depth is reduced to 1 to allow implementations without recursive display list execution. □

5.5   Flush and Finish

Flush and Finish are supported.

OpenGL 1.3	Safety-Critical
Flush(void)	✓
Finish(void)	✓

■ Applications need some manner to guarantee rendering has completed, so **Finish** needs to be supported. **Flush** can be trivially supported. □

5.6   Hints

Hints related to supported features are retained. The implementation must specify precisely how the functionality referred to by each hint is implemented, including the semantics of FASTEST, NICEST, and in particular DONT_CARE.

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OpenGL 1.3	Safety-Critical
Hint(enum target, enum mode)	
target = PERSPECTIVE_CORRECTION_HINT	✓
target = POINT_SMOOTH_HINT	✓
target = LINE_SMOOTH_HINT	✓
target = POLYGON_SMOOTH_HINT	—
target = FOG_HINT	—
target = TEXTURE_COMPRESSION_HINT	—

■ Hints are supported because safety-critical applications are often developed on desktop systems where OpenGL implementations usually set the hint mode DONT_CARE (the default) equal to FASTEST. Safety-critical applications prefer to use NICEST, therefore the hints are being used. For certification purposes, an implementation must document the semantics of the hint modes. □

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Chapter 6

State and State Requests

6.1 Querying GL State

State queries are supported for *static* and *dynamic* states, errors (see GL Errors) and strings. Query of derived dynamic states is not supported.

The values of the strings returned by **GetString** are specified as part of the profile definition. In particular, the version string indicates the OpenGL SC profile as well as the version of that profile. Strings are listed in Table 6.1.

As the profile is revised, the `VERSION` string is updated to indicate the revision. The string format is fixed and includes the two-character profile identifier SC for the Safety-Critical profile; and the two-digit version number (`X.Y`).

Table 6.1   String State

Strings	
VENDOR	as defined by OpenGL 1.3
RENDERER	as defined by OpenGL 1.3
VERSION	"OpenGL SC 1.0"
EXTENSIONS	as defined by OpenGL 1.3

Client and server attribute stacks are not supported by the profile; consequently, the

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commands **PushAttrib**, **PopAttrib**, **PushClientAttrib**, and **PopClientAttrib** are not supported.

OpenGL 1.3	Safety-Critical
GetBooleanv(enum pname, boolean *params)	✓‡
GetClipPlane(enum plane, double eqn[4])	—
GetCompressedTexImage(enum target, int level, void *image)	—
GetDoublev(enum pname, double *params)	—
GetFloatv(enum pname, float *params)	✓‡
GetIntegerv(enum pname, int *params)	✓‡
GetLightfv(enum light, enum pname, float *params)	✓‡
GetMapifdv(enum target, enum pname, T *params)	—
GetMaterialfv(enum face, enum pname, float *params)	✓‡
GetMaterialiv(enum face, enum pname, int *params)	—
GetPixelMap{f ui us}v(enum map, T *params)	—
GetPointerv(enum pname, void **params)	✓‡
GetPolygonStipple(ubyte *mask)	✓
GetString(enum name)	✓
GetTexEnvfv(enum env, enum pname, float *params)	✓‡
GetTexEnviv(enum env, enum pname, int *params)	✓‡
GetTexGen{if}v(enum coord, enum pname, T *params)	—
GetTexImage(enum target, int level, enum format, enum type, void *pixels)	—
GetTexLevelParameter{if}v(enum target, int level, enum pname, T *params)	—
GetTexParameterfv(enum target, enum pname, float *params)	—
GetTexParameteriv(enum target, enum pname, int *params)	✓‡
IsEnabled(enum cap)	✓‡
IsTexture(uint texture)	—
IsList(uint list)	—
PushAttrib(bitfield mask)	—
PopAttrib(void)	—
PushClientAttrib(bitfield mask)	—
PopClientAttrib(void)	—

■ For small and monolithic safety-critical applications, there should never be the need for the application to query the OpenGL state. Anything which the application does that is based

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on a query of a static piece of data, for example, could (and should) easily have been built into the application at compile time, thus reducing the certification effort.

Large-scale safety-critical applications are composed of multiple modules, potentially from different vendors. The modules are certified individually, simplifying the certification effort of the integrated application.

Without a mechanism for state preservation, the vendors have to rely on conventions and completeness of API documentation with respect to state changes. To allow defensive implementation of middleware, either **Get**s or attribute stacks are required.

Gets are real-time friendlier: For hardware implementations, the queryable states can be shadowed. The dynamic states can be queried within a predicted time window. **Get**s do not require dynamic memory allocation. State memory management is pushed back to the application. **Get**s can also be helpful for certification tests.

Attribute stacks are easier to use and may be more efficient when many states have to be changed. Attribute stacks may be accelerated by hardware implementations. Attribute stacks have a stack size limit.

As the real-time requirements which are easily satisfiable by **Get**s outweigh the convenience and possible performance improvements of attribute stacks, the choice is to support **Get**s.

Static **Get**s ease conformance test porting and development of middleware for large-scale safety-critical applications. The certification burden of static **Get**s is minimal. Although the values returned by static **Get**s could be obtained otherwise at build time, it is better to have a standard way to provide this information.

The string queries are retained as they provide important versioning, and extension information. □

6.2   State Tables

Table 6.2 through Table 6.19 indicate which state variables may be obtained by which commands. State variables that can be obtained using any of **GetBooleanv**, **GetIntegerv**, or **GetFloatv** are listed with just one of these commands – the one that is most appropriate given the type of data to be returned and the profile used. These state variables cannot be obtained using **IsEnabled**. However, state variables for which **IsEnabled** is listed as the query command can also be obtained using **GetBooleanv**, **GetIntegerv**, and **GetFloatv**. State variables for which any command other than **IsEnabled** is listed as the query command can be obtained only by using that command. State appearing in italics indicates unnamed state. All state has initial values identical to those specified in OpenGL 1.3.

Table 6.2   GL Internal begin-end state variables

State	Exposed	Queriable	Command
Begin/end object	✓	–	–
Previous line vertex	✓	–	–

State	Exposed	Queriable	Command
First line-vertex flag	✓	−	−
First vertex of line loop	✓	−	−
Line stipple counter	✓	−	−
Polygon vertices	−	−	−
Number of polygon vertices	−	−	−
Previous two triangle strip vertices	✓	−	−
Number of triangle strip vertices	✓	−	−
Triangle strip A/B pointer	✓	−	−
Quad vertices	−	−	−
Number of quad strip vertices	−	−	−

Table 6.3   Current Values and Associated Data

State	Exposed	Queriable	Command
CURRENT_COLOR	✓	✓	**GetFloatv**
CURRENT_INDEX	−	−	−
CURRENT_TEXTURE_COORDS	✓	✓	**GetFloatv**
CURRENT_NORMAL	✓	✓	**GetFloatv**
Color associated with last vertex	✓	−	−
Color index associated with last vertex	−	−	−
Texture coordinates associated with last vertex	✓	−	−
CURRENT_RASTER_POSITION	✓	−	−
CURRENT_RASTER_DISTANCE	✓	−	−
CURRENT_RASTER_COLOR	✓	✓	**GetFloatv**
CURERNT_RASTER_INDEX	−	−	−
CURRENT_RASTER_TEXTURE_COORDS	✓	✓	**GetFloatv**
CURRENT_RASTER_POSITION_VALID	✓	−	−
EDGE_FLAG	−	−	−

Table 6.4   Vertex Array Data

State	Exposed	Queriable	Command
CLIENT_ACTIVE_TEXTURE	✓	✓	**GetIntegerv**
VERTEX_ARRAY	✓	✓	**IsEnabled**
VERTEX_ARRAY_SIZE	✓	✓	**GetIntegerv**
VERTEX_ARRAY_STRIDE	✓	✓	**GetIntegerv**
VERTEX_ARRAY_TYPE	✓	✓	**GetIntegerv**
VERTEX_ARRAY_POINTER	✓	✓	**GetPointerv**

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State	Exposed	Queriable	Command
NORMAL_ARRAY	✓	✓	**IsEnabled**
NORMAL_ARRAY_STRIDE	✓	✓	**GetIntegerv**
NORMAL_ARRAY_TYPE	✓	✓	**GetIntegerv**
NORMAL_ARRAY_POINTER	✓	✓	**GetPointerv**
COLOR_ARRAY	✓	✓	**IsEnabled**
COLOR_ARRAY_SIZE	✓	✓	**GetIntegerv**
COLOR_ARRAY_STRIDE	✓	✓	**GetIntegerv**
COLOR_ARRAY_TYPE	✓	✓	**GetIntegerv**
COLOR_ARRAY_POINTER	✓	✓	**GetPointerv**
INDEX_ARRAY	–	–	–
INDEX_ARRAY_STRIDE	–	–	–
INDEX_ARRAY_TYPE	–	–	–
INDEX_ARRAY_POINTER	–	–	–
TEXTURE_COORD_ARRAY	✓	✓	**IsEnabled**
TEXTURE_COORD_ARRAY_SIZE	✓	✓	**GetIntegerv**
TEXTURE_COORD_ARRAY_STRIDE	✓	✓	**GetIntegerv**
TEXTURE_COORD_ARRAY_TYPE	✓	✓	**GetIntegerv**
TEXTURE_COORD_ARRAY_POINTER	✓	✓	**GetPointerv**
EDGE_FLAG_ARRAY	–	–	–
EDGE_FLAG_ARRAY_STRIDE	–	–	–
EDGE_FLAG_ARRAY_POINTER	–	–	–

Table 6.5   Transformation State

State	Exposed	Queriable	Command
COLOR_MATRIX	–	–	–
MODEL_VIEW_MATRIX	✓	✓	**GetFloatv**
PROJECTION_MATRIX	✓	✓	**GetFloatv**
TEXTURE_MATRIX	–	–	–
VIEWPORT	✓	✓	**GetIntegerv**
DEPTH_RANGE	✓	✓	**GetFloatv**
COLOR_MATRIX_STACK_DEPTH	–	–	–
MODELVIEW_STACK_DEPTH	✓	✓	**GetIntegerv**
PROJECTION_STACK_DEPTH	✓	✓	**GetIntegerv**
TEXTURE_STACK_DEPTH	–	–	–
MATRIX_MODE	✓	✓	**GetIntegerv**
NORMALIZE	✓	✓	**IsEnabled**
RESCALE_NORMAL	✓	✓	**IsEnabled**

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State	Exposed	Queriable	Command
CLIP_PLANE{0-5}	—	—	—

Table 6.6   Coloring

State	Exposed	Queriable	Command
FOG_COLOR	—	—	—
FOG_INDEX	—	—	—
FOG_DENSITY	—	—	—
FOG_START	—	—	—
FOG_END	—	—	—
FOG_MODE	—	—	—
FOG	—	—	—
SHADE_MODEL	✓	✓	**GetIntegerv**

Table 6.7   Lighting

State	Exposed	Queriable	Command
LIGHTING	✓	✓	**IsEnabled**
COLOR_MATERIAL	✓	✓	**IsEnabled**
COLOR_MATERIAL_PARAMETER	—	—	—
COLOR_MATERIAL_FACE	—	—	—
AMBIENT (material)	✓	✓	**GetMaterialfv**
DIFFUSE (material)	✓	✓	**GetMaterialfv**
SPECULAR (material)	✓	✓	**GetMaterialfv**
EMISSION (material)	✓	✓	**GetMaterialfv**
SHININESS (material)	✓	✓	**GetMaterialfv**
LIGHT_MODEL_AMBIENT	✓	✓	**GetFloatv**
LIGHT_MODEL_LOCAL_VIEWER	—	—	—
LIGHT_MODEL_TWO_SIDE	—	—	—
LIGHT_MODEL_COLOR_CONTROL	—	—	—
AMBIENT (light$_i$)	✓	✓	**GetLightfv**
DIFFUSE (light$_i$)	✓	✓	**GetLightfv**
SPECULAR (light$_i$)	✓	✓	**GetLightfv**
POSITION (light$_i$)	✓	✓	**GetLightfv**
CONSTANT_ATTENUATION	—	—	—
LINEAR_ATTENUATION	—	—	—
QUADRATIC_ATTENUATION	—	—	—
SPOT_DIRECTION	—	—	—

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State	Exposed	Queriable	Command
SPOT_EXPONENT	–	–	–
SPOT_CUTOFF	–	–	–
LIGHT{0-1}	✓	✓	**IsEnabled**
COLOR_INDEXES	–	–	–

Table 6.8   Rasterization

State	Exposed	Queriable	Command
POINT_SIZE	✓	✓	**GetFloatv**
POINT_SMOOTH	✓	✓	**IsEnabled**
LINE_WIDTH	✓	✓	**GetFloatv**
LINE_SMOOTH	✓	✓	**IsEnabled**
LINE_STIPPLE_PATTERN	✓	✓	**GetIntegerv**
LINE_STIPPLE_REPEAT	✓	✓	**GetIntegerv**
LINE_STIPPLE	✓	✓	**IsEnabled**
CULL_FACE	✓	✓	**IsEnabled**
CULL_FACE_MODE	✓	✓	**GetIntegerv**
FRONT_FACE	✓	✓	**GetIntegerv**
POLYGON_SMOOTH	–	–	–
POLYGON_MODE	–	–	–
POLYGON_OFFSET_FACTOR	✓	✓	**GetFloatv**
POLYGON_OFFSET_UNITS	✓	✓	**GetFloatv**
POLYGON_OFFSET_POINT	–	–	–
POLYGON_OFFSET_LINE	–	–	–
POLYGON_OFFSET_FILL	✓	✓	**IsEnabled**
polygon stipple pattern	✓	✓	**GetPolygonStipple**
POLYGON_STIPPLE	✓	✓	**IsEnabled**

Table 6.9   Multisampling

State	Exposed	Queriable	Command
MULTISAMPLE	–	–	–
SAMPLE_ALPHA_TO_COVERAGE	–	–	–
SAMPLE_ALPHA_TO_ONE	–	–	–
SAMPLE_COVERAGE	–	–	–
SAMPLE_COVERAGE_VALUE	–	–	–
SAMPLE_COVERAGE_INVERT	–	–	–

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Table 6.10   Texture Objects

State	Exposed	Queriable	Command
TEXTURE_1D	—	—	—
TEXTURE_2D	✓	✓	**IsEnabled**
TEXTURE_3D	—	—	—
TEXTURE_CUBE_MAP	—	—	—
TEXTURE_BINDING_1D	—	—	—
TEXTURE_BINDING_2D	✓	✓	**GetIntegerv**
TEXTURE_BINDING_3D	—	—	—
TEXTURE_BINDING_CUBE_MAP	—	—	—
TEXTURE_CUBE_MAP_POSITIVE_X	—	—	—
TEXTURE_CUBE_MAP_NEGATIVE_X	—	—	—
TEXTURE_CUBE_MAP_POSITIVE_Y	—	—	—
TEXTURE_CUBE_MAP_NEGATIVE_Y	—	—	—
TEXTURE_CUBE_MAP_POSITIVE_Z	—	—	—
TEXTURE_CUBE_MAP_NEGATIVE_Z	—	—	—
TEXTURE_WIDTH	✓	—	—
TEXTURE_HEIGHT	✓	—	—
TEXTURE_DEPTH	—	—	—
TEXTURE_BORDER	—	—	—
TEXTURE_INTERNAL_FORMAT	✓	—	—
TEXTURE_RED_SIZE	✓	—	—
TEXTURE_GREEN_SIZE	✓	—	—
TEXTURE_BLUE_SIZE	✓	—	—
TEXTURE_ALPHA_SIZE	✓	—	—
TEXTURE_LUMINANCE_SIZE	✓	—	—
TEXTURE_INTENSITY_SIZE	—	—	—
TEXTURE_COMPRESSED	—	—	—
TEXTURE_COMPRESSED_IMAGE_SIZE	—	—	—
TEXTURE_BORDER_COLOR	—	—	—
TEXTURE_MIN_FILTER	✓	✓	**GetTexParameteriv**
TEXTURE_MAG_FILTER	✓	✓	**GetTexParameteriv**
TEXTURE_WRAP_S	✓	✓	**GetTexParameteriv**
TEXTURE_WRAP_T	✓	✓	**GetTexParameteriv**
TEXTURE_WRAP_R	—	—	—
TEXTURE_PRIORITY	—	—	—
TEXTURE_RESIDENT	—	—	—
TEXTURE_MIN_LOD	✓	—	—
TEXTURE_MAX_LOD	✓	—	—

State	Exposed	Queriable	Command
TEXTURE_BASE_LEVEL	✓	—	—
TEXTURE_MAX_LEVEL	✓	—	—

Table 6.11   Texture Environment and Generation

State	Exposed	Queriable	Command
ACTIVE_TEXTURE	✓	✓	**GetIntegerv**
TEXTURE_ENV_MODE	✓	✓	**GetTexEnviv**
TEXTURE_ENV_COLOR	✓	✓	**GetTexEnvfv**
TEXTURE_GEN_{STRQ}	—	—	—
EYE_PLANE	—	—	—
OBJECT_PLANE	—	—	—
TEXTURE_GEN_MODE	—	—	—
COMBINE_RGB	—	—	—
COMBINE_ALPHA	—	—	—
SOURCE{012}_RGB	—	—	—
SOURCE{012}_ALPHA	—	—	—
OPERAND{012}_RGB	—	—	—
OPERAND{012}_ALPHA	—	—	—
RGB_SCALE	—	—	—
ALPHA_SCALE	—	—	—

Table 6.12   Pixel Operations

State	Exposed	Queriable	Command
SCISSOR_TEST	✓	✓	**IsEnabled**
SCISSOR_BOX	✓	✓	**GetIntegerv**
ALPHA_TEST	✓	✓	**IsEnabled**
ALPHA_TEST_FUNC	✓	✓	**GetIntegerv**
ALPHA_TEST_REF	✓	✓	**GetFloatv**
STENCIL_TEST	✓	✓	**IsEnabled**
STENCIL_FUNC	✓	✓	**GetIntegerv**
STENCIL_VALUE_MASK	✓	✓	**GetIntegerv**
STENCIL_REF	✓	✓	**GetIntegerv**
STENCIL_FAIL	✓	✓	**GetIntegerv**
STENCIL_PASS_DEPTH_FAIL	✓	✓	**GetIntegerv**
STENCIL_PASS_DEPTH_PASS	✓	✓	**GetIntegerv**
DEPTH_TEST	✓	✓	**IsEnabled**

State	Exposed	Queriable	Command
DEPTH_FUNC	✓	✓	**GetIntegerv**
BLEND	✓	✓	**IsEnabled**
BLEND_SRC	✓	✓	**GetIntegerv**
BLEND_DST	✓	✓	**GetIntegerv**
BLEND_EQUATION	–	–	–
BLEND_COLOR	–	–	–
DITHER	–	–	–
INDEX_LOGIC_OP	–	–	–
COLOR_LOGIC_OP	–	–	–
LOGIC_OP_MODE	–	–	–

Table 6.13   Framebuffer Control

State	Exposed	Queriable	Command
DRAW_BUFFER	–	–	–
INDEX_WRITEMASK	–	–	–
COLOR_WRITEMASK	✓	✓	**GetBooleanv**
DEPTH_WRITEMASK	✓	✓	**GetBooleanv**
STENCIL_WRITEMASK	✓	✓	**GetIntegerv**
COLOR_CLEAR_VALUE	✓	✓	**GetFloatv**
INDEX_CLEAR_VALUE	–	–	–
DEPTH_CLEAR_VALUE	✓	✓	**GetFloatv**
STENCIL_CLEAR_VALUE	✓	✓	**GetIntegerv**
ACCUM_CLEAR_VALUE	–	–	–

Table 6.14   Pixels

State	Exposed	Queriable	Command
UNPACK_SWAP_BYTES	–	–	–
UNPACK_LSB_FIRST	–	–	–
UNPACK_IMAGE_HEIGHT	–	–	–
UNPACK_SKIP_IMAGES	–	–	–
UNPACK_ROW_LENGTH	–	–	–
UNPACK_SKIP_ROWS	–	–	–
UNPACK_SKIP_PIXELS	–	–	–
UNPACK_ALIGNMENT	✓	✓	**GetIntegerv**
PACK_SWAP_BYTES	–	–	–
PACK_LSB_FIRST	–	–	–

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State	Exposed	Queriable	Command
PACK_IMAGE_HEIGHT	—	—	—
PACK_SKIP_IMAGES	—	—	—
PACK_ROW_LENGTH	—	—	—
PACK_SKIP_ROWS	—	—	—
PACK_SKIP_PIXELS	—	—	—
PACK_ALIGNMENT	✓	✓	**GetIntegerv**
MAP_COLOR	—	—	—
MAP_STENCIL	—	—	—
INDEX_SHIFT	—	—	—
INDEX_OFFSET	—	—	—
RED_SCALE	—	—	—
GREEN_SCALE	—	—	—
BLUE_SCALE	—	—	—
ALPHA_SCALE	—	—	—
DEPTH_SCALE	—	—	—
RED_BIAS	—	—	—
GREEN_BIAS	—	—	—
BLUE_BIAS	—	—	—
ALPHA_BIAS	—	—	—
DEPTH_BIAS	—	—	—
COLOR_TABLE	—	—	—
POST_CONVOLUTION_COLOR_TABLE	—	—	—
POST_COLOR_MATRIX_COLOR_TABLE	—	—	—
COLOR_TABLE_FORMAT	—	—	—
COLOR_TABLE_WIDTH	—	—	—
COLOR_TABLE_RED_SIZE	—	—	—
COLOR_TABLE_GREEN_SIZE	—	—	—
COLOR_TABLE_BLUE_SIZE	—	—	—
COLOR_TABLE_ALPHA_SIZE	—	—	—
COLOR_TABLE_LUMINANCE_SIZE	—	—	—
COLOR_TABLE_INTENSITY_SIZE	—	—	—
COLOR_TABLE_SCALE	—	—	—
COLOR_TABLE_BIAS	—	—	—
CONVOLUTION_1D	—	—	—
CONVOLUTION_2D	—	—	—
SEPARABLE_2D	—	—	—
CONVOLUTION	—	—	—
CONVOLUTION_BORDER_COLOR	—	—	—

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State	Exposed	Queriable	Command
CONVOLUTION_BORDER_MODE	—	—	—
CONVOLUTION_FILTER_SCALE	—	—	—
CONVOLUTION_FILTER_BIAS	—	—	—
CONVOLUTION_FORMAT	—	—	—
CONVOLUTION_WIDTH	—	—	—
CONVOLUTION_HEIGHT	—	—	—
POST_CONVOLUTION_RED_SCALE	—	—	—
POST_CONVOLUTION_GREEN_SCALE	—	—	—
POST_CONVOLUTION_BLUE_SCALE	—	—	—
POST_CONVOLUTION_ALPHA_SCALE	—	—	—
POST_CONVOLUTION_RED_BIAS	—	—	—
POST_CONVOLUTION_GREEN_BIAS	—	—	—
POST_CONVOLUTION_BLUE_BIAS	—	—	—
POST_CONVOLUTION_ALPHA_BIAS	—	—	—
POST_COLOR_MATRIX_RED_SCALE	—	—	—
POST_COLOR_MATRIX_GREEN_SCALE	—	—	—
POST_COLOR_MATRIX_BLUE_SCALE	—	—	—
POST_COLOR_MATRIX_ALPHA_SCALE	—	—	—
POST_COLOR_MATRIX_RED_BIAS	—	—	—
POST_COLOR_MATRIX_GREEN_BIAS	—	—	—
POST_COLOR_MATRIX_BLUE_BIAS	—	—	—
POST_COLOR_MATRIX_ALPHA_BIAS	—	—	—
HISTOGRAM	—	—	—
HISTOGRAM_WIDTH	—	—	—
HISTOGRAM_FORMAT	—	—	—
HISTOGRAM_RED_SIZE	—	—	—
HISTOGRAM_GREEN_SIZE	—	—	—
HISTOGRAM_BLUE_SIZE	—	—	—
HISTOGRAM_ALPHA_SIZE	—	—	—
HISTOGRAM_LUMINANCE_SIZE	—	—	—
HISTOGRAM_SINK	—	—	—
MINMAX	—	—	—
MINMAX_FORMAT	—	—	—
MINMAX_SINK	—	—	—
ZOOM_X	—	—	—
ZOOM_Y	—	—	—
PIXEL_MAP_I_TO_I	—	—	—
PIXEL_MAP_S_TO_S	—	—	—

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State	Exposed	Queriable	Command
PIXEL_MAP_I_TO_{RGBA}	–	–	–
PIXEL_MAP_R_TO_R	–	–	–
PIXEL_MAP_G_TO_G	–	–	–
PIXEL_MAP_B_TO_B	–	–	–
PIXEL_MAP_A_TO_A	–	–	–
PIXEL_MAP_x_TO_y_SIZE	–	–	–
READ_BUFFER	–	–	–

Table 6.15   Evaluators

State	Exposed	Queriable	Command
ORDER	–	–	–
COEFF	–	–	–
DOMAIN	–	–	–
MAP1_x	–	–	–
MAP2_x	–	–	–
MAP1_GRID_DOMAIN	–	–	–
MAP2_GRID_DOMAIN	–	–	–
MAP1_GRID_SEGMENTS	–	–	–
MAP2_GRID_SEGMENTS	–	–	–
AUTO_NORMAL	–	–	–

Table 6.16   Hints

State	Exposed	Queriable	Command
PERSPECTIVE_CORRECTION_HINT	✓	✓	**GetIntegerv**
POINT_SMOOTH_HINT	✓	✓	**GetIntegerv**
LINE_SMOOTH_HINT	✓	✓	**GetIntegerv**
POLYGON_SMOOTH_HINT	–	–	–
FOG_HINT	–	–	–
TEXTURE_COMPRESSION_HINT	–	–	–

Table 6.17   Hints

State	Exposed	Queriable	Command
MAX_LIGHTS	✓	✓	**GetIntegerv**
MAX_CLIP_PLANES	–	–	–
MAX_COLOR_MATRIX_STACK_DEPTH	–	–	–

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State	Exposed	Queriable	Command
MAX_MODELVIEW_STACK_DEPTH	✓	✓	**GetIntegerv**
MAX_PROJECTION_STACK_DEPTH	✓	✓	**GetIntegerv**
MAX_TEXTURE_STACK_DEPTH	–	–	–
SUBPIXEL_BITS	✓	✓	**GetIntegerv**
MAX_3D_TEXTURE_SIZE	–	–	–
MAX_TEXTURE_SIZE	✓	✓	**GetIntegerv**
MAX_CUBE_MAP_TEXTURE_SIZE	–	–	–
MAX_PIXEL_MAP_TABLE	–	–	–
MAX_NAME_STACK_DEPTH	–	–	–
MAX_LIST_NESTING	✓	✓	**GetIntegerv**
MAX_EVAL_ORDER	–	–	–
MAX_VIEWPORT_DIMS	✓	✓	**GetIntegerv**
MAX_ATTRIB_STACK_DEPTH	–	–	–
MAX_CLIENT_ATTRIB_STACK_DEPTH	–	–	–
Maximum size of a color table	–	–	–
Maximum size of the histogram table	–	–	–
AUX_BUFFERS	–	–	–
RGBA_MODE	–	–	–
INDEX_MODE	–	–	–
DOUBLEBUFFER	–	–	–
ALIASED_POINT_SIZE_RANGE	✓	✓	**GetFloatv**
SMOOTH_POINT_SIZE_RANGE	✓	✓	**GetFloatv**
SMOOTH_POINT_SIZE_GRANULARITY	✓	✓	**GetFloatv**
ALIASED_LINE_WIDTH_RANGE	✓	✓	**GetFloatv**
SMOOTH_LINE_WIDTH_RANGE	✓	✓	**GetFloatv**
SMOOTH_LINE_WIDTH_GRANULARITY	✓	✓	**GetFloatv**
MAX_CONVOLUTION_WIDTH	–	–	–
MAX_CONVOLUTION_HEIGHT	–	–	–
MAX_ELEMENTS_INDICES	✓	✓	**GetIntegerv**
MAX_ELEMENTS_VERTICES	✓	✓	**GetIntegerv**
MAX_TEXTURE_UNITS	✓	✓	**GetIntegerv**
SAMPLE_BUFFERS	–	–	–
SAMPLES	–	–	–
COMPRESSED_TEXTURE_FORMATS	–	–	–
NUM_COMPRESSED_TEXTURE_FORMATS	–	–	–

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Table 6.18   Implementation Dependent Pixel Depths

State	Exposed	Queriable	Command
`RED_BITS`	✓	✓	**GetIntegerv**
`GREEN_BITS`	✓	✓	**GetIntegerv**
`BLUE_BITS`	✓	✓	**GetIntegerv**
`ALPHA_BITS`	✓	✓	**GetIntegerv**
`INDEX_BITS`	—	—	—
`DEPTH_BITS`	✓	✓	**GetIntegerv**
`STENCIL_BITS`	✓	✓	**GetIntegerv**
`ACCUM_BITS`	—	—	—

Table 6.19   Miscellaneous

State	Exposed	Queriable	Command
`LIST_BASE`	✓	✓	**GetIntegerv**
`LIST_INDEX`	✓	—	—
`LIST_MODE`	—	—	—
Server attribute stack	—	—	—
`ATTRIB_STACK_DEPTH`	—	—	—
Client attribute stack	—	—	—
`CLIENT_ATTRIB_STACK_DEPTH`	—	—	—
`NAME_STACK_DEPTH`	—	—	—
`RENDER_MODE`	—	—	—
`SELECTION_BUFFER_POINTER`	—	—	—
`SELECTION_BUFFER_SIZE`	—	—	—
`FEEDBACK_BUFFER_POINTER`	—	—	—
`FEEDBACK_BUFFER_SIZE`	—	—	—
`FEEDBACK_BUFFER_TYPE`	—	—	—
Current error code(s)	✓	✓	**GetError**
Corresponding error flags	✓	—	—

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Chapter 7

Core Additions and Extensions

The OpenGL SC profile consists of two parts: a subset of the full OpenGL pipeline, and some extended functionality that is drawn from a set of OpenGL ES-specific extensions as well as OpenGL extensions to the full OpenGL specification. Each extension is pruned to match the profile's command subset and added to the profile as either a core addition or a profile extension. Core additions differ from profile extensions in that the commands and tokens do not include extension suffixes in their names.

Profile extensions are further divided into required (mandatory) and optional extensions. Required extensions must be implemented as part of a conforming implementation, whereas the implementation of optional extensions are left to the discretion of the implementer. Both types of extensions use extension suffixes as part of their names, are present in the `EXTENSIONS` string, and participate in function address queries defined in the platform embedding layer. Required extensions have the additional packaging constraint, that commands defined as part of a required extension must also be available as part of a static binding if core commands are also available in a static binding. The commands comprising an optional extension may optionally be included as part of a static binding.

From an API perspective, commands and tokens comprising a core addition are indistinguishable from the original OpenGL subset. However, to increase application portability, an implementation may also implement a core addition as an extension by including suffixed versions of commands and tokens in the appropriate dynamic and optional static bindings and the extension name in the `EXTENSIONS` string.

■ Extensions preserve all traditional extension properties regardless of whether they are required or optional. Required extensions must be present; therefore, additionally providing static bindings simplifies application usage and reinforces the ubiquity of the extension. Permitting core additions to be included as extensions allows extensions that are promoted to core additions in later profile revisions to continue to be available as extensions, retaining application compatibility. The disposition of Safety-Critical Extensions is shown in Table 7.1. □

Table 7.1   Safety-Critical Extension Disposition

Extension Name	Extension Type
`OES_single_precision`	core addition
`EXT_paletted_texture`	required extension
`EXT_shared_texture_palette`	optional extension

7.1   Single-precision Commands

The `OES_single_precision` extension creates new single-precision parameter command variants of commands that have no such variants (e.g. **DepthRange**, **Frustum**, **Ortho**). Only the subset matching the profile feature set is included in the Safety-Critical profile.

OES_single_precision
DepthRangef(clampf n, clampf f)
Frustumf(float l, float r, float b, float t, float n, float f)
Orthof(float l, float r, float b, float t, float n, float f)
ClearDepthf(clampf depth)

7.2   Paletted Textures

The `EXT_paletted_texture` extension is supported only for texture internal format `COLOR_INDEX8_EXT`. Only the subset matching the profile feature set is included in the Safety-Critical profile.

EXT_paletted_texture	Safety-Critical

TexImage2D(enum target, int level, int internalFormat, sizei width, sizei height, int border, enum format, enum type, const void *pixels)
   internalFormat = COLOR_INDEX8_EXT,
   format = COLOR_INDEX,
   type = UNSIGNED_BYTE
	✓

GetTexLevelParameter{if}v(enum target, int level, enum pname, T *params)	─

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EXT_paletted_texture	Safety-Critical

ColorTableEXT(enum target, enum internalformat, sizei width, enum format, enum type, const void *data)
   target = TEXTURE_2D
   target = all other values
	
	✓
	—

ColorSubTableEXT(enum target, sizei start, sizei count, enum format, enum type, const void *data)
   target = TEXTURE_2D
   target = all other values
	
	✓
	—

GetColorTableEXT(enum target, enum format, enum type, void *data)
   target = TEXTURE_2D
   target = all other values
	
	✓
	—

GetColorTableParameterivEXT(enum target, enum pname, int *params)
   target = TEXTURE_2D
   target = all other values
	
	✓
	—

GetColorTableParameterfvEXT(enum target, enum pname, float *params)	—

■ The EXT_paletted_texture extension separates textures into indices and palette. It allows saving of texture memory and efficient modification of the palette without the need to update an entire texture. □

7.3   Shared Texture Palette

Support of the EXT_shared_texture_palette extension is optional. If it is supported, only the subset matching the profile feature set is included in the Safety-Critical profile.

EXT_shared_texture_palette	Safety-Critical
Enable/**Disable**(SHARED_TEXTURE_PALETTE_EXT)	✓
IsEnabled(SHARED_TEXTURE_PALETTE_EXT)	✓
GetBooleanv(enum pname, boolean *params) target = SHARED_TEXTURE_PALETTE_EXT	 ✓
GetFloatv(enum pname, float *params) target = SHARED_TEXTURE_PALETTE_EXT	 ✓
GetIntegerv(enum pname, int *params) target = SHARED_TEXTURE_PALETTE_EXT	 ✓
ColorTableEXT(enum target, enum internalformat, sizei width, enum format, enum type, const void *data) target = SHARED_TEXTURE_PALETTE_EXT	 ✓
ColorSubTableEXT(enum target, sizei start, sizei count, enum format, enum type, const void *data) target = SHARED_TEXTURE_PALETTE_EXT	 ✓
GetColorTableEXT(enum target, enum format, enum type, void *data) target = SHARED_TEXTURE_PALETTE_EXT	 ✓

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EXT_shared_texture_palette	Safety-Critical
GetColorTableParameterivEXT(enum target, enum pname, int *params) target = SHARED_TEXTURE_PALETTE_EXT	✓

■ The EXT_shared_texture_palette extension is useful to update palettes shared between multiple textures. This feature is optional, as it is only used by specific (mapping) applications. □

Chapter 8

Packaging

8.1   Header Files

The header file structure is the same as a full OpenGL distribution, using a single header file: `gl.h`. An additional enumerant `OSC_VERSION_x_y`, where `x` and `y` are the major and minor version numbers as described in Section 6.1, is included in the header file. These enumerants indicate the versions of profiles supported at compile-time.

8.2   Libraries

Each profile defines a distinct link-library. The library name includes the profile name as `libGLSC.z` where `.z` is a platform specific library suffix (i.e., `.a`, `.so`, `.lib`, etc.). The symbols for the platform specific embedding library are also included in the link-library. Availability of static and dynamic function bindings is platform dependent. Rules regarding the export of bindings for core additions, required profile extensions, and optional platform extensions are described in Chapter 7.

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Appendix A

Acknowledgements

The OpenGL Safety-Critical profile is the result of the contributions of many people, representing a cross section of the desktop, hand-held, and embedded computer industry. Following is a partial list of the contributors, including the company that they represented at the time of their contribution:

John Boal, Alt Software
Neal Countryman, Seaweed Systems
Ben Crocker, Seaweed Systems
Pete Daniel, Quantum3D
Chris Hall, Seaweed Systems
John Jarvis, Alt Software
Claude Knaus, Esmertec
Michal Krupa, Barco
Bill Marshall, Alt Software
Ville Miettinen, Hybrid Graphics
Mark Snyder, Quantum3D
Bruce Stockwell, Seaweed Systems
Neil Trevett, NVIDIA
Steve Viggers, Alt Software
Hans-Martin Will, Vincent

The acknowledgements extend to the Common profiles working group for the creation of the OES_single_precision extension used by OpenGL SC.

Appendix B

OSC Extension Specifications

B.1　OES_single_precision

Name

　　　OES_single_precision

Name Strings

　　　GL_OES_single_precision

Contact

　　　David Blythe (blythe 'at' bluevoid.com)

Status

　　　Ratified by the Khronos BOP, July 23, 2003.
　　　Ratified by the Khronos BOP, Aug 5, 2004.

Version

　　　Last Modifed Date: 28 June 2004
　　　Author Revision : 0.5

Number

　　　293

Dependencies

```
      None
      The extension is written against the OpenGL 1.3 Specification.
```

Overview

```
      This extension adds commands with single-precision floating-point
      parameters corresponding to the commands that only variants that accept
      double-precision floating-point input. This allows an application to
      avoid using double-precision floating-point data types. New commands are
      added with an 'f' prefix.
```

IP Status

```
      None
```

Issues

```
      An alternative is to suggest platforms define GLfloat and * GLdouble to
      be the same type, since it is unlikely that both singleand double-
      precision are required at the same time.

      Resolved: This might create additional confusion, so it is better to
      define new commands.
```

New Procedures and Functions

```
      void DepthRangefOES(clampf n, clampf f);
      void FrustumfOES(float l, float r, float b, float t, float n, float f);
      void OrthofOES(float l, float r, float b, float t, float n, float f);

      void ClipPlanefOES(enum plane, const float* equation);
      void GetClipPlanefOES(enum plane, float* equation);

      void void glClearDepthfOES(clampd depth);
```

New Tokens

```
      None
```

Additions to Chapter 2 of the OpenGL 1.3 Specification (OpenGL Operation)

```
      Section 2.10 Coordinate Transformations

      Revise to include 'f' suffix.
      Add alternate suffixed versions of DepthRange (2.10.1).
      Add alternate suffixed versions of Ortho and Frustum (2.10.2).

      Section 2.11 Clipping

      Add alternate suffixed version of ClipPlane.
```

Additions to Chapter 3 of the OpenGL 1.3 Specification (Rasterization)

```
      None
```

Additions to Chapter 4 of the OpenGL 1.3 Specification (Per-Fragment Operations
and the Frame Buffer)

```
       Section 4.2.3 Clearing the Buffers
       Add alternate suffixed version of ClearDepth.
```

Additions to Chapter 5 of the OpenGL 1.3 Specification (Special Functions)

```
       None
```

Additions to Chapter 6 of the OpenGL 1.3 Specification (State and State
Requests)

```
       None
```

Additions to Appendix A of the OpenGL 1.3 Specification (Invariance)

```
       None
```

Additions to the AGL/GLX/WGL Specifications

```
       None
```

Additions to the WGL Specification

```
       None
```

Additions to the AGL Specification

```
       None
```

Additions to Chapter 2 of the GLX 1.3 Specification (GLX Operation)

```
       The data representation is client-side only. The GLX layer performs
       translation between float and double representations.
```

Additions to Chapter 3 of the GLX 1.3 Specification (Functions and Errors)

Additions to Chapter 4 of the GLX 1.3 Specification (Encoding on the X Byte
Stream)

Additions to Chapter 5 of the GLX 1.3 Specification (Extending OpenGL)

Additions to Chapter 6 of the GLX 1.3 Specification (GLX Versions)

GLX Protocol

```
       Five new GL rendering commands are added. The following commands are sent
       to the server as part of a glXRender request:
```

```
       ClearDepthfOES
```

```
               2         8               rendering command length
               2         4308            rendering command opcode
               4         FLOAT32         z
```

```
       DepthRangefOES
```

```
               2         12              rendering command length
               2         4309            rendering command opcode
               4         FLOAT32         n
```

```
        4           FLOAT32         f

    FrustumfOES

        2           28              rendering command length
        2           4310            rendering command opcode
        4           FLOAT32         l
        4           FLOAT32         r
        4           FLOAT32         b
        4           FLOAT32         t
        4           FLOAT32         n
        4           FLOAT32         f

    OrthofOES

        2           28              rendering command length
        2           4311            rendering command opcode
        4           FLOAT32         l
        4           FLOAT32         r
        4           FLOAT32         b
        4           FLOAT32         t
        4           FLOAT32         n
        4           FLOAT32         f

    ClipPlanefOES

        2           24              rendering command length
        2           4312            rendering command opcode
        4           ENUM            plane
        4           FLOAT32         v[0]
        4           FLOAT32         v[1]
        4           FLOAT32         v[2]
        4           FLOAT32         v[3]
```

The remaining commands are non-rendering commands. These commands are sent separately (i.e., not as part of a glXRender or glXRenderLarge request), using the glXVendorPrivateWithReply request:

```
    GetClipPlanefOES

        1           CARD8           opcode (X assigned)
        1           17              GLX opcode (glXVendorPrivateWithReply)
        2           4               request length
        4           1421            vendor specific opcode
        4           GLX_CONTEXT_TAG context tag
        4           ENUM            plane
        =>
        1           1               reply
        1                           unused
        2           CARD16          sequence number
        4           0               reply length
        4           FLOAT32         v[0]
        4           FLOAT32         v[1]
        4           FLOAT32         v[2]
        4           FLOAT32         v[3]
        8                           unused
```

Errors

        None

New State

      None

New Implementation Dependent State

      None

Revision History

      03/27/2003 0.1
      First draft created.

      07/08/2003 0.2
      Delete unused Dependencies on section
      Added extension number

      07/09/2003 0.3
      Added missing ClearDepthfOES
      Removed '_'s from names.

      07/22/2003 0.4
      Added GLX protocol (Thomas Roell)

      06/28/2004 0.5
      Added ClipPlanef function (Aaftab Munshi)

B.2   EXT_paletted_texture

Name

```
EXT_paletted_texture
```

Name Strings

```
GL_EXT_paletted_texture
```

Contact

```
Mark J. Kilgard, NVIDIA Corporation (mjk 'at' nvidia.com)
```

Version

```
Last Modified Date: March 24, 2004
Revision: 1.4
```

Number

```
78
```

Support

```
Intel 810/815.

Mesa.

Microsoft software OpenGL implementation.

Selected NVIDIA GPUs: NV1x (GeForce 256, GeForce2, GeForce4 MX, GeForce4
Go, Quadro, Quadro2), NV2x (GeForce3, GeForce4 Ti, Quadro DCC, Quadro4
XGL), and NV3x (GeForce FX 5xxxx, Quadro FX 1000/2000/3000). NV3 (Riva
128) and NV4 (TNT, TNT2) GPUs and NV4x GPUs do NOT support this
functionality (no hardware support). Future NVIDIA GPU designs will no
longer support paletted textures.

S3 ProSavage, Savage 2000.

3Dfx Voodoo3, Voodoo5.

3Dlabs GLINT.
```

Dependencies

```
GL_EXT_paletted_texture shares routines and enumerants with
GL_SGI_color_table with the minor modification that EXT replaces SGI. In
all other ways these calls should function in the same manner and the
enumerant values should be identical. The portions of GL_SGI_color_table
that are used are:

    ColorTableSGI, GetColorTableSGI, GetColorTableParameterivSGI,
    GetColorTableParameterfvSGI. COLOR_TABLE_FORMAT_SGI,
    COLOR_TABLE_WIDTH_SGI, COLOR_TABLE_RED_SIZE_SGI,
    COLOR_TABLE_GREEN_SIZE_SGI, COLOR_TABLE_BLUE_SIZE_SGI,
    COLOR_TABLE_ALPHA_SIZE_SGI, COLOR_TABLE_LUMINANCE_SIZE_SGI,
    COLOR_TABLE_INTENSITY_SIZE_SGI.
```

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Portions of GL_SGI_color_table which are not used in
GL_EXT_paletted_texture are:

        CopyColorTableSGI, ColorTableParameterivSGI,
        ColorTableParameterfvSGI. COLOR_TABLE_SGI,
        POST_CONVOLUTION_COLOR_TABLE_SGI,
        POST_COLOR_MATRIX_COLOR_TABLE_SGI, PROXY_COLOR_TABLE_SGI,
        PROXY_POST_CONVOLUTION_COLOR_TABLE_SGI,
        PROXY_POST_COLOR_MATRIX_COLOR_TABLE_SGI, COLOR_TABLE_SCALE_SGI,
        COLOR_TABLE_BIAS_SGI.

EXT_paletted_texture can be used in conjunction with EXT_texture3D.
EXT_paletted_texture modifies TexImage3DEXT to accept paletted image data
and allows TEXTURE_3D_EXT and PROXY_TEXTURE_3D_EXT to be used a targets
in the color table routines. If EXT_texture3D is unsupported then
references to 3D texture support in this spec are invalid and should be
ignored.

EXT_paletted_texture can be used in conjunction with
ARB_texture_cube_map. EXT_paletted_texture modifies TexImage2D to accept
paletted image data and allows TEXTURE_CUBE_MAP_ARB, and
PROXY_TEXTURE_CUBE_MAP_ARB to be used a targets in the color table
routines. If ARB_texture_cube_map is unsupported then references to cube
map texture support in this spec are invalid and should be ignored.

Overview

EXT_paletted_texture defines new texture formats and new calls to support
the use of paletted textures in OpenGL. A paletted texture is defined by
giving both a palette of colors and a set of image data which is composed
of indices into the palette. The paletted texture cannot function
properly without both pieces of information so it increases the work
required to define a texture. This is offset by the fact that the overall
amount of texture data can be reduced dramatically by factoring redundant
information out of the logical view of the texture and placing it in the
palette.

Paletted textures provide several advantages over full-color textures:

*   As mentioned above, the amount of data required to define a *
texture can be greatly reduced over what would be needed for full-color
specification. For example, consider a source texture that has only 256
distinct colors in a 256 by 256 pixel grid. Full-color representation
requires three bytes per pixel, taking 192K of texture data. By putting
the distinct colors in a palette only eight bits are required per pixel,
reducing the 192K to 64K plus 768 bytes for the palette. Now add an alpha
channel to the texture. The full-color representation increases by 64K
while the paletted version would only increase by 256 bytes. This
reduction in space required is particularly important for hardware
accelerators where texture space is limited.

*   Paletted textures allow easy reuse of texture data for images *
which require many similar but slightly different colored objects.
Consider a driving simulation with heavy traffic on the road. Many of the
cars will be similar but with different color schemes. If full-color
textures are used a separate texture would be needed for each color
scheme, while paletted textures allow the same basic index data to be
reused for each car, with a different palette to change the final colors.

*   Paletted textures also allow use of all the palette tricks *
developed for paletted displays. Simple animation can be done, along with

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strobing, glowing and other palette-cycling effects. All of these
techniques can enhance the visual richness of a scene with very little
data.

IP Status

None.

New Procedures and Functions

```
void ColorTableEXT(
        enum target,
        enum internalFormat,
        sizei width,
        enum format,
        enum type,
        const void *data);

void ColorSubTableEXT(
        enum target,
        sizei start,
        sizei count,
        enum format,
        enum type,
        const void *data);

void GetColorTableEXT(
        enum target,
        enum format,
        enum type,
        void *data);

void GetColorTableParameterivEXT(
        enum target,
        enum pname,
        int *params);

void GetColorTableParameterfvEXT(
        enum target,
        enum pname,
        float *params);
```

New Tokens

Accepted by the internalformat parameter of TexImage1D, TexImage2D and
TexImage3DEXT:

```
COLOR_INDEX1_EXT 0x80E2 COLOR_INDEX2_EXT 0x80E3 COLOR_INDEX4_EXT
0x80E4 COLOR_INDEX8_EXT 0x80E5 COLOR_INDEX12_EXT 0x80E6
COLOR_INDEX16_EXT 0x80E7
```

Accepted by the pname parameter of GetColorTableParameterivEXT and
GetColorTableParameterfvEXT:

```
COLOR_TABLE_FORMAT_EXT 0x80D8 COLOR_TABLE_WIDTH_EXT 0x80D9
COLOR_TABLE_RED_SIZE_EXT 0x80DA COLOR_TABLE_GREEN_SIZE_EXT 0x80DB
COLOR_TABLE_BLUE_SIZE_EXT 0x80DC COLOR_TABLE_ALPHA_SIZE_EXT 0x80DD
COLOR_TABLE_LUMINANCE_SIZE_EXT 0x80DE
COLOR_TABLE_INTENSITY_SIZE_EXT 0x80DF
```

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Accepted by the value parameter of GetTexLevelParameter{if}v:

TEXTURE_INDEX_SIZE_EXT 0x80ED

Accepted by the target parameter of ColorTableEXT,
GetColorTableParameterivEXT, and GetColorTableParameterfvEXT:

TEXTURE_1D 0x0DE0 TEXTURE_2D 0x0DE1 TEXTURE_3D_EXT 0x806F
TEXTURE_CUBE_MAP_ARB 0x8513 PROXY_TEXTURE_1D 0x8063
PROXY_TEXTURE_2D 0x8064 PROXY_TEXTURE_3D_EXT 0x8070
PROXY_TEXTURE_CUBE_MAP_ARB 0x851B

Accepted by the target parameter of ColorSubTableEXT and
GetColorTableEXT:

TEXTURE_1D 0x0DE0 TEXTURE_2D 0x0DE1 TEXTURE_3D_EXT 0x806F
TEXTURE_CUBE_MAP_ARB 0x8513

Additions to Chapter 2 of the GL Specification (OpenGL Operation)

None

Additions to Chapter 3 of the GL Specification (Rasterization)

Section 3.6.4, 'Pixel Transfer Operations,' subsection 'Color Index
Lookup,'

Point two is modified from 'The groups will be loaded as an image
into texture memory' to 'The groups will be loaded as an image
into texture memory and the internalformat parameter is not one of
the color index formats from table 3.8.'

Section 3.8, 'Texturing,' subsection 'Texture Image Specification' is
modified as follows:

The portion of the first paragraph discussing interpretation of
format, type and data is split from the portion discussing target,
width and height. The target, width and height section now ends
with the sentence 'Arguments width and height specify the image's
width and height.'

The format, type and data section is moved under a subheader
'Direct Color Texture Formats' and begins with 'If internalformat
is not one of the color index formats from table 3.8,' and
continues with the existing text through the internalformat
discussion.

After that section, a new section 'Paletted Texture Formats' has
the text:

If format is given as COLOR_INDEX then the image data is
composed of integer values representing indices into a
table of colors rather than colors themselves. If
internalformat is given as one of the color index formats
from table 3.8 then the texture will be stored internally
as indices rather than undergoing index-to-RGBA mapping as
would previously have occurred. In this case the only valid
values for type are BYTE, UNSIGNED_BYTE, SHORT,
UNSIGNED_SHORT, INT and UNSIGNED_INT.

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The image data is unpacked from memory exactly as for a
DrawPixels command with format of COLOR_INDEX for a context
in color index mode. The data is then stored in an internal
format derived from internalformat. In this case the only
legal values of internalformat are COLOR_INDEX1_EXT,
COLOR_INDEX2_EXT, COLOR_INDEX4_EXT, COLOR_INDEX8_EXT,
COLOR_INDEX12_EXT and COLOR_INDEX16_EXT and the internal
component resolution is picked according to the index
resolution specified by internalformat. Any excess
precision in the data is silently truncated to fit in the
internal component precision.

An application can determine whether a particular
implementation supports a particular paletted format (or
any paletted formats at all) by attempting to use the
paletted format with a proxy target. TEXTURE_INDEX_SIZE_EXT
will be zero if the implementation cannot support the
texture as given.

An application can determine an implementation's desired
format for a particular paletted texture by making a
TexImage call with COLOR_INDEX as the internalformat, in
which case target must be a proxy target. After the call
the application can query TEXTURE_INTERNAL_FORMAT to
determine what internal format the implementation suggests
for the texture image parameters. TEXTURE_INDEX_SIZE_EXT
can be queried after such a call to determine the suggested
index resolution numerically. The index resolution
suggested by the implementation does not have to be as
large as the input data precision. The resolution may also
be zero if the implementation is unable to support any
paletted format for the given texture image.

Table 3.8 should be augmented with a column titled 'Index bits.'
All existing formats have zero index bits. The following formats
are added with zeroes in all existing columns:

Name	Index bits
COLOR_INDEX1_EXT	1
COLOR_INDEX2_EXT	2
COLOR_INDEX4_EXT	4
COLOR_INDEX8_EXT	8
COLOR_INDEX12_EXT	12
COLOR_INDEX16_EXT	16

At the end of the discussion of level the following text should be
added:

All mipmapping levels share the same palette. If levels are
created with different precision indices then their
internal formats will not match and the texture will be
inconsistent, as discussed above.

In the discussion of internalformat for CopyTexImage{12}D, at end
of the sentence specifying that 1, 2, 3 and 4 are illegal there
should also be a mention that paletted internalformat values are
illegal.

At the end of the width, height, format, type and data section
under TexSubImage there should be an additional sentence:

If the target texture has an color index internal format
then format may only be COLOR_INDEX.

At the end of the first paragraph describing TexSubImage and
CopyTexSubImage the following sentence should be added:

If the target of a CopyTexSubImage is a paletted texture image
then INVALID_OPERATION is returned.

After the Alternate Image Specification Commands section, a new
'Palette Specification Commands' section should be added.

Paletted textures require palette information to translate
indices into full colors. The command

void ColorTableEXT(enum target, enum internalformat, sizei
        width, enum format, enum type, const void *data);

is used to specify the format and size of the palette for
paletted textures. target specifies which texture is to
have its palette changed and may be one of TEXTURE_1D,
TEXTURE_2D, PROXY_TEXTURE_1D, PROXY_TEXTURE_2D,
TEXTURE_3D_EXT, PROXY_TEXTURE_3D_EXT, TEXTURE_CUBE_MAP_ARB,
or PROXY_TEXTURE_CUBE_MAP_ARB. internalformat specifies the
desired format and resolution of the palette when in its
internal form. internalformat can be any of the non-index
values legal for TexImage internalformat although
implementations are not required to support palettes of all
possible formats. width controls the size of the palette
and must be a power of two greater than or equal to one.
format and type specify the number of components and type
of the data given by data. format can be any of the formats
legal for DrawPixels although implementations are not
required to support all possible formats. type can be any
of the types legal for DrawPixels except GL_BITMAP.

Data is taken from memory and converted just as if each
palette entry were a single pixel of a 1D texture. Pixel
unpacking and transfer modes apply just as with texture
data. After unpacking and conversion the data is translated
into a internal format that matches the given format as
closely as possible. An implementation does not, however,
have a responsibility to support more than one precision
for the base formats.

If the palette's width is greater than the range of the
color indices in the texture data then some of the palettes
entries will be unused. If the palette's width is less than
the range of the color indices in the texture data then the
most-significant bits of the texture data are ignored and
only the appropriate number of bits of the index are used
when accessing the palette.

Specifying a proxy target causes the proxy texture's
palette to be resized and its parameters set but no data is
transferred or accessed. If an implementation cannot handle
the palette data given in the call then the color table
width and component resolutions are set to zero.

Portions of the current palette can be replaced with

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```
void ColorSubTableEXT(enum target, sizei start, sizei
        count, enum format, enum type, const void *data);
```

target can be any of the non-proxy values legal for
ColorTableEXT. start and count control which entries of the
palette are changed out of the range allowed by the
internal format used for the palette indices. count is
silently clamped so that all modified entries all within
the legal range. format and type can be any of the values
legal for ColorTableEXT. The data is treated as a 1D
texture just as in ColorTableEXT.

In the 'Texture State and Proxy State' section the sentence
fragment beginning 'six integer values describing the
resolutions...' should be changed to refer to seven integer
values, with the seventh being the index resolution.

Palette data should be added in as a third category of texture
state.

After the discussion of properties, the following should be added:

Next there is the texture palette. All textures have a
palette, even if their internal format is not color index.
A texture's palette is initially one RGBA element with all
four components set to 1.0.

The sentence mentioning that proxies do not have image data or
properties should be extended with 'or palettes.'

The sentence beginning 'If the texture array is too large'
describing the effects of proxy failure should change to read:

If the implementation is unable to handle the texture image
data the proxy width, height, border width and component
resolutions are set to zero. This situation can occur when
the texture array is too large or an unsupported paletted
format was requested.

Additions to Chapter 4 of the GL Specification (Per-Fragment Operations and the
Framebuffer)

        None

Additions to Chapter 5 of the GL Specification (Special Functions)

        Section 5.4, 'Display Lists' is modified as follows:

                Include PROXY_TEXTURE_1D, PROXY_TEXTURE_2D, PROXY_TEXTURE_3D, and
                PROXY_TEXTURE_CUBE_MAP_ARB in the list of tokens for which
                ColorTableEXT is executed immediately.

Additions to Chapter 6 of the GL Specification (State and State Requests)

        In the section on GetTexImage, the sentence saying 'The components are
        assigned among R, G, B and A according to' should be changed to be

                If the internal format of the texture is not a color index format
                then the components are assigned among R, G, B, and A according to
                Table 6.1. Specifying COLOR_INDEX for format in this case will

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generate the error INVALID_ENUM. If the internal format of the
texture is color index then the components are handled in one of
two ways depending on the value of format. If format is not
COLOR_INDEX, the texture's indices are passed through the
texture's palette and the resulting components are assigned among
R, G, B, and A according to Table 6.1. If format is COLOR_INDEX
then the data is treated as single components and the palette
indices are returned. Components are taken starting...

Following the GetTexImage section there should be a new section:

GetColorTableEXT is used to get the current texture palette.

void GetColorTableEXT(enum target, enum format, enum type, void
      *data);

GetColorTableEXT retrieves the texture palette of the texture
given by target. target can be any of the non-proxy targets valid
for ColorTableEXT. format and type are interpreted just as for
ColorTableEXT. All textures have a palette by default so
GetColorTableEXT will always be able to return data even if the
internal format of the texture is not a color index format.

Palette parameters can be retrieved using

void GetColorTableParameterivEXT(enum target, enum pname, int
      *params);

void GetColorTableParameterfvEXT(enum target, enum pname, float
      *params);

target specifies the texture being queried and pname controls
which parameter value is returned. Data is returned in the memory
pointed to by params.

Querying COLOR_TABLE_FORMAT_EXT returns the internal format
requested by the most recent ColorTableEXT call or the default.
COLOR_TABLE_WIDTH_EXT returns the width of the current palette.
COLOR_TABLE_RED_SIZE_EXT, COLOR_TABLE_GREEN_SIZE_EXT,
COLOR_TABLE_BLUE_SIZE_EXT and COLOR_TABLE_ALPHA_SIZE_EXT return
the actual size of the components used to store the palette data
internally, not the size requested when the palette was defined.

Table 6.11, 'Texture Objects' should have a line appended for
TEXTURE_INDEX_SIZE_EXT:

TEXTURE_INDEX_SIZE_EXT   n x Z+ GetTexLevelParameter 0 xD
                              texture image i's index resolution 3.8 –

New State

In table 6.16, Texture Objects, p. 224, add the following:

Get Value	Type	Get Command	Initial Value
TEXTURE_1D	I	GetColorTableEXT	empty
TEXTURE_2D	I	GetColorTableEXT	empty
TEXTURE_3D	I	GetColorTableEXT	empty
TEXTURE_CUBE_MAP	I	GetColorTableEXT	empty
COLOR_TABLE_FORMAT_EXT	2x4xZn	GetColorTableParameterivEXT	RGBA

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```
        COLOR_TABLE_WIDTH_EXT   2x4xZ+  GetColorTableParameteriv    0
        COLOR_TABLE_x_SIZE_EXT  6x2x4xZ+ GetColorTableParameteriv   0
        TEXTURE_INDEX_SIZE_EXT  nxZ+    GetTexLevelParameter        0


        Get Value               Description                   Sec.    Attrib.
        ------------------------------------------------------------------
        TEXTURE_1D              1D palette                    3.8      -
        TEXTURE_2D              2D palette                    3.8      -
        TEXTURE_3D              3D palette                    3.8      -
        TEXTURE_CUBE_MAP        cube map palette              3.8      -
        COLOR_TABLE_FORMAT_EXT  paletted texture formats      3.8      -
        COLOR_TABLE_WIDTH_EXT   paletted texture width        3.8      -
        COLOR_TABLE_x_SIZE_EXT  paletted texture component sizes 3.8    -
        TEXTURE_INDEX_SIZE_EXT  texture image's index resolution 3.8    -
```

New Implementation Dependent State

        None

Revision History

Original draft, revision 0.5, December 20, 1995 (drewb) Created

Minor revisions and clarifications, revision 0.6, January 2, 1996 (drewb)
        Replaced all request-for-comment blocks with final text based on
        implementation.

Minor revisions and clarifications, revision 0.7, Feburary 5, 1996 (drewb)
        Specified the state of the palette color information when existing data
        is replaced by new data.

        Clarified behavior of TexPalette on inconsistent textures.

Major changes due to ARB review, revision 0.8, March 1, 1996 (drewb)
        Switched from using TexPaletteEXT and GetTexPaletteEXT to using SGI's
        ColorTableEXT routines. Added ColorSubTableEXT so equivalent
        functionality is available.

        Allowed proxies in all targets.

        Changed PALETTE?_EXT values to COLOR_INDEX?_EXT. Added support for one
        and two bit palettes. Removed PALETTE_INDEX_EXT in favor of COLOR_INDEX.

        Decoupled palette size from texture data type. Palette size is controlled
        only by ColorTableEXT.

Changes due to ARB review, revision 1.0, May 23, 1997 (drewb)
        Mentioned texture3D.

        Defined TEXTURE_INDEX_SIZE_EXT.

        Allowed implementations to return an index size of zero to indicate no
        support for a particular format.

        Allowed usage of GL_COLOR_INDEX as a generic format in proxy queries for
        determining an optimal index size for a particular texture.

        Disallowed CopyTexImage and CopyTexSubImage to paletted formats.

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Deleted mention of index transfer operations during GetTexImage with paletted formats.

Changes due to ARB_texture_cube_map, revision 1.1, June 27, 2002 (Mark Kilgard)
Add language to section 5.4 about proxy texture tokens for ColorTable executing immediately.

Document ARB_texture_cube_map interactions.

Document texture target usage for ColorTable API.

Add "New State" section with table and "New Implementation Dependent State" sections.

Changes when incorporating into the registry, September 4, 2002 (Jon Leech)
Added missing IP Status / Contact fields (without bumping the revision) and incorporated Mark's changes into the registry.

Changes, revision 1.4, March 24, 2004 (Mark Kilgard)
Document vendor support for this extension; note that future NVIDIA GPU designs will not support this extension.

B.3   EXT_shared_texture_palette

Name

```
EXT_shared_texture_palette
```

Name Strings

```
GL_EXT_shared_texture_palette
```

Contact

```
Jon Leech, SGI (ljp 'at' sgi.com)
Mark J. Kilgard, NVIDIA Corporation (mjk 'at' nvidia.com)
```

Version

```
Last Modified Date: March 24, 2004
Revision: 1.4
```

Number

```
141
```

Support

```
Mesa.

Selected NVIDIA GPUs: NV1x (GeForce 256, GeForce2, GeForce4 MX, GeForce4
Go, Quadro, Quadro2), NV2x (GeForce3, GeForce4 Ti, Quadro DCC, Quadro4
XGL), and NV3x (GeForce FX 5xxxx, Quadro FX 1000/2000/3000). NV3 (Riva
128) and NV4 (TNT, TNT2) GPUs and NV4x GPUs do NOT support this
functionality (no hardware support). Future NVIDIA GPU designs will no
longer support paletted textures.

S3 ProSavage, Savage 2000.

3Dfx Voodoo3, Voodoo5.

3Dlabs GLINT.
```

Dependencies

```
EXT_paletted_texture is required.
```

Overview

```
EXT_shared_texture_palette defines a shared texture palette which may be
used in place of the texture object palettes provided by
EXT_paletted_texture. This is useful for rapidly changing a palette
common to many textures, rather than having to reload the new palette for
each texture. The extension acts as a switch, causing all lookups that
would normally be done on the texture's palette to instead use the shared
palette.
```

IP Status

```
None.
```

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Issues

* Do we want to use a new <target> to ColorTable to specify the *
  shared palette, or can we just infer the new target from the
  corresponding Enable?

* A future extension of larger scope might define a "texture palette
  object" and bind these objects to texture objects dynamically, rather
  than making palettes part of the texture object state as the current
  EXT_paletted_texture spec does.

* Should there be separate shared palettes for 1D, 2D, and 3D textures?

  Probably not; palette lookups have nothing to do with the
  dimensionality of the texture. If multiple shared palettes are
  needed, we should define palette objects.

* There's no proxy mechanism for checking if a shared palette can be
  defined with the requested parameters. Will it suffice to assume that
  if a texture palette can be defined, so can a shared palette with the
  same parameters?

* The changes to the spec are based on changes already made for
  EXT_paletted_texture, which means that all three documents must be
  referred to. This is quite difficult to read.

* The changes to section 3.8.6, defining how shared palettes are
  enabled and disabled, might be better placed in section 3.8.1.
  However, the underlying EXT_paletted_texture does not appear to
  modify these sections to define exactly how palette lookups are done,
  and it's not clear where to put the changes.

* How does the shared texture palette interact with multitexture
  support? There is a single global shared texture palette that all
  texture units utilize (as opposed to a shared texture palette per
  texture unit).

New Procedures and Functions

    None

New Tokens

    Accepted by the <pname> parameters of GetBooleanv, GetIntegerv,
    GetFloatv, GetDoublev, IsEnabled, Enable, Disable, ColorTableEXT,
    ColorSubTableEXT, GetColorTableEXT, GetColorTableParameterivEXT, and
    GetColorTableParameterfd EXT:

    SHARED_TEXTURE_PALETTE_EXT   0x81FB

Additions to Chapter 2 of the 1.1 Specification (OpenGL Operation)

    None

Additions to Chapter 3 of the 1.1 Specification (Rasterization)

    Section 3.8, 'Texturing,' subsection 'Texture Image Specification' is
    modified as follows:

In the Palette Specification Commands section, the sentence
beginning 'target specifies which texture is to' should be changed
to:

> target specifies the texture palette or shared palette to
> be changed, and may be one of TEXTURE_1D, TEXTURE_2D,
> PROXY_TEXTURE_1D, PROXY_TEXTURE_2D, TEXTURE_3D_EXT,
> PROXY_TEXTURE_3D_EXT, or SHARED_TEXTURE_PALETTE_EXT.

In the 'Texture State and Proxy State' section, the sentence
beginning 'A texture's palette is initially...' should be changed
to:

> There is also a shared palette not associated with any
> texture, which may override a texture palette. (Even when
> multiple texture units are available, there is still only a
> single shared texture palette.) All palettes are
> initially...

Section 3.8.6, 'Texture Application' is modified by appending the
following:

> Use of the shared texture palette is enabled or disabled using the
> generic Enable or Disable commands, respectively, with the
> symbolic constant SHARED_TEXTURE_PALETTE_EXT.

> The required state is one bit indicating whether the shared
> palette is enabled or disabled. In the initial state, the shared
> palettes is disabled.

Additions to Chapter 4 of the 1.1 Specification (Per-Fragment Operations and
the Frame buffer)

Additions to Chapter 5 of the 1.1 Specification (Special Functions)

Additions to Chapter 6 of the 1.1 Specification (State and State Requests)

In the section on GetTexImage, the sentence beginning "If format is not
COLOR_INDEX...' should be changed to:

> If format is not COLOR_INDEX, the texture's indices are passed
> through the texture's palette, or the shared palette if one is
> enabled, and the resulting components are assigned among R, G, B,
> and A according to Table 6.1.

In the GetColorTable section, the first sentence of the second paragraph
should be changed to read:

> GetColorTableEXT retrieves the texture palette or shared palette
> given by target.

The first sentence of the third paragraph should be changed to read:

> Palette parameters can be retrieved using

> void GetColorTableParameterivEXT(enum target, enum pname, int
>   *params);

> void GetColorTableParameterfvEXT(enum target, enum pname, float
>   *params);

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target specifies the texture palette or shared palette being
queried and pname controls which parameter value is returned.

Additions to the GLX Specification

    None

New State

```
Get Value                      Type Get Command                 Initial Value
------------------------------------------------------------------
SHARED_TEXTURE_PALETTE_EXT B    IsEnabled                        False
SHARED_TEXTURE_PALETTE_EXT I    GetColorTableEXT                 empty
COLOR_TABLE_FORMAT_EXT     Zn   GetColorTableParameterivEXT RGBA
COLOR_TABLE_WIDTH_EXT      Z+   GetColorTableParameteriv    0
COLOR_TABLE_x_SIZE_EXT     6xZ+ GetColorTableParameteriv    0
```

```
Get Value                      Type Description    Sec    Attribute
-------------------------------------------------------------------
SHARED_TEXTURE_PALETTE_EXT  B     shared texture   3.8.6  texture/enable
                                  palette enable
SHARED_TEXTURE_PALETTE_EXT  I     shared texture   3.8    -
                                  palette table
COLOR_TABLE_FORMAT_EXT       Zn    shared texture   3.8    -
                                  palette format
COLOR_TABLE_WIDTH_EXT        Z+    shared texture   3.8    -
                                  palette width
COLOR_TABLE_x_SIZE_EXT       6xZ+ shared texture   3.8    -
                                  palette
                                  component sizes
```

New Implementation Dependent State

    None

Revision History

    September 4, 2002 - Add missing IP Status / Contact fields (without
    bumping the revision) and incorporated Mark's changes into the registry.
    (Jon Leech)

    July 10, 2002 (version 1.3) - Added "New State" tables entries. Clarify
    that there is a single global shared texture palette, rather than a per-
    texture unit palette when multitexture is available. (Mark Kilgard)

    March 24, 2004 (version 1.4) - Document vendor support for this
    extension; note that future NVIDIA GPU designs will not support this
    extension. (Mark Kilgard)

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