Chapter 8 Graphics Adapters

IMPORTANT: The requirements in this guide provide instructions for designing PC systems that will result in an optimal user experience with typical Windows-based applications running under either the Microsoft Windows Millennium Edition or Windows 2000 Professional or later operating systems. These design requirements are not the basic system requirements for running any version of Windows operating systems.

This chapter presents the requirements for the graphics subsystem. The key design goal is that graphics hardware behaves consistently across a wide range of applications, based on the need of the system to provide fast, high-quality rendering.

Unless this chapter defines a specific requirement or exception, all requirements for graphics adapters apply as presented in Chapter 3, "PC System," and Chapter 6, "Buses and Interfaces."

For requirements for the internal graphics subsystem on mobile PCs, see "Mobile PC Graphics Design."

Baseline Graphics Features

This section defines the baseline requirements for graphics adapters and the graphics subsystem.

GRPH–0163. Primary graphics adapter uses AGP or another high-speed connection

Accelerated Graphics Port (AGP) requirements are defined in *Accelerated Graphics Port Interface Specification, Revision 2.0*. PC 2001 requirements are defined in "Requirements for AGP and PCI Graphics Adapters." Specific AGP requirements are as follows:

- Discrete graphics solutions require the equivalent of AGP 2.X.
- Integrated graphics solutions require the equivalent of AGP 1.X.

Other buses, such as PCI, may be used for secondary graphics adapters.

GRPH–0164. System provides hardware-accelerated 3-D graphics

Many of the level-of-quality features and enhanced user interface features planned for future versions of Windows rely on Microsoft DirectDraw® and Microsoft Direct3D® being fully implemented in the graphics subsystem. Accordingly, all systems must include DirectX acceleration for 2-D and 3-D as listed in the sections “Hardware Acceleration for 2-D Graphics” and “Hardware Acceleration for 3-D Graphics.”

For all systems, 3-D acceleration is based on Direct3D capabilities provided in the operating system.

A system designed as a Windows graphics workstation must include a 3-D accelerator that supports Direct3D and may optionally support OpenGL as well. All hardware-accelerated features of the OpenGL accelerator must be accelerated under Direct3D except for those features not supported by the current released version of Direct3D. OpenGL support can be implemented under Windows as a Mini Client Driver (MCD) or Installable Client Driver (ICD). OpenGL driver support for Windows Me can only be implemented as an ICD.

Implementation details for OpenGL and DirectX are contained in the Windows 98 DDK and Windows 2000 DDK.

GRPH–0165. If Digital Video Interface is implemented, it conforms to DVI specification

DVI is the required interface for connecting monitors with a digital interface. For analog video output, the DVI connector analog feature is the preferred connector for monitors with analog interfaces.

GRPH–0166. Primary graphics adapter works normally with default VGA mode driver

The default VGA driver is required for installing the operating system. The primary adapter must support 4-bit planar VGA mode as described in the Windows 98 DDK and the Windows 2000 DDK.

GRPH–0167. Adapter and driver support multiple adapters and multiple monitors

System expansion buses that allow graphics adapters such as PCI and AGP can support the simultaneous use of more than one graphics adapter in the system. Multiple-monitor support can be implemented using add-on PCI graphics adapters. The device drivers for each graphics adapter must provide the required support to allow the presence of multiple adapters and multiple monitors.

For more information, see “Multiple-Adapter and Multiple-Monitor Support.”

GRPH–0168. Screen resolution and graphics memory capacity meet PC 2001 minimum requirements

All PC 2001 systems must support a minimum resolution of 1024 × 768 × 32 bpp, double buffered in 2-D mode with a 32-bit Z-buffer (defined as 24-bit Z with 8-bit stencil) in 3-D mode.

GRPH–0169. Adapter meets industry specifications for external display interface

Display adapters often implement more than one display interface (for example, VGA and DVI, VGA and National Television System Committee (NTSC), Dual VGA, DVI and NTSC, and so on). Each interface that is implemented must comply with the appropriate industry specifications for that interface as outlined in the following list:

- **Analog VGA.** Among other resolutions and refresh rates, the graphics adapter must support the 85 hertz (Hz) ergonomic timings for all required resolutions supported by the monitor up to 1024 × 768. These timings must conform to the *Computer Display Monitor Timing Specifications*, *Version 1*, *Rev. 0.8*, or the *VESA Generalized Timing Formula (GTF), Version 1.1*. Any higher timings and resolutions must conform to established industry standards. Additionally, in order to provide optimal support for video playback of NTSC broadcasts, the display adapter must support the NTSC (59.94 Hz) refresh rate to assure smooth frame delivery in TV-based video content applications. Phase Alternation Line (PAL) is important in many regions, but there are no specific PC 2001 requirements.
- **Digital Visual Interface (both digital and analog implementations).** Devices using DVI must implement the timings as specified in the *Digital Visual Interface (DVI), Revision 1.0* specification, provided by the Digital Display Working Group. Support for 85 Hz refresh at specified resolutions is also required to support analog monitors with digital interfaces. VGA Mode 3 typically requires a 70 Hz refresh rate, which is not compatible with liquid crystal displays (LCDs). DVI graphics adapters must support the ability to convert VGA Mode 3 70 Hz outputs to the VESA-equivalent 60 Hz timing standards for these displays. Additionally, in order to provide optimal support for video playback of NTSC broadcasts, the display adapter must support the NTSC refresh rate. PAL is important in many regions, but there are no specific PC 2001 requirements.

Single-chip, multihead devices that support independent displays with different images on each display must be able to meet this requirement on both displays simultaneously and independently unless one of the images is a DVD or MPEG-2 video stream—for example, 85 Hz on the PC monitor while displaying NTSC TV out or DVI at a minimum of 1024 × 768 at 32 bpp. This requirement does not imply that TV out support requires simultaneous VGA or DVI support (see GRPH–0207, “If support for TV or DVD-Video playback is implemented,

hardware supports video overlay surface with scaling"), but if such simultaneous support exists, this independence requirement must be met.

Support for interlaced display modes is not required. However, if interlaced modes are implemented and the user selects 1024 × 768 resolution, the graphics adapter must default to a noninterlaced refresh rate with the following exceptions:

- The attached monitor is not compatible with Display Data Channel (DDC) and the user has not selected a monitor type in the display control panel.
- The monitor does not support 1024 × 768 noninterlaced mode, as determined from the Extended Display Identification Data (EDID) or monitor registry settings.

GRPH–0170. All supported color depths are enumerated

The driver must enumerate all modes supported so that applications can choose their preferred color depth. The driver must comply with the following guidelines for enumeration:

- For 16 bpp, the 5:5:5 mode, the 5:6:5 mode, or both must be supported.
- If only the 5:5:5 mode is supported, the driver must also enumerate this as 16-bpp mode. This is required because some applications only look for 16-bpp support and will run in 8-bit mode if they fail to find a 16-bit mode.
- If both 5:5:5 and 5:6:5 modes are supported, both modes must be enumerated.

For each color depth supported, color ordering must be implemented as shown in the following list. Color ordering is shown in the following list from the most significant bit (MSB) to the least significant bit (LSB).

Mode	Color ordering
15 bpp	1 undefined, 5 red, 5 green, 5 blue (URRR RRGG GGGB BBBB)
16 bpp	5 red, 6 green, 5 blue (RRRR RGGG GGGB BBBB)
24 bpp	8 red, 8 green, 8 blue (RRRR RRRR GGGG GGGG BBBB BBBB)
32 bpp	8 alpha, 8 red, 8 green, 8 blue (AAAA AAAA RRRR RRRR GGGG GGGG BBBB BBBB)

GRPH–0171. Graphics operations use relocatable registers only

VGA registers must not be used to perform graphics operations such as bit block transferring (blting), palette setting, and pointer movement. The registers used for these graphics operations can be either I/O locations or memory-mapped locations, but must be relocatable. Normal system operation never requires the use of base VGA registers, except for system start-up and mode setting.

GRPH–0178. Adapter supports adjustable gamma correction

ICM uses this capability to perform gamma correction for the attached monitor and to allow game applications to switch palettes. This capability also supports transition effects in applications. To provide support for ICM, the graphics adapter gamma must be programmatically adjustable. It is required that downloadable RAM digital-to-analog converter entries be included to perform gamma correction in hardware at 24 bpp or 32 bpp.

This capability must be supported without requiring the use of any VGA resources as defined in GRPH–0171, "Graphics operations use relocatable registers only."

GRPH–0179. Adapter for external display supports Plug and Play monitor detection

The adapter must support the DDC2B host requirements identified in the *VESA Enhanced Extended Display Data Channel Standard (E-DDC), Version 1*, which defines the communication channel between the display and host system. The software can use this information to properly manage output to the various displays and to prevent the disabling of television output if no monitor is attached. Devices capable of multihead display must support this feature for all attached monitors.

Multiple-Adapter and Multiple-Monitor Support

This section defines the requirements for multiple-adapter and multiple-monitor support. If a user then adds a second adapter, resources will automatically be available and the operating system can automatically manage multiple display adapters.

Examples of multiple display adapters include:

- Multiple adapters added to the PC system.
- A single adapter with a single graphics chip supporting two monitors (single-chip multihead).
- A single adapter with multiple graphics chips supporting multiple monitors (multihead).
- Any combination of these scenarios.

Multimonitor support requires multiple-adapter and multiple-monitor compatibility in the BIOS, the graphics adapter, and its driver. This support also allows the system to enable any secondary graphics adapters in VGA mode, thus temporarily disabling that VGA for the previous adapter. For systems with the graphics chip on the system board, see GRPH–0199, "Onboard graphics device can be used as a system boot device." For systems with integrated graphics devices that support AGP slot upgrade capability, see GRPH–0202, "System-board graphics device is not hidden from Plug and play enumeration."

With this support, a single adapter that supports multiple monitors can display independent screen images. The operating system support therefore also assumes that the different displays might have differing X, Y coordinates, resolutions, color depths, refresh rates, and display capabilities.

For technical details about implementing driver support for multiple adapters and multiple monitors, see the Windows 98 DDK and the Windows 2000 DDK.

For additional information about relocatable registers, see GRPH–0171, “Graphics operations use relocatable registers only.”

GRPH–0180. Extended resources can be dynamically relocated after system boot

To support Plug and Play for multiple-adapter and multiple-monitor capabilities, all non-VGA standard display resources must be capable of being dynamically relocated after system boot (after POST). Register sets are examples of non-VGA standard display resources, which are also known as extended resources.

GRPH–0181. VGA resources can be disabled by software

A means must be provided to allow a driver to disable its adapter from decoding standard VGA addresses so that the adapter is independent of all other graphics adapters in the system. The adapter must remain fully functional without the VGA addresses.

Hardware Acceleration for 2-D Graphics

This section summarizes requirements related to 2-D graphics features, which can be implemented as hardware acceleration features.

All PC 2001 systems require hardware acceleration for 2-D graphics. Robust DirectDraw support is also required to allow 3-D hardware accelerators to take full advantage of the DirectX architecture.

GRPH–0182. Frame buffer can be accessed asynchronously by the CPU and graphics accelerator

It must be possible for applications to perform direct frame buffer accesses at any time, even while asynchronous accelerator operations are being executed.

GRPH–0183. Hardware supports transparent blter

There is no restriction on source size. A transparent blter can perform a block transfer (blt) with a source key transparent color. This requirement assumes that the blter is asynchronous with the host processor.

GRPH–0184. Hardware provides support to prevent tearing

The hardware must support a mechanism for preventing visible artifacts such as tearing. The mechanism for doing this is at the discretion of the hardware designer, but it must support tear-free capabilities for both full-screen and nonoccluded windowed applications. Only one of two simultaneous displays of the same image on two displays (for example, internal mobile panel and external VGA monitor attached) must meet this requirement. The mechanism to prevent tearing must be performed in synchronization with the vertical blanking interval (VBI).

Except when explicitly requested to do otherwise by an application (via Microsoft DirectDraw), blts must synchronize with the vertical scan line to avoid tearing. The ability to read the current scan line supports blting or writing to the screen without tearing. In some contexts, such as video playback, this support eliminates the need for the secondary overlay buffer. Other exceptions to this requirement may be allowed and are documented in the Windows 2000 DDK.

Hardware Acceleration for 3-D Graphics

This section summarizes requirements related to Microsoft Direct3D technologies that can be implemented as hardware acceleration features. Supporting the items in this section results in improved performance and improved memory use.

GRPH–0185. Hardware supports RGB rasterization

In red-green-blue (RGB) mode under Microsoft Direct3D, shading across a surface is accomplished by independently interpolating all color components. The following capabilities are required for RGB rasterization:

- **GRPH–0185.1. Textures.** These include the following:
  - MIP–mapped textures
  - Bilinear, or better filtered textures, rather than point-sampled, with perspective correction
- **GRPH–0185.2. Alpha blending for 3-D graphics.** Support for source alpha blending (that is, the blend operation does not require an alpha channel in the render target) and destination alpha blending (that is, the blend operation requires an alpha channel in the render target) is required for all devices. The following table shows the blend modes that must be supported as source and destination factors for alpha blending. All modes must be available in any combination and without dependency on other modes.

Alpha Blending Modes

Blend Mode	Source Factor	Destination Factor
D3DBLEND_BOTHINVSRCALPHA	Required	
D3DBLEND_BOTHSRCALPHA	Required	
D3DBLEND_DESTALPHA	Required	Required
D3DBLEND_DESTCOLOR	Required	
D3DBLEND_INVDESTALPHA	Required	Required
D3DBLEND_INVDESTCOLOR	Required	
D3DBLEND_INVSRCALPHA	Required	Required
D3DBLEND_INVSRCCOLOR		Required
D3DBLEND_ONE	Required	Required
D3DBLEND_SRCALPHA	Required	Required
D3DBLEND_SRCALPHASAT	Required	
D3DBLEND_SRCCOLOR		Required
D3DBLEND_ZERO	Required	Required

- **GRPH–0185.3. Lighting and fogging.** These requirements include the following:
  - Flat and Gouraud shading (that is, constant and linear interpolation of per-vertex diffuse and specular color attributes). The linear interpolation need not be perspective-correct.
  - Specular highlighting through the addition of an RGB specular color, interpolated from per-vertex specular color attributes. The linear interpolation need not be perspective-correct.
  - Fog effects through blending with an arbitrary RGB fog color. The fog blending term is computed on a per-pixel rather than per-vertex basis, and is range-based (range-based fog) or depth-based (pixel fog). See Windows 98 DDK and Windows 2000 DDK for definition and discussion of range-based fog and pixel fog.
  - Driver support for triangle strips and fans.

The Direct3D reference rasterizer provided in DirectX supports all of these capabilities.

GRPH–0186. Hardware supports multitexturing

Multitexturing hardware can apply multiple textures to a polygon. The most common application of multitexturing is with map-based techniques for diffuse lighting and specular reflections.

Implementing this capability requires supporting two or more sets of independent texture coordinates.

The following texture combination operations are required:

- MODULATERGB: Component-wise multiplication of both texture colors.
- MODULATELPHA: Multiply colors of one texture by the alpha of the other.
- ADD: Component-wise addition of both textures.
- BLEND: Linear combination of textures weighted by a scalar specified in a register or in a polygon alpha.

Multitexturing is used to compute the texture value that participates in the pixel pipeline implemented in Direct3D.

This technique must work in combination with fogging and alpha blending, but is not required to operate at the same time as other advanced filtering. Multipass multitexturing is acceptable; single-pass multitexturing is preferred.

For more information on Windows display and video support, see the Display Technology Web page, listed in "Graphics Adapters References."

GRPH–0187. Hardware supports texture formats

Hardware that implements 3D acceleration must support the following 2D, color texture formats:

- 16 bpp nonpalletized 1:5:5:5 ARGB
- 16 bpp nonpalletized 4:4:4:4 ARGB
- 32 bpp nonpalletized 8:8:8:8 ARGB

GRPH–0188. Hardware complies with texture size limitations

MIP mapping requires that textures of size 1 × 1 be supported. To meet PC 2001 requirements, a 3-D accelerator must support this lower limit on texture size. The texture units must support square and nonsquare power-of-two textures (2n × 2m) up to 1024 × 1024 for all texture operations.

GRPH–0189. Hardware supports Z comparison modes and Direct3D-compatible formats

The 3-D hardware must support 32-bit (24-bit Z and 8-bit stencil), unsigned, lockable Z buffer format and all Z comparison modes.

Hardware that supports Z buffering must support clearing of the Z buffer through the DirectDraw depth-fill blt mechanism. In addition, hardware must support clearing of color, Z buffers, and destination surfaces using this method as well.

Television Output Requirements

This section summarizes requirements for television output capabilities. The requirements in this section apply only if the television output capability is present on a PC 2001 system or on a graphics adapter that supports television output capabilities.

The required support allows an NTSC or PAL television to be used as a primary display surface for the Microsoft Windows family of operating systems and for Windows-based applications. If television output capabilities are provided in a PC 2001 system, support is required for either NTSC or PAL standards.

GRPH–0190. If TV out is implemented, adapter supports overscan/underscan scaling

The television output adapter must be able to correct horizontal and vertical overscan/underscan using hardware scaling. Software must be able to disable and enable this feature.

Mobile PC Note This requirement does not apply to mobile PC platforms.

GRPH–0191. If TV out is implemented, software supports positioning

Software must be able to program the television output hardware to position the television image in increments of 4 pixels horizontally and 4 scan lines vertically (or finer). The supported range must be at least +/– 40 pixels horizontal and +/– 20 scan lines vertical.

Mobile PC Note This requirement does not apply to mobile PC platforms.

GRPH–0192. If TV out is implemented, adapter supports flicker filter

The television output adapter must use multiline (three-tap minimum) hardware filtering techniques for flicker reduction. Enable, disable, and adjust capabilities for the flicker filter must be software controllable.

The TV out capability must be able to accept up to a 1024 × 768 progressive desktop and convert it to an interlaced TV resolution output signal.

GRPH–0193. If TV out is implemented, adapter supports composite video or S-video connectors

Support for composite video or S-video is required.

A dongle with a composite video connector meets this requirement if the dongle ships as part of the TV out implementation.

GRPH–0194. If TV out is implemented, adapter also supports DVI or VGA and television output

A graphics adapter that supports TV out must also support either DVI or VGA or both. This requirement does not apply to systems with integrated displays. The usefulness of a system is greatly enhanced when any combination of outputs can be active concurrently, but concurrent output support is not required.

Plug and Play Requirements for Graphics Adapters

This section summarizes requirements for Plug and Play and other resource- and bus-related capabilities.

GRPH–0195. Display devices do not use VGA BIOS POST to populate PCI SID

System-board and add-on display devices cannot use the VGA BIOS POST routine to populate the SID because the device's POST code might not be executed until later in the process, after device enumeration occurs. For system-board devices, the system BIOS must populate the SID at power on. Add-on display adapters must provide a method for populating the SID at the point when power is applied and the device is initialized to the state that is ready for POST.

GRPH–0196. System supports conflict resolution, VGA compatibility, and extended registers

When the end user changes or adds a graphics adapter to the system, setting resource assignments must not require changing jumpers or switches on either the card or the system board. The system must be able to automatically relocate the resources used by a graphics adapter on the system board when a graphics adapter expansion card is added to the system. In the event of an irreconcilable conflict with other devices on the system, the system must be able to disable one of the adapters in order to prevent the system from stalling.

The system must support the VGA graphics standard for application compatibility and Windows setup and error-recovery process. If a VGA BIOS exists on the graphics adapter, it must be able to configure its base address to C0000h and one alternate address, at a minimum, to prevent conflicts.

Extended resources are additional I/O ports, direct-access frame buffers, or data transfer areas on a graphics adapter that use more resources than does standard VGA. The Windows configuration manager must be able to map the resources to avoid conflicts with other system devices. At least one alternate configuration must be provided for each non-VGA display resource in the event of conflict during the IPL boot.

The software drivers and VGA BIOS (if used) must be able to use alternate configuration register addresses. The system must be able to dynamically disable or relocate VGA resources from C0000h. It must also be possible to re-enable these resources upon system reboot or reset.

For additional related requirements for multiple-monitor support, see "Multiple-Adapter and Multiple-Monitor Support."

BIOS and Option ROM Requirements for Graphics Adapters

This section provides requirements related to BIOS support for graphics adapters.

GRPH–0197. Chips support linear packed-pixel frame buffer, relocatable above 16 MB

Note: For DirectDraw, the graphics adapter's chip set must support linear access to the frame buffer by the host.

For optimized support with Windows, a linear packed-pixel frame buffer is required over a bank-switched frame buffer. Use 32-bit addresses to allow the linear frame buffer to be placed above the 16-MB ISA boundary, which enables a system to be populated with large amounts of RAM.

If memory or other resources conflict with the frame buffer being mapped into a linear address space, the page frame address can be used with minimal degradation of performance.

GRPH–0198. Option ROM supports DDC2B

The option ROM for the graphics adapter must meet current DDC2B host requirements documented in *VESA Display Data Channel (DDC) Standard, Version 3*, Level 2B protocol (DDC2B). This standard defines the functions that support the data channel between the graphics adapter and a DDC monitor.

GRPH–0199. Onboard graphics device can be used as a system boot device

Systems that have the graphics chip on the system board, and mobile PCs that are capable of docking in a docking station with PCI slots, must provide a means in the BIOS setup utility to force the system to boot using the onboard graphics device, even when an add-in graphics adapter is installed. This capability is required so the onboard graphics device can be used in a multiple-monitor configuration and for hot undock of a docked mobile system.

For systems with integrated graphics devices that support AGP slot upgrade capability, it is acceptable for the integrated graphics to be disabled automatically.

When an add-on card is installed in the AGP slot, integrated devices must support multimonitor.

GRPH–0200. System BIOS supports large frame buffers for graphics adapters

The system BIOS must support large frame-buffer graphics adapters that have up to 256 MB of frame buffers.

Requirements for AGP and PCI Graphics Adapters

This section provides requirements for graphics adapters that use the PCI bus.

GRPH–0201. Graphics device supports IRQ and correctly populates PCI BARs

Proper IRQ support is needed for optimal support of video playback. The display driver queries the actual device to find its register locations and so on. The PCI BARs must be populated correctly for this information to be correct in the registry.

On adapters that do not support an IRQ, the Interrupt Pin Register (3Dh) must be zero (0).

GRPH–0202. System-board graphics device is not hidden from Plug and Play enumeration

The system-board device must disable the PCI device rather than hiding it. Hiding the system-board graphics adapter from the PCI bus when another graphics adapter is detected in the system causes problems for supporting multiple-monitor capabilities.

For systems with integrated graphics devices that support AGP slot upgrade capability, it is acceptable for the integrated graphics to be disabled automatically. When an add-on card is installed in the AGP slot, integrated devices must support multimonitor.

Power Management for Graphics Adapters

This section summarizes the specific power management requirements for graphics adapters.

GRPH–0203. Graphics adapter complies with device class power management reference specification

The *Default Device Class Power Management Reference Specification, Version 1.0,* provides definitions of the OnNow device power states (D0–D3) for

display and graphics devices. The specification also covers device functionality expected in each power state and the possible wakeup event definitions for the class, if any.

GRPH–0204. Graphics adapter complies with VBE/Core 2.0 extensions for power management

The *VESA BIOS Extension Standard/Core Functions 2.0* (VBE/Core 2.0) specification defines extensions to VGA ROM BIOS services for power management.

Device Drivers and Installation for Graphics Adapters and Video Devices

This section summarizes the requirements for graphics adapters. The requirements in this section are required for all PC 2001 devices.

For additional driver-related requirements for multiple-monitor support, see "Multiple-Adapter and Multiple-Monitor Support."

GRPH–0205. Driver does not bypass any Microsoft-provided system components

The driver must not bypass or patch any Microsoft-provided system components. For Windows, this includes Gdi.exe, Kernel.exe, User.exe, Dibeng.dll, Mmsystem.dll, Ddraw.dll, D3d*.dll, and so on.

For Windows 2000, this requirement applies for all files normally installed in the System32 directory. These files include, but are not limited to, Win32k.sys, Ntoskrnl.exe, Gdi32.dll, User32.dll, and Mcdsrv32.dll.

GRPH–0206. Driver supports dynamic color depth and resolution change

The graphics adapter must operate properly and must not fail when asked by the operating system to change the color depth or resolution. A restart must not be required to accomplish this.

Graphics Subsystem Support for Video

This section presents requirements for the graphics subsystem to support TV or DVD-Video playback.

GRPH-0207. If support for TV or DVD-Video playback is implemented, hardware supports video overlay surface with scaling

It is envisioned that the overlay surface will be implemented using one of the required YUV formats. The graphics adapter must be able to support a minimum of one off-screen video overlay surface that has following characteristics:

- **GRPH–0207.1. Size.** Discrete graphics solutions support 1280 × 720 or larger. Mobile platforms and integrated graphics solutions support 720 × 576 or larger.
- **GRPH–0207.2. Screen Resolutions.** The video overlay must be fully operative at 640 × 480 and 1024 × 768 and color depths of 16 bpp and 32 bpp.

Mobile PC Note

Mobile platforms must support video overlay up to their native resolution and color depth.

- **GRPH–0207.3. Color formats.** The required formats must include the following:
  - YUV 4:2:2 (YUY2): A packed-pixel byte stream for every pixel in the order of Y1, U, Y2, V is required in all overlay surface buffers. No intra-image padding is allowed.

    YUV 4:2:0 (YV12): A system-board byte stream for the entire plane in the order of Y plane, V plane, U plane is required in the final overlay surface buffer when double buffering is supported.
  - If double buffering is not supported, YV12 support must be provided in the overlay surface.

    Support for the YUV 4:2:0 format is not a requirement if the graphics chip supports on-chip MPEG decoding.
- **GRPH–0207.4. Scaling.** When upscaling and downscaling to any size window, the high quality video scaling can occur anywhere between the video input to the chip, on the AGP, PCI, or side port and the video appearing on the screen.

  Video scaling must be implemented using the DirectDraw and Microsoft DirectShow® APIs.

  For PCs to effectively compete with dedicated consumer electronics video devices, it is necessary to raise the quality of video scaling on the PC. Specifying scaling quality is hard because of the difficulty of quantifying viewer-perceived video quality. These requirements for the quality of the video filter used in the resizing operations are specified:

- Use bilinear scaling or better; a filter with a minimum of two vertical taps and a minimum of two horizontal taps is required.
- Video display must be able to shrink or zoom by a variable factor of up to 8:1 in one-pixel increments.
- The image quality must not be perceptibly degraded when shrinking by factors up to 2:1. Some image degradation is acceptable for the larger shrink ratios.
- The scaling engine on a PC that is not enabled for digital television (DTV) must be able to accept a standard definition video input (480i or 576i), such as input that might come from a DVD or NTSC source.

  For a DTV-enabled PC, the scaling engine must be able to accept an input with a rate of 720p60 (1280 horizontal pixels) and 540p60 (bobbed from 1080i) (1280 horizontal pixels).

  For video sources that horizontally exceed 720 pixels, the hardware can upscale vertically using replication and downscale vertically using decimation. For such video sources, playback quality reductions may result as defined in Chapter 9, "Video."

  Note: The exception for video sources that horizontally exceed 720 pixels will be removed in a later version of this design guide.
- Upscaling and downscaling can be done in hardware and software; however, if a part-software solution is implemented, performance must not be degraded. All video requirements in Chapter 9, "Video," that pertain to video quality and CPU utilization apply independent of scaling ratios.

Scaling 4:2:2 or 4:2:0 YUV video must achieve two-pixel granularity.

GRPH–0208. If support for TV or DVD-Video playback is implemented, colorspace conversion can be configured for different color primary standards

Support is required for the ITU-R [BT.601-5] standard, formerly CCIR 601.

GRPH–0395. Hardware supports color keying for video

This is a requirement for video overlays. The hardware must be capable of independently controlling the pixels for compositing the video plane under the graphics plane. This destination color keying must function in all video modes using either or both of the following:

- A specific color/color range, for example, on 4-bit, 8-bit, 15-bit modes.
- Additional alpha blending bits in the color plane bits on 16-bit and 32-bit modes.

Color keying allows certain graphics pixels to replace underlying video pixels on a pixel-by-pixel basis. This feature enables video overlays, controls, Windows pop-up menus, dialog boxes, and so on, and it allows for irregular-shaped graphics compositing. Color keying must work simultaneously with any vertical/horizontal scaling active for the underlying video.

Mobile PC Graphics Design

This section defines the specific graphics capabilities for mobile PC 2001 systems.

GRPH–0393. Mobile system meets mobile PC 2001 basic graphics requirements

The basic graphics requirements for mobile PC systems provide support for operating system startup and for running mainstream applications reliably. Additional features must meet additional requirements only on an "if implemented" basis, as defined in the following list.

- **GRPH–0393.1. Mobile system supports display resolution of at least 640 × 480 with 256 colors.** Windows requires a display resolution of at least 640 × 480 with 256 colors (8 bpp using a color look-up table) to run properly. Mobile systems that optionally have 3-D support must implement at least 16 bpp color.
- **GRPH–0393.2. Mobile PC system uses PCI or better interconnect.** Mobile systems that support 3-D require the performance equivalent of AGP. AGP implementations must support Graphics Address Remapping Table (GART) at a minimum. AGP equivalent implementations must support GART equivalent functionality. PCI implementations are not required to support GART.
- **GRPH–0393.3. Optional 3-D capabilities meet minimum requirements.** For mobile systems, 3-D hardware is optional. If 3-D is supported, the mobile PC must meet all 3-D requirements at all supported resolutions up to and including the native display panel resolution of at least 640 × 480, and it must support a color depth of 16 bpp, with the following exceptions:
  - Support of per-pixel fog is not required; however, support of per-vertex fog is required.
  - Support of range-based or table-based fog is not required.
  - Support of 32-bit textures is not required; however, support of 16-bit textures is required.
  - Support of 32-bit Z buffers is not required; however, support of 16-bit Z buffers is required.
  - Support of Stencil buffers is not required.
  - Support of 32 bpp (ARGB 8:8:8:8) is not required.

  - Support of nonsquare power-of-two textures up to 1024×1024 for all textures operations is not required.
  - Support for square, power-of-two textures of sizes up to and including 256×256 is required.
- **GRPH–0393.4. Mobile PC resolution requirements.** Resolution and color depth requirements are limited to the capabilities of the integrated display panel when using an integrated panel or a simultaneous external display. Mobile systems that implement a single-chip, multihead configuration must meet the resolution and color depth requirements on the external display only up to the native resolution and color depth of the integrated display panel. Mobile PC systems that provide 3-D hardware acceleration must support a color depth of 16 bpp.
- **GRPH–0393.5. Mobile PC refresh frequency requirements.** Mobile systems must support refresh frequencies only up to the native capabilities of the integrated display panel. A mobile system that implements a single-chip, multihead, multimonitor configuration must meet the refresh frequency requirements on the external display only up to the native capabilities of the integrated display panel.
- **GRPH–0393.6. Mobile PC requirements for Plug and Play support for external displays.** Mobile PC systems that support external displays must support DDC detection for external displays, as defined in GRPH–0179, "Adapter for external display supports Plug and Play monitor detection," with the following exceptions:
  - Mobile systems do not have to supply +5V to the VGA connector at any time.
  - The DVI connector must supply +5V only during operating system boot, when the user first enables external video, and when the system is actually outputting analog or digital video through the DVI connector.
  - Mobile systems that implement a single-chip, multihead, multimonitor configuration are not required to display the system boot screen on the external display. In this configuration, the expectation is that the external display will be active when the display driver is enabled and the system is configured for multimonitor operation. If the system is configured for operation with only the external display active, the boot screen must be displayed.
- **GRPH–0393.7. Mobile PC multiple-monitor requirements.** For mobile PCs, multiple adapter support as described in GRPH–0167, "Adapter and driver support multiple adapters and multiple monitors," is not required unless the system supports single-chip, multihead, multiple-monitor capabilities, or the mobile PC supports a docking station with PCI expansion slots. If the docked mobile PC supports only Mini-PCI, the system is not required to support multiple-monitor requirements.

- **GRPH–0393.8. Mobile BIOS setup utility can force use of system-board graphics.** If the mobile system supports docking stations that allow for an additional display adapter (typically via a PCI slot), the manufacturer must provide an option in the system BIOS setup utility to force the system-board graphics device to be used as the boot device. This option always allows a docked mobile system to undock because the VGA device will be in the mobile unit.

See also MON–0235, "Monitor supports sRGB output or an ICC profile is provided," in Chapter 10, which applies for mobile PC flat-panel displays.

GRPH–0394. All mobile systems meet basic interoperability requirements

All mobile systems must meet basic graphics requirements to reliably run Windows and applications. Specifically, the following requirements must be met.

- **GRPH–0166. Primary graphics adapter works normally with default VGA mode driver**
- **GRPH–0169. Adapter meets industry specifications for external display interfaces**
- **GRPH–0170. All supported color depths are enumerated**
- **GRPH–0171. Graphics operations use relocatable registers only**
- **GRPH–0178. Adapter supports adjustable gamma correction**
- **GRPH–0179. Adapter for external display supports Plug and Play monitor detection**
- **GRPH–0180. Extended resources can be dynamically relocated after boot**
- **GRPH–0181. VGA resources can be disabled by software.** This requirement needs to be met by mobile systems only if multiheaded, multidisplay support exists.
- **GRPH–0182. Frame buffer can be accessed directly by applications**
- **GRPH–0183. Hardware supports transparent blter**
- **GRPH–0195. Display devices do not use VGA BIOS POST to populate PCI Subsystem ID**
- **GRPH–0196. System supports conflict resolution, VGA compatibility, and extended registers**
- **GRPH–0197. Chips support linear packed-pixel frame buffer, relocatable above 16 MB**
- **GRPH–0198. Option ROM supports DDC2B.** For external displays only
- **GRPH–0200. BIOS supports large frame buffers for graphics adapters.** For adapters added through docking-station or as PC-card only.

- **GRPH–0203. Graphics adapter complies with device class power management reference specification**
- **GRPH–0204. Graphics adapter complies with VBE/Core 2.0 extensions for power management**
- **GRPH–0205. Driver does not bypass any Microsoft-provided system components**
- **GRPH–0206. Driver supports dynamic color depth and resolution changes**

Graphics Adapters References

Following are the references, services, and tools cited in this chapter that are available to help build hardware that works optimally with Windows operating systems.

Accelerated Graphics Port Interface Specification, Revision 2.0

http://developer.intel.com

Computer Display Monitor Timing Specifications, Version 1, Rev. 0.8

http://www.vesa.org/standards.html

Default Device Class Power Management Reference Specification, Version 1.0

http://www.microsoft.com/hwdev/specs/PMref/

Digital Visual Interface (DVI), Revision 1.0

http://www.ddwg.org

ITU-R [BT.601-5] (formerly CCIR 601)

ITU (International Telecommunication Union)
E-mail: sales@itu.ch
http://www.itu.int

VESA BIOS Extension Standard/Core Functions 2.0 (VBE/Core 2.0)
VESA Display Data Channel (DDC) Standard, Version 3
VESA Enhanced Extended Display Data Channel Standard (E-DDC), Version 1
VESA Generalized Timing Formula (GTF), Version 1.1

http://www.vesa.org/standards.html

Display Technology Web page

http://www.microsoft.com/hwdev/video/

Windows 98 DDK, Windows 2000 DDK, and DirectX DDK

http://www.microsoft.com/ddk/

Checklist for Graphics Adapters

GRPH–0163. Primary graphics adapter uses AGP or another high-speed connection

GRPH–0164. System provides hardware-accelerated 3-D graphics

GRPH–0165. If Digital Video Interface is implemented, it conforms to DVI specification

GRPH–0166. Primary graphics adapter works normally with default VGA mode driver

GRPH–0167. Adapter and driver support multiple adapters and multiple monitors

GRPH–0168. Screen resolution and graphics memory capacity meet PC 2001 minimum requirements

GRPH–0169. Adapter meets industry specifications for external display interface

GRPH–0170. All supported color depths are enumerated

GRPH–0171. Graphics operations use relocatable registers only

GRPH–0178. Adapter supports adjustable gamma correction

GRPH–0179. Adapter for external display supports Plug and Play monitor detection

GRPH–0180. Extended resources can be dynamically relocated after system boot

GRPH–0181. VGA resources can be disabled by software

GRPH–0182. Frame buffer can be accessed asynchronously by the CPU and graphics accelerator

GRPH–0183. Hardware supports transparent blter

GRPH–0184. Hardware provides support to prevent tearing

GRPH–0185. Hardware supports RGB rasterization

GRPH–0186. Hardware supports multitexturing

GRPH–0187. Hardware supports texture formats

GRPH–0188. Hardware complies with texture size limitations

GRPH–0189. Hardware supports Z comparison modes and Direct3D-compatible formats

GRPH–0190. If TV out is implemented, adapter supports overscan/underscan scaling

GRPH–0191. If TV out is implemented, software supports positioning

GRPH–0192. If TV out is implemented, adapter supports flicker filter

GRPH–0193. If TV out is implemented, adapter supports composite video or S-video connectors

GRPH–0194. If TV out is implemented, adapter also supports DVI or VGA and television output

GRPH–0195. Display devices do not use VGA BIOS POST to populate PCI SID

GRPH–0196. System supports conflict resolution, VGA compatibility, and extended registers

GRPH–0197. Chips support linear packed-pixel frame buffer, relocatable above 16 MB

GRPH–0198. Option ROM supports DDC2B

GRPH–0199. Onboard graphics device can be used as a system boot device

GRPH–0200. System BIOS supports large frame buffers for graphics adapters

GRPH–0201. Graphics device supports IRQ and correctly populates PCI BARs

GRPH–0202. System-board graphics device is not hidden from Plug and Play enumeration

GRPH–0203. Graphics adapter complies with device class power management reference specification

GRPH–0204. Graphics adapter complies with VBE/Core 2.0 extensions for power management

GRPH–0205. Driver does not bypass any Microsoft-provided system components

GRPH–0206. Driver supports dynamic color depth and resolution change

GRPH–0207. If support for TV or DVD-Video playback is implemented, hardware supports video overlay surface with scaling

GRPH–0208. If support for TV or DVD-Video playback is implemented, colorspace conversion can be configured for different color primary standards

GRPH–0395. Hardware supports color keying for video

GRPH–0393. Mobile system meets mobile PC 2001 basic graphics requirements

GRPH–0394. All mobile systems meet basic interoperability requirements