Microsoft

Windows Hardware Compatibility Specifications for Windows 10, version 1809 and Windows Server 2019 - Systems

Microsoft Corporation

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Overview of Windows Hardware Compatibility Program

The Windows Hardware Compatibility Program (WHCP) is the primary channel that we use to communicate to the partner community the core expectations that Windows places on devices, kernel-affecting software, systems and solutions. The purpose of the document is to help ensure that products can successfully and seamlessly integrate into Windows. This communication starts with the core tenets and user scenarios that drove Windows design. Those design principles translate into a set of features that cover fundamentals, connectivity, and product-specific features. These design features are codified as discrete requirements which define what Windows expects from the various components and connected devices. A product designed to meet the requirements will be reliable, stable, efficient in power and performance, and provide a great Windows experience.

The program is unique in the industry in terms of the detail and engineering tools that Microsoft freely provides in order to assist partners build, test, secure, and maintain products for success in the Windows environment. No other program provides access to in-the-field telemetry in order to facilitate end-user support and quality assurance, nor as powerful a method to deliver software, drivers and certain firmware updates to end-users necessary to correct identified problems or allow new features to be embraced.

Partners can self-assess how their products comply with WHCP requirements by using the tests in the Windows Hardware Lab Kit (Windows HLK) for Windows 10. The Windows HLK contains significant enhancements to encourage efficient testing practices, such as early and focused testing, distributed testing and merged multifunction device fundamental testing. Not all requirements are able to be tested in an automated fashion, and automated testing can't fully assure absolute compliance with the requirements, so we continually analyze the end-user experience and improve the tools over time.

All products will expose a suite of features that can be categorized into four basic groupings, and they must meet all applicable requirements in order to be qualified for Windows Compatibility status. The four groups are:

- Device.Devfund - fundamental requirements expected of any device, filter or system (the fundamental features).
- Device.Connectivity - The connectivity requirements exposed for the type of connectivity the device uses. Devices that use more than one type of connectivity bus must meet all of the applicable connectivity buses requirements.
- Device/Filter/System specific requirements - The Device/System specific requirements assure that the device/system behaves as Windows expects.
- Additional requirements that are related to secondary functions added to the product. For example, removable storage is commonly found on mobile broadband USB-connected units. Both storage and the mobile broadband portion of the requirements must be met in order to be considered as Compatible.

Compatibility is a public statement of confidence from us that the tested device, filter driver, or system works well with Windows. Compatibility benefits include:

- Signing device drivers.
- Publishing the product as qualified in various catalogs and on the compatibility center.
- Collecting and pre-analyzing telemetry on your product in the field to improve your quality assurance efforts.
- Providing a free and extremely effective distribution channel for driver updates.
- Providing eligibility for various marketing incentives and a logo license.

Glossary

If-Implemented: An If-Implemented requirement is a mandatory requirement for an optional feature or function. The product is not required to implement the feature or function defined by the requirement, however if the feature or function is implemented, it must comply with the requirement.

> For example: Systems are not required to support USB Type C in the current requirements. If a system does support USB Type C functionality, then the system is required to comply with all of the defined USB Type C requirements.

Optional: An optional requirement is a recommendation that Microsoft strongly encourages be implemented when a product supports the described features or functions. This optional requirement is not enforced during the Windows Hardware Compatibility Program qualification. Therefore, it is possible to become Windows Hardware Compatibility Program qualified and not comply with the given optional requirement.

> For example: Microsoft recommends that HDD and SDD storage devices support Self-Monitoring, Analysis and Reporting Technology (SMART) metrics per the ATA8-ACS4 specification in order to reduce the chance of unexpected device failure or data loss. A storage device is not required to comply with this optional requirement, even when the device supports SMART.

System Requirements

System.Client.BluetoothController.Base

These requirements apply to systems that have generic Bluetooth controllers

System.Client.BluetoothController.Base.4LeSpecification

If a system includes a Bluetooth enabled controller it must support the Bluetooth 4.0 specification requirements.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

The Bluetooth enabled controller must comply with the Basic Rate (BR) and Low Energy (LE) Combined Core Configuration Controller Parts and Host/Controller Interface (HCI) Core Configuration requirements outlined in the Compliance Bluetooth Version 4.0 specifications.

System.Client.BluetoothController.Base.CS

Systems that support Modern Standby with Bluetooth enabled controllers must ship with Microsoft's inbox Bluetooth stack and support the MSFT Defined HCI extensions support for hardware offload of advertisement and RSSI monitoring (see System.Client.BluetoothController.Base.HciExtensions).

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

Systems that support Modern Standby that ship with Bluetooth enabled controllers must ship with Microsoft's inbox Bluetooth stack.

System.Client.BluetoothController.Base.HciExtensions

MSFT Defined HCI extensions support for hardware offload of advertisement and RSSI monitoring

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Terms: If-Implemented

Description

Radios that support the Microsoft-OSG Defined Bluetooth HCI Extensions must comply with the specification and pass the related HLKWLK tests. The details of the specifications will be shared at a later date. Partners will be notified via Connect.

System.Client.BluetoothController.Base.LEStateCombinations

Systems with Bluetooth enabled controllers must support a minimum set of LE state combinations.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

The Bluetooth enabled controller must allow the spec LE state combinations (as allowed in section [Vol 6] Part B, Section 1.1.1 of the Bluetooth version 4.0 spec).

System.Client.BluetoothController.Base.LEWhiteList

Systems with Bluetooth enabled controllers must support a minimum LE allow list size of 25 entries.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

The Bluetooth enabled controller on the system must support a minimum of 25 entries in its allow list for remote Low Energy (LE) devices.

System.Client.BluetoothController.Base.NoBluetoothLEFilterDriver

Bluetooth LE filter drivers are not allowed to load on BTHLEENUM.SYS.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM**

	Windows v10.0 Mobile ARM64 **Windows v10.0 Mobile x86**

Description

To ensure a uniform experience across Windows Store Apps using the Bluetooth LE (GATT) WinRT API, filter drivers shall not be loaded on BTHLEENUM.SYS.

System.Client.BluetoothController.Base.OnOffStateControllableViaSoftware

Bluetooth enabled controllers' On/Off state must be controllable via software.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

When turning the radio "off", Bluetooth enabled controllers shall be powered down to its lowest supported power state and no transmission/reception shall take place. Windows will terminate Bluetooth activity by unloading the inbox protocol drivers and their children, submitting the HCI_Reset command to the controller, and then setting the controller to the D3 logical power state, allowing bus drivers to power down the radio as appropriate. The radio can be completely powered off if a bus-supported method is available to turn the radio back on. No additional vendor software control components will be supported.

On turning the radio back on, the Bluetooth stack for Windows shall resume the device to D0, allowing bus drivers to restart the device. The Windows Bluetooth stack shall then reinitialize the Bluetooth enabled components of the controller.

Bluetooth Radio Management shall only be enabled for internal Bluetooth 4.0 enabled controllers.

Bluetooth enabled controllers' On/Off state shall be controllable via software as described in Bluetooth Software Radio Switch. The Off state is defined, at a minimum, as disabling the antenna component of the Bluetooth enabled module so there can be no transmission/reception. There must not be any hardware-only switches to control power to the Bluetooth enabled radio.

The radio must maintain on/off state across sleep and reboot.

System.Client.BluetoothController.Base.SimultaneousBrEdrAndLeTraffic

Bluetooth enabled controllers must support simultaneous BR/EDR and LE traffic.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64**

	Windows v10.0 Mobile x86

Description

Bluetooth enabled controllers must allow the simultaneous use of both Basic Rate (BR)/Enhanced Data Rate (EDR) and Low Energy (LE) radios.

System.Client.BluetoothController.Base.WidebandSpeech

Applies to	**Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description:

Wideband speech enables high definition voice quality (audio is sampled at 16 KHz as opposed to only 8 KHz) for telephony audio on Windows devices when the user is communicating via a Bluetooth peripheral that also supports wideband speech.

What this means is that Bluetooth radios must support wideband speech in the hardware as defined by the Bluetooth SIG Hands-Free Profile (HFP) 1.6 specification and the Core Specification Addendum (CSA) 2 which is included in the Core Version 4.1 Bluetooth specification. At a minimum it must use at least one Bluetooth SIG defined wideband speech codec (currently mSBC).

Business Justification:

We want users to experience the best possible quality audio when using Bluetooth peripherals on Windows. Wideband speech is becoming a standard for peripherals that support the HFP profile. Our competition already supports it

System.Client.BluetoothController.Base.WLANBTCoexistence

Windows Systems that support both WLAN and Bluetooth must meet WLAN-BT Co-existence requirements.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

Windows systems that support both WLAN and Bluetooth must meet WLAN-BT Co-existence requirements listed below. The requirement is applicable to all WLAN devices across all bus types.

- Must not drop the connection with WLAN AP when Bluetooth is scanning for new devices.
- Must be able to scan simultaneously for both WLAN and Bluetooth networks.

System.Client.BluetoothController.NonUSB

These requirements apply to systems that have non-USB Bluetooth enabled controllers.

System.Client.BluetoothController.NonUSB.NonUsbUsesMicrosoftsStack

Any platform using a non-USB connected Bluetooth enabled controller must ship with Microsoft's inbox Bluetooth stack.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

Any platform using a non-USB connected Bluetooth enabled controller must ship with *Microsoft's inbox Bluetooth* stack.

System.Client.BluetoothController.NonUSB.ScoSupport

Any platform with a non-USB connected Bluetooth enabled controller must use a sideband channel for SCO.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

Any platform using a Non-USB connected Bluetooth enabled controller must use sideband channel for SCO (such as SCO over an I2S/PCM interface).

System.Client.BluetoothController.USB

These requirements apply to systems that have USB Bluetooth enabled controllers.

System.Client.BluetoothController.USB.ScoDataTransportLayer

Bluetooth enabled host controllers support the SCO data transport layer as specified in the Bluetooth 2.1+EDR specifications.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM**

	Windows v10.0 Mobile ARM64 **Windows v10.0 Mobile x86**

Description

A System with a Bluetooth enabled controller must comply with the Synchronous Connection Oriented (SCO)-USB requirements that are outlined in the Specification of the Bluetooth System, Version 2.1 + Enhanced Data Rate (EDR), Part A, Section 3.5.

System.Client.BrightnessControls

This section describes requirements systems with brightness controls.

System.Client.BrightnessControls.BacklightOptimization

Windows Display Driver Model (*WDDM) 1.2 drivers must enable scenario based backlight power optimization to reduce backlight level used by integrated panel*.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

a. If WDDM driver supports scenario based backlight power optimization, it must indicate the support by implementing the DXGK_BRIGHTNESS_INTERFACE2 interface.

b. When Windows sets the current scenario by using the DxgkDdiSetBacklightOptimization function, the WDDM driver is required to honor the intent of the scenario as follows:

    a. DxgkBacklightOptimizationDisable: Driver is required to completely disable all backlight optimization.

    b. DxgkBacklightOptimizationDesktop: Driver is required to enable backlight optimization at a lower aggressiveness level. Driver must optimize for scenarios like photo viewing, browser, and Office documents.

    c. DxgkBacklightOptimizationDynamic: Driver is required to enable backlight optimization at a higher aggressiveness level. Driver must optimize for scenarios like video playback and gaming.

    d. DxgkBacklightOptimizationDimmed: Driver is required to enable backlight optimization at a higher aggressiveness level. Driver must make sure that the content on the screen is visible but it need not be easily readable.

c. Driver is allowed to dynamically change the aggressiveness level based on the content on the screen.

d. Driver is required to handle Windows requests for change to brightness level (based on user input or ambient light sensor) while keeping backlight optimization enabled.

e. Driver is required to gradually transition between aggressiveness levels:

    a. This is important in the case when user briefly invokes playback controls. At that time, Windows will reset the scenario from DxgkBacklightOptimizationDynamic to DxgkBacklightOptimizationDesktop. The transition must not be a step but must be gradual.

f. WDDM driver is required to provide accurate information when Windows queries DxgkDdiGetBacklightReduction.

g. Connecting additional display devices to the system must not impact the ability to perform backlight optimization on the integrated panel of the system.

System.Client.BrightnessControls.BrightnessControlButtons

Systems that have built in physical brightness control function keys use standard ACPI events and support control of LCD backlight brightness via ACPI methods in the system firmware.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

Windows provides users with an LCD brightness control user interface. If the system implements keys that are invisible to the operating system, these keys must use Advanced Configuration and Power Interface (ACPI) methods. These keys must not directly control the brightness after Bit 2 of the _DOS method has been set. This requires the implementation of ACPI brightness methods in the system firmware.

The following methods are required:

_BCL

_BCM

Bit 2 of the _DOS method must be disabled so that the system firmware cannot change the brightness levels automatically.

The following methods are optional:

Support for the _BQC method is highly recommended but not required. Systems must map keys to the following ACPI notification values:

1. ACPI_NOTIFY_CYCLE_BRIGHTNESS_HOTKEY 0x85
2. ACPI_NOTIFY_INC_BRIGHTNESS_HOTKEY 0x86
3. ACPI_NOTIFY_DEC_BRIGHTNESS_HOTKEY 0x87
4. ACPI_NOTIFY_ZERO_BRIGHTNESS_HOTKEY 0x88

Design Notes:

The _BCL and _BCM methods in the firmware enable the operating system to query the brightness range and values and to set new values. Refer to the ACPI 3.0 specification for more details.

System.Client.BrightnessControls.SmoothBrightness

Driver must support a smooth transition in response to all brightness change requests from Windows.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

A. All Windows systems that support brightness control, are required to support smooth brightness control

B. All Windows systems are required to report 101 brightness levels to Windows. Brightness is reported as a % so this means 0 to 100 levels, including 0 and 100. Internally the driver might support more granular brightness control.

C. This is to ensure that Windows has the ability to make fine grained changes to the screen brightness. However, the brightness slider UI might expose fewer levels through the slider because it might be cumbersome for the user to adjust so many levels.

D. WDDM driver is required to implement smooth brightness control in the driver without depending on the embedded controller (EC) for the smoothness.

E. WDDM driver is required to indicate support for smooth brightness control using the capability bit defined in the DXGK_BRIGHTNESS_INTERFACE2 interface.

F. WDDM driver must enable/disable smooth brightness control based on state set using DxgkDdiSetBrightnessState.

G. When Windows requests a change to brightness, driver is required to gradually change the brightness level over time so that the change is not a step.

H. WDDM driver is allowed to select an appropriate slope for transition. However, the transition must complete in less than 2s.

I. WDDM driver is allowed to alter the slope based on panel characteristics to ensure smoothness of brightness control.

J. WDDM driver is required to start responding immediately to new brightness level requests. This must be honored even if the system is already in the process of an existing transition. At such a time, the system must stop the existing transition at the current level and start the new transition from the current position. This will ensure that when a user is using the slider to manually adjust the brightness, the brightness control is still responsive and not sluggish.

K. WDDM driver is required to continue supporting smooth brightness control, even if content based adaptive brightness optimization is currently in effect.

L. When WDDM driver is pnp started, it must detect the brightness level applied by the firmware and smoothly transition from that level to the level set by Windows.

M. Connecting additional display devices to the system must not impact the ability to do smooth brightness control on the integrated panel of the system.

N. Brightness levels are represented as a % in Windows. Therefore there is no absolute mapping between brightness % level and physical brightness level. For Windows 8, the following is the guidance.

Percent represented to Windows	User Experience
0%	Brightness level such that the contents of the screen are barely visible to the user
100%	Max brightness supported by panel

System.Client.Buttons

System.Client.Buttons.HardwareButtons

Hardware buttons are implemented correctly

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description:

This requirement is currently optional and will not be enforced until 2017.

Hardware buttons must be implemented according to the guidance on the following page: https://msdn.microsoft.com/en-us/library/windows/hardware/dn957423(v=vs.85).aspx

GPIO buttons must be specified using the standardized ACPI generic button device (ACPI0011): https://msdn.microsoft.com/en-us/library/windows/hardware/dn957422(v=vs.85).aspx

In the case where buttons are not wired through GPIO interrupts, buttons must be reported to Windows as HID collections. HID button report descriptors must follow the report descriptors specified on the following page: https://msdn.microsoft.com/en-us/library/windows/hardware/dn457881(v=vs.85).aspx

System.Client.Camera

System.Client.Camera.CameraControls

Systems with integrated cameras meet the requirements of, and can support the Windows Capture Infrastructure.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

System Memory:

System Memory must be supported.

Independent Streaming:

All integrated Cameras must support independent streaming between different pins and different filters (cameras) according to the capabilities listed in the Profiles advertised by the device. If the camera does not support Profiles, then concurrent streaming for *all* system cameras is required.

Mirroring:

The default state for mirroring must be "not mirrored."

Camera Controls (*If Implemented)*:

Each of the following camera controls are optional.

- Region of Interest (ROI)
- Focus
- Exposure
- White Balance
- Zoom
- Camera Flash
- Scene Mode
- Optimization Hints
- Optical Image Stabilization
- Backlight Compensation
- Brightness
- Contrast
- Exposure Compensation
- Hue
- Pan
- Tilt
- Roll
- Video Stabilization
- Variable Frame Rate
- Face Detection
- Video HDR
- Histogram
- Advanced Photo

If any individual control is implemented in the camera driver, it must comply with the control specification in the WDK.

Photo Sequence (*If Implemented)*:

Photo Sequence captures a sequence of photos in response to a single photo click. Capture pipeline would send buffers to the camera driver continuously to capture the photos in sequence. This mode also allows capturing photos from the time before the "user click" thus helping users not to lose a moment.

If camera HW supports Photo Sequence, it must expose the capability through the Photo Mode property and comply with the performance requirements.

Photo Sequence must be enabled by the device and driver to:

- Support the same resolutions that are exposed in Normal mode
- Report the current frame rates possible in Photo Sequence Mode based on the current light conditions. Device must honor and not exceed the maximum frame rate set by the application.
- Support at minimum 4fps measured at lesser of the maximum resolution exposed by the image pin or 8MP.
- Provide at least 4 frames in the past at lesser of the maximum resolution exposed by the image pin or 8MP.
- Photo Sequence should be performed independently, regardless preview on/off.
- Provide frames continuously in Photo Sequence mode at lesser of the maximum resolution exposed by the image pin or 8MP.
- If the driver outputs JPEG format for Photo Sequence it must also support thumbnails, upon request, at 1/2x, 1/4x, 1/8x, and 1/16x of the width and height of the original image resolution.
- The JPEG image generated by the camera may optionally have EXIF metadata indicating the "flash fired" information. EXIF information shall not include personally identifiable information, such as location, unique ids, among others.

Variable Photo Sequence (*If Implemented)*:

Variable Photo Sequence captures a finite number of images and supports the ability to vary the capture parameters for each of the captured images. If implemented in Camera driver then the driver should be able to return the requested number of images, in order, each with varying capture parameters as instructed by the application. The driver shall be able to preprogram the number of frames needed and set independent capture parameters for each frame before capture is initiated.

It is recommended that the variable photo sequence allows the application to specify the following parameters for each frame, but at least one of these must be implemented if VPS is supported:

1. Exposure
2. ISO
3. Exposure Compensation in EV
4. Focus position
5. Flash

If any parameter is not set in per frame settings the driver shall follow the global settings and 3A locks. For example when EV bracketing is used, the driver shall ensure that exposure related parameters like gain and exposure are set according to EV bracketing settings. The driver may vary auto white balance settings for image frames unless the per frame settings use manual white balance settings or in case of application uses white balance lock. It not recommended that lens position is automatically changed between the VPS frames (unless manually specified by the application).

System.Client.Camera.Device

Systems with integrated cameras must meet camera device requirements.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

Each integrated camera on a system must comply with **Device.Streaming.Camera.Base** and all related requirements. If the integrated camera is a USB camera, it must also comply with **Device.Streaming.Camera.UVC** for the system seeking certification.

Note: With regards to '**Device.Streaming.Camera.Base.UsageIndicator'** if a system has multiple cameras, then one physical indicator (e.g. LED) is acceptable so long as it indicates usage whenever one or more cameras are in use. Systems without a display must have a physical indicator.

System.Client.Camera.PhysicalLocation

Systems with integrated cameras must report the physical location of each camera.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

For any camera device that is built into the chassis of the system and has mechanically fixed direction, the firmware must provide the _PLD method and set the panel field (bits [69:67]) to the appropriate value for the panel on which the camera is mounted. For example, "Front" indicates the camera faces the user, while "back" indicates that the camera faces away from the end user.

In addition, bits 143:128 (Vertical Offset), and bits 159:144 (Horizontal Offset) must provide the relative location of the camera with respect to the display. This origin is relative to the native pixel addressing in the display component. The origin is the lower left hand corner of the display, where positive Horizontal and Vertical Offset values are to the right and up, respectively. For more information, see the ACPI version 5.0 Section 6.1.8 "Device Configuration _PLD (Physical Device Location)."

Camera device orientation with respect to the default system display orientation (also known as native system display orientation) must be specified in the _PLD rotation field (bits 115-118). When the pixels read out from the camera sensor can be displayed correctly without any rotation, then the camera sensor's _PLD rotation value must be set to 0. When the pixels read out from the camera sensor need to be rotated clockwise to display correctly, then the camera sensor's _PLD rotation value must be set accordingly ('0' for 0°, '2' for 90°, '4' for 180°, and '6' for 270°).

All other fields in the _PLD are optional.

System.Client.Camera.SensorCapture

Systems with integrated cameras meet the requirements of, and can support the Windows Capture Infrastructure.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

Systems supporting a sensor capture camera must be able to support basic Windows Media Pipeline streaming. There is currently no requirements on the definition of the payload provided, but the device must provide samples that can be captured and provided to a generic, third party application even if no standard definition of that payload exists.

System.Client.Camera.VideoCapture

Systems with integrated cameras meet the requirements of, and can support the Windows Capture Infrastructure.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

Systems supporting a video capture camera must be able to support basic Windows Media Pipeline scenarios. These include, but are not limited to:

- Video Preview of mediatypes available from the output of either the camera source or its user mode component
- (Optional) Video Record of compressed mediatypes available from the output of either the camera source or its user mode component to Windows provided record sinks
- Video Record of uncompressed mediatypes available from the output of either the camera source or its user mode components to system provided encoders and finalized in Windows provided record sinks
- Photo of mediatypes available from the output of either the camera source or its user mode components to Windows provided photo sinks.
- All mediatypes provided by the output of the camera source or its user mode components (which ever is the latest in the pipeline) must be consumable by a generic, third party application

System.Client.Digitizer

System.Client.Digitizer.Base.SystemDigitizerBase

System Digitizer Base

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Digitizer Base device level requirements must be met and verified upon integration into a system. Please refer to the following **Device.Input.Digitizer.Base** requirements for full requirement details:

Device.Input.Digitizer.Base.ContactReports

Device.Input.Digitizer.Base.HIDCompliant

Device.Input.Digitizer.Base.ThirdPartyDrivers

System.Client.Digitizer.SystemPen

System Pen

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Pen device level requirements must be met and verified upon integration into a system. Please refer to the following **Device.Input.Digitizer.Pen** requirements for full requirement details:

Device.Input.Digitizer.Pen.Accuracy

Device.Input.Digitizer.Pen.Buffering

Device.Input.Digitizer.Pen.CustomGestures

Device.Input.Digitizer.Pen.Eraser

Device.Input.Digitizer.Pen.HoverRange

Device.Input.Digitizer.Pen.Jitter

Device.Input.Digitizer.Pen.Latency

Device.Input.Digitizer.Pen.Pressure

Device.Input.Digitizer.Pen.ReportRate

Device.Input.Digitizer.Pen.Resolution

System.Client.Digitizer.SystemTouch

System Touch

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

The following Touch device level requirements must be met and verified upon integration into a system. Please refer to the following **Device.Input.Digitizer.Touch** requirements for full requirement details:

Device.Input.Digitizer.Touch.Accuracy

Device.Input.Digitizer.Touch.Buffering

Device.Input.Digitizer.Touch.CustomGestures

Device.Input.Digitizer.Touch.FingerSeparation

Device.Input.Digitizer.Touch.Jitter

Device.Input.Digitizer.Touch.Latency

Device.Input.Digitizer.Touch.MinContactCount

Device.Input.Digitizer.Touch.ReportRate

Device.Input.Digitizer.Touch.Resolution

Microsoft strongly recommends touch solutions capable of reporting 5 or more simultaneous contact points. This ensures that the platform is compatible with third party applications that rely upon touch input, and that end users are able to invoke all of the system gestures provided by Windows.

Microsoft recognizes that extenuating circumstances exist whereby an extended gesture experience is not necessary. In order to accommodate this very limited set of systems, we make the following allowances:

Systems that are sold as build to configure, custom enterprise images, or are designed for specific vertical enterprise markets, have the option to ship a touch screen capable of reporting only a single contact point. Examples include systems designed for health care, military applications, and Point of Sale.

Any system incapable of supporting more than a single contact point will be unable to invoke any system gestures other than generic mouse-like behavior.

A system reliant upon a keyboard and mouse as the primary input modality, without the capability to convert into a tablet mode device, may choose to integrate a touch solution capable of supporting a minimum of 2 simultaneous contact points. Examples include: external displays, All-In-One desktop systems.

Any system incapable of supporting more than 2 simultaneous contact points will be unable to invoke 4 finger accessibility gestures.

All other systems must support a minimum of 5 simultaneous contact points

System.Client.Digitizer.SystemPrecisionTouchpad

Precision Touchpad

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows Server 2019 x64**

Description

The following Precision Touchpad device level requirements must be met and verified upon integration into a system. Please refer to the following **Device.Input.Digitizer.PrecisionTouchpad** requirements for full requirement details:

Device.Input.Digitizer.PrecisionTouchpad.Accuracy

Device.Input.Digitizer.PrecisionTouchpad.Buffering

Device.Input.Digitizer.PrecisionTouchpad.Buttons

Device.Input.Digitizer.PrecisionTouchpad.ContactTipSwitchHeight

Device.Input.Digitizer.PrecisionTouchpad.DeviceTypeReporting

Device.Input.Digitizer.PrecisionTouchpad.Dimensions

Device.Input.Digitizer.PrecisionTouchpad.FingerSeparation

Device.Input.Digitizer.PrecisionTouchpad.Jitter

Device.Input.Digitizer.PrecisionTouchpad.Latency

Device.Input.Digitizer.PrecisionTouchpad.MinMaxContacts

Device.Input.PrecisionTouchpad.Precision.InputResolution

Device.Input.Digitizer.PrecisionTouchpad.SelectiveReporting

A touchpad may not be marketed as a Precision Touchpad if the device requires a 3rd party driver be installed in order to report as a Precision Touchpad.

System.Client.Digitizer.Pen

System.Client.Digitizer.Pen.Accuracy

System Pen Contact Accuracy

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Pen device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.Pen.Accuracy** requirement for full requirement details.

System.Client.Digitizer.Pen.Buffering

System Pen Buffering for buses with High Resume latency

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Pen device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.Pen.Buffering** requirement for full requirement details.

System.Client.Digitizer.Pen.ContactReports

System Pen Digitizer Reliability

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Pen device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.Pen.ContactReports** requirement for full requirement details.

System.Client.Digitizer.Pen.CustomGestures

System Pen Custom Run-Time System Gestures

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Pen device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.Pen.CustomGestures** requirement for full requirement details.

System.Client.Digitizer.Pen.Eraser

System Pen Eraser Affordance

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Pen device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.Pen.Eraser** requirement for full requirement details.

System.Client.Digitizer.Pen.HIDCompliant

System Pen HID Compliant Device Firmware and/or HID Mini-port Driver

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Pen device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.Pen.HIDCompliant** requirement for full requirement details.

System.Client.Digitizer.Pen.HoverRange

System Pen Hover Range

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Pen device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.Pen.HoverRange** requirement for full requirement details.

System.Client.Digitizer.Pen.Jitter

System Pen Jitter and Linearity

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Pen device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.Pen.Jitter** requirement for full requirement details.

System.Client.Digitizer.Pen.Latency

System Pen Response Latencies

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Pen device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.Pen.Latency** requirement for full requirement details.

System.Client.Digitizer.Pen.Pressure

System Pen Pressure Reporting

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64**

	Windows v10.0 Mobile ARM **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Pen device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.Pen.Pressure** requirement for full requirement details.

System.Client.Digitizer.Pen.ReportRate

System Pen Report Rate

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Pen device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.Pen.ReportRate** requirement for full requirement details.

System.Client.Digitizer.Pen.Resolution

System Pen Input Resolution

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Pen device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.Pen.Resolution** requirement for full requirement details.

System.Client.Digitizer.Pen.ThirdPartyDrivers

System Pen Servicing and 3rd Party Driver Availability

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

	Windows Server 2019 x64

Description

The following Pen device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.Pen.ThirdPartyDrivers** requirement for full requirement details.

System.Client.Digitizer.PrecisionTouchpad

System.Client.Digitizer.PrecisionTouchpad.Accuracy

System Precision Touchpad Accuracy

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Precision Touchpad device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.PrecisionTouchpad.Accuracy** requirement for full requirement details.

System.Client.Digitizer.PrecisionTouchpad.Buffering

System Precision Touchpad Buffering for Buses with High Resume Latency

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Precision Touchpad device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.PrecisionTouchpad.Buffering** requirement for full requirement details.

System.Client.Digitizer.PrecisionTouchpad.Buttons

System Precision Touchpad Physical Buttons and Button Reporting

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Precision Touchpad device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.PrecisionTouchpad.Buttons** requirement for full requirement details.

System.Client.Digitizer.PrecisionTouchpad.ContactReports

System Precision Touchpad Digitizer Reliability

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Precision Touchpad device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.PrecisionTouchpad.ContactReports** requirement for full requirement details.

System.Client.Digitizer.PrecisionTouchpad.ContactTipSwitchHeight

System Precision Touchpad Contact Tip Switch Height

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Precision Touchpad device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.PrecisionTouchpad.ContactTipSwitchHeight** requirement for full requirement details.

System.Client.Digitizer.PrecisionTouchpad.DeviceTypeReporting

System Precision Touchpad Device Type

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Precision Touchpad device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.PrecisionTouchpad.DeviceTypeReporting** requirement for full requirement details.

System.Client.Digitizer.PrecisionTouchpad.Dimensions

System Precision Touchpad Dimensions

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Precision Touchpad device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.PrecisionTouchpad.Dimensions** requirement for full requirement details.

System.Client.Digitizer.PrecisionTouchpad.FingerSeparation

System Precision Touchpad Finger Separation

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Precision Touchpad device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.PrecisionTouchpad.FingerSeparation** requirement for full requirement details.

System.Client.Digitizer.PrecisionTouchpad.HIDCompliant

System Precision Touchpad HID Compliant Device Firmware and/or HID Mini-port Driver

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Precision Touchpad device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.PrecisionTouchpad.HIDCompliant** requirement for full requirement details.

System.Client.Digitizer.PrecisionTouchpad.InputResolution

System Precision Touchpad Input Resolution

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Precision Touchpad device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.PrecisionTouchpad.Input Resolution** requirement for full requirement details.

System.Client.Digitizer.PrecisionTouchpad.Jitter

System Precision Touchpad Jitter and Linearity

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Precision Touchpad device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.PrecisionTouchpad.Jitter** requirement for full requirement details.

System.Client.Digitizer.PrecisionTouchpad.Latency

System Precision Touchpad Response Latencies

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Precision Touchpad device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.PrecisionTouchpad.Latency** requirement for full requirement details.

System.Client.Digitizer.PrecisionTouchpad.MinMaxContacts

System Precision Touchpad Contact Count

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Precision Touchpad device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.PrecisionTouchpad.MinMaxContacts** requirement for full requirement details.

System.Client.Digitizer.PrecisionTouchpad.ReportRate

System Precision Touchpad Report Rates

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Precision Touchpad device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.PrecisionTouchpad.ReportRate** requirements for full requirement details.

System.Client.Digitizer.PrecisionTouchpad.SelectiveReporting

System Precision Touchpad Selective Reporting

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Precision Touchpad device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.PrecisionTouchpad.SelectiveReporting** requirements for full requirement details.

System.Client.Digitizer.PrecisionTouchpad.ThirdPartyDrivers

System Precision Touchpad Servicing and 3rd Party Driver Availability

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following Precision Touchpad device level requirement must be met and verified upon integration into a system. Please refer to the **Device.Input.Digitizer.PrecisionTouchpad.ThirdPartyDrivers** requirements for full requirement details.

Microsoft highly recommend the touchpad module to support Microsoft Precision Touchpad via Firmware. This recommendation may become a requirement for the future release of the Windows Hardware Compatibility Program at Microsoft's discretion.

System.Client.Digitizer.Touch

System.Client.Digitizer.Touch.Accuracy

System Touch Accuracy

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

The following Touch device level requirements must be met and verified upon integration into a system. Please refer to the following **Device.Input.Digitizer.Touch.Accuracv** requirement for full requirement details.

System.Client.Digitizer.Touch.Buffering

System Touch Buffering for Buses with High Resume Latency

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

The following Touch device level requirements must be met and verified upon integration into a system. Please refer to the following **Device.Input.Digitizer.Touch.Buffering** requirement for full requirement details.

System.Client.Digitizer.Touch.ContactReports

System Touch Digitizer Reliability

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

The following Touch device level requirements must be met and verified upon integration into a system. Please refer to the following **Device.Input.Digitizer.Touch.ContactReports** requirement for full requirement details.

System.Client.Digitizer.Touch.CustomGestures

System Touch Custom Run-Time System Gestures

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

The following Touch device level requirements must be met and verified upon integration into a system. Please refer to the following **Device.Input.Digitizer.Touch.CustomGestures** requirement for full requirement details.

System.Client.Digitizer.Touch.FingerSeparation

System Touch Finger Separation

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

The following Touch device level requirements must be met and verified upon integration into a system. Please refer to the following **Device.Input.Digitizer.Touch.FingerSeparation** requirement for full requirement details.

System.Client.Digitizer.Touch.HIDCompliant

System Touch HID Compliant Device Firmware and/or HID Mini-port Driver

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

The following Touch device level requirements must be met and verified upon integration into a system. Please refer to the following **Device.Input.Digitizer.Touch.HIDCompliant** requirement for full requirement details.

System.Client.Digitizer.Touch.Jitter

System Touch Jitter and Linearity

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

The following Touch device level requirements must be met and verified upon integration into a system. Please refer to the following **Device.Input.Digitizer.Touch.Jitter** requirement for full requirement details.

System.Client.Digitizer.Touch.Latency

System Touch Response Latency

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

The following Touch device level requirements must be met and verified upon integration into a system. Please refer to the following **Device.Input.Digitizer.Touch.Latency** requirement for full requirement details.

System.Client.Digitizer.Touch.MinContactCount

System Touch Minimum Simultaneous Reportable Contacts

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64**

	Windows v10.0 Mobile ARM **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

The following Touch device level requirements must be met and verified upon integration into a system. Please refer to the following **Device.Input.Digitizer.Touch.MinContactCount** requirement for full requirement details.

System.Client.Digitizer.Touch.ReportRate

System Touch Report Rate

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

The following Touch device level requirements must be met and verified upon integration into a system. Please refer to the following **Device.Input.Digitizer.Touch.ReportRate** requirement for full requirement details.

System.Client.Digitizer.Touch.Resolution

System Touch Input Resolution

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

The following Touch device level requirements must be met and verified upon integration into a system. Please refer to the following **Device.Input.Digitizer.Touch.Resolution** requirement for full requirement details.

System.Client.Digitizer.Touch.ThirdPartyDrivers

System Touch Servicing and 3rd Party Driver Availability

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

The following Touch device level requirements must be met and verified upon integration into a system. Please refer to the following **Device.Input.Digitizer.Touch.ThirdPartyDrivers** requirement for full requirement details.

System.Client.Firmware.UEFI.GOP

System.Client.Firmware.UEFI.GOP.Display

System firmware must support Graphics Output Protocol (GOP) and Windows display requirements.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

Every firmware on a Windows client system must support the GOP as defined in UEFI 2.3.1.

The display is controlled by the system UEFI before the WDDM graphics driver takes over. GOP must be available when the Windows EFI boot manager loads. VBIOS is not supported. It is also required for prior UI, such as OEM logo, firmware setup, or password prompt screens to enable GOP. During this time when the firmware is in control, the following are the requirements.

Topology Selection

- UEFI must reliably detect all the displays that are connected to the POST adapter. The Pre-OS screen can only be displayed on a display connected to the POST adapter.
- In case multiple displays are detected, UEFI must display the Pre-OS screen based on the following logic:
    - System with an Integrated display(Laptop, All In One, Tablet): UEFI must display the Pre-OS screen only on the integrated display.
    - System **without** an Integrated display (integrated display is shut or desktop system): UEFI must display the Pre-OS screen on one display. UEFI must select the display by prioritizing the displays based on connector type. The prioritization is as follows: DisplayPort, HDMI, DVI, HD15, Component, S-Video. If there are multiple monitors connected using the same connector type, the firmware can select which one to use.

Mode Selection

- Once UEFI has determined which display to enabled to display the Pre-OS screen, it must select the mode to apply based on the following logic.
    - System with an Integrated display (Laptop, All In One, Tablet): The display must always be set to its native resolution and native timing.
    - System **without** an Integrated display (desktop):

        - UEFI must attempt to set the native resolution and timing of the display by obtaining it from the EDID.
        - If that is not supported, UEFI must select an alternate mode that matches the same aspect ratio as the native resolution of the display.
        - At the minimum, UEFI must set a mode of 1024 x 768.
        - If the display device does not provide an EDID, UEFI must set a mode of 1024 x 768.
    - The firmware must always use a 32 bit linear frame buffer to display the Pre-OS screen.
    - PixelsPerScanLine must be equal to the HorizontalResolution.
    - PixelFormat must be PixelBlueGreenRedReserved8BitPerColor. Note that a physical frame buffer is required; PixelBltOnly is not supported.

Mode Pruning

- UEFI must prune the list of available modes in accordance with the requirements called out in EFI_GRAPHICS_OUTPUT_PROTOCOL.QueryMode() (as specified in the UEFI specification version 2.1)

Providing the EDID

- Once the UEFI has set a mode on the appropriate display (based on Topology Selection), UEFI must obtain the EDID of the display and pass it to Windows when Windows uses the EFI_EDID_DISCOVERED_PROTOCOL (as specified in the UEFI specification version 2.1)to query for the EDID:
    - It is possible that some integrated panels might not have an EDID in the display panel itself. In this case, UEFI must manufacture the EDID. The EDID must accurately specify the native timing and the physical dimensions of the integrated panel.
    - If the display is not integrated and does not have an EDID, then the UEFI does not need to manufacture an EDID.

System.Client.Graphics

System.Client.Graphics.FullGPU

A Windows client system must have a "Full" graphics device and that device must be the post device.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

WDDM 1.3 introduces multiple driver/device types: Full, Render only, and Display only. For a detailed description of each, refer to the WDDM 1.3 in requirement **Device.Graphics.WDDM13.Base**.
Each of these driver/device types are designed for specific scenarios and usage case. All client scenarios expect a "full" graphics device. Also
many applications assume that the post device is the "best" graphics devices and use that device exclusively. For this

reason, a Windows client system must have a "full" graphics driver/device that is capable of display, rendering, and video.

System.Client.Graphics.NoMoreThanOneInternalMonitor

Graphics driver must not enumerate more than one monitor as internal.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

The graphics driver must not enumerate more than one display target of the D3DKMDT_VOT_INTERNAL type on any adapter.

Design Notes:
For more information, see the Graphics guide for Windows 7 at http://go.microsoft.com/fwlink/?LinkId=237084.

System.Client.Graphics.WDDM

All Windows graphics drivers must be Windows Display Driver Model (WDDM).

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

The WDDM architecture offers functionality to enable features such as desktop composition, enhanced fault Tolerance, video memory manager, scheduler, cross process sharing of D3D surfaces and so on. WDDM was specifically designed for modern graphics devices that are a minimum of Direct3D 10 Feature Level 9_3 with pixel shader 2.0 or better and have all the necessary hardware features to support the WDDM functionality of memory management, scheduling, and fault tolerance.

WDDMv1.3 is required by all systems shipped with Windows 10.

Table below explains the scenario usage for the Graphic driver types:

	Client	Server	Client running in a Virtual Environment	Server Virtual
Full Graphics	Required as post device	Optional	Optional	Optional

Display Only	Not allowed	Optional	Optional	Optional
Render Only	Optional as non primary adapter	Optional	Optional	Optional
Headless	Not allowed	Optional	N/A	N/A

System.Client.Graphics.WDDMSupportRotatedModes

If accelerometer is present, Windows Display Driver Model (WDDM) driver must support all rotated modes.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

On a system with an accelerometer, the WDDM driver is required to support all rotated modes for every resolution enumerated for the integrated panel:

- A WDDM driver is required to enumerate source modes for the integrated display. The WDDM driver must support rotated modes (0, 90, 180 and 270) for every mode that it enumerates for the integrated panel.
- The rotation is required to be supported even if the integrated panel is in a duplicate or extended topology with another display device. For duplicate mode, it is acceptable to rotate all targets connected to the rotated source. Per path rotation is allowed but not required.

Both the above mentioned requirements are optional for Stereo 3D capable resolutions.

System.Client.Graphics.WirelessUSBDisplay

System limitations for wireless and USB connected displays.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

- Display devices (Monitor, LCD, TV, Projectors) are enumerated to Windows only via the WDDM Graphics driver. An Indirect Display is a WDDM driver for the purposes of this document
- There must be at least one display device physically connected to a full WDDM graphics hardware that supports at least DX 9_1 in the hardware.
- Windows only supports a fixed set of display connectors as defined in WDDM as part of the D3DKMDT_VIDEO_OUTPUT_TECHNOLOGY enumeration.

- The WDDM (or Indirect Display) driver is required to accurately report the connection medium used to connect the display device to the system.
- Windows supports wireless displays via Miracast connection or Indirect Display, via WDDM1.3 or WDDM2.0 display drivers.
- Systems may connect a display using the USB Type C alternate mode for DisplayPort, and this display should be enumerated as a typical DisplayPort connection.
- Systems may use an Indirect Display driver to connect a USB display.

System.Client.MobileBroadBand

These are requirements for Mobile Broadband devices integrated in the systems.

System.Client.MobileBroadBand.ClassDriver

USB interface based GSM and CDMA class of Mobile Broadband device firmware must comply with USB-IF's Mobile Broadband Interface Model Specification.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

USB interface based GSM and CDMA class of Mobile Broadband device firmware implementation must comply with the USB-IF's Mobile Broadband Interface Model (MBIM) Specification. No additional IHV drivers are needed for the functionality of the device and the device must work with Microsoft's Mobile Broadband(MB) class driver implementation. Note that Microsoft generic class driver doesn't support non-USB interface devices. Non-USB based devices require device manufacturer's device driver compliant with MB driver model specification.
Additional Details: Mobile Broadband Interface Model Specification:
http://www.usb.org/developers/devclass_docs/MBIM10.zip Mobile Broadband Driver Model Specification:
http://msdn.microsoft.com/en-us/library/windows/hardware/ff560543(v=VS.85).aspx
Exception: - Device models that are announced as End of life (EOL) as of December, 2011.- Device models that are no longer in production line. Note that above exceptions are applicable only if:- devices are used in Windows 8 Client x86 and Windows 8 Client x64. - devices are pre-certified for multiple operators (at least 20).

System.Client.MobileBroadBand.ConcurrentRadioUsage

System Builders must ensure that the RF performance is optimized for Mobile Broadband, Wi-Fi and Bluetooth enabled radios running at the same time.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM**

	Windows v10.0 Mobile ARM64 **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

System Builders must ensure that the RF performance is optimized for Mobile Broadband, Wi-Fi and Bluetooth enabled radios running at the same time. Systems that enable internet connection sharing (tethering), multi-homing, and network switching all require multiple radios to be active simultaneously. Systems should ensure high throughput, high reliability, optimal power efficiency and minimum RF interference under these conditions regardless of the system form factor.

System.Client.MobileBroadBand.MobileBroadBand

Systems that include Broadband support meet Windows requirements.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

Firmware Requirements

USB based devices for GSM and CDMA technologies (3GPP/3GPP2 standards based) need to be firmware compliant with the Mobile Broadband Interface Model specification. These devices need to be certified by the USB Forum for compliance (when it becomes available for MB devices).

In addition to the above, firmware needs to support the features listed below as specified by NDIS.

Firmware Feature	Requirement
No Pause on Suspend	Required
USB Selective Suspend	Required – If USB based
Radio Management	Required
Wake on Mobile Broadband	Required
Fast Dormancy	Required

No additional Connection Manager software is required for the operation of mobile broadband devices.

Value-add Mobile Broadband Connection Managers, if implemented, need to implement the Mobile Broadband API (http://msdn.microsoft.com/en-us/library/dd323271(VS.85).aspx).

Microsoft strongly recommends USB-based bus interfaces such as analog USB, HSIC (where applicable) and SSIC (When available). Mobile Broadband stack in Windows 8 is designed to support only USB protocol based bus interfaces. The following table summarizes the required mobile broadband features.

Attribute	Requirement
Bus	USB-HSCI (preferred) or USB

Systems must also comply with Mobile Broadband requirements:

- Devices MUST support 16 bitmap wake patterns of 128 bytes each.
- Devices MUST wake the system on register state change.
- Devices MUST wake the system on media connect.
- Devices MUST wake the system on media disconnect.
- GSM and CDMA class of Devices MUST wake the system on receiving an incoming SMS message.
- Devices that support USSD MUST wake the system on receiving USSD message.
- Devices MUST support wake packet indication. NIC should cache the packet causing the wake on hardware and pass it up when the OS is ready for receives.
- Mobile Broadband class of devices must support Wake on Mobile Broadband. It should wake the system on above mentioned events. Note that wake on USSD is mandatory only if the device reports that it supports USSD. Else it is optional. See the following MSDN documentation for more information on the SMS and register state wake events.
- NDIS_STATUS_WWAN_REGISTER_STATE
- NDIS_STATUS_WWAN_SMS_RECEIVE

System.Client.PCContainer

Windows is moving towards a device centric presentation of computers and devices. Elements of the Windows user interface (UI), such as the Devices and Printers folder, will show the computer and all devices that are connected to the computer. The requirements in this section detail what is required to have the PC appear as a single object in the Windows UI.

System.Client.PCContainer.PCAppearsAsSingleObject

Computers must appear as a single object in the Devices and Printers folder.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

Computers must appear as a single object in the Devices and Printers folder. Windows has a platform layer which groups all functionality exposed by the computer into a single object. This object is referred to as the computer device container. The computer device container must contain all of the device functions that are located physically inside the computer chassis. This includes, but is not limited to, keyboards, touch-pads; media control/media transport keys, wireless radios, storage devices, and audio devices. The computer device container is used throughout the Windows platform and is visibly exposed to the user in the Devices and Printers user interface. This requirement ensures a consistent and high quality user experience by enforcing the "one object per physical device" rule in the Devices and Printers folder.

The computer must appear as a single device container in the Devices and Printers folder for the following reason:

- Devices and Printers will be unable to provide a logical and understandable representation of the computer to the user. Accurate information as to which devices are physically integrated with the computer must be supplied to support this and dependent Windows features.

Design Notes:

Windows is moving towards a device centric presentation of computers and devices. The Devices and Printers folder will show the computer and all devices that are connected to the computer. In Devices and Printers the computer is represented by a single icon. All of the functionality exposed by the computer will be available through this single icon object, providing one location for users to discover devices integrated with the computer and execute specific actions on those integrated devices. To enable this experience, the computer must be able to detect and group all computer integrated devices (all devices physically inside the PC). This requires that computer integrated devices properly identify themselves as integrated components. This can be achieved by indicating that the device is not removable from computer, properly configuring ACPI for the port to which the device is attached, or creating a registry DeviceOverride entry for the device. (Note: Each bus type has different mechanisms for identifying the removable relationship for devices attached to that bus.

To group the functionality exposed by the computer into a single device container, Windows uses information available in the device hardware, bus driver, and system UEFI or BIOS and Windows registry. The bus type to which a given device is attached determines the heuristic Windows applies to group that device. The whitepaper titled "Multifunction Device Support and Device Container Groupings in Windows 7," which can be found at http://www.microsoft.com/whdc/Device/DeviceExperience/ContainerIDs.mspx, explains the heuristic for many bus types, including:

- Universal Serial Bus (USB)
- Bluetooth
- IP connected devices using Plug and Play Extensions (PnP-X)
- 1394
- eSATA
- PCI Express (PCIe)

The Single Computer Display Object test (ComputerSingleDDOTest.exe) must be executed on the system to check if this requirement has been met. The tool is available in Windows Lab Kit.

System.Client.RadioManagement

This feature contains requirements for buttons that control the management of any radios in a laptop or Tablet/convertible PC. It also contains requirements for GPS radios, Near Field Proximity radios, and Bluetooth enabled radios that do not use the Windows native Bluetooth stack.

System.Client.RadioManagement.HardwareButton

If a PC has a physical (hardware) button switch on a PC that turns wireless radios on and off, it must be software controllable and interact appropriately with the Radio Management UI.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

There does not need to be a hardware button for wireless radios on Windows 10 laptops or tablet/convertible PCs. A wireless hardware button is one of the following:

- Toggle Button (Laptops and Tablets)
- Toggle Button with LED (Non-Modern standby supported laptops and tablets)
- A-B slider switch (Laptops and Tablets)
- A-B slider switch with LED (Non-Modern standby supported laptops and tablets)

When there is a hardware button for wireless radios there must not be more than one, and it must control all the radios present in the computer. An LED to indicate the state of the switch is optional. Please note that an LED indicating wireless status is not allowed on systems that support modern standby. If an LED is present along with the button, it must behave as defined here:

- There must only be one LED to indicate wireless status (there must not be one LED for Bluetooth, one for Wi-Fi, etc.).
- If the global wireless state is ON, the LED must be lit.
- When the global wireless state is OFF, the LED must not be lit.
- When the button is pressed or switch is flipped, it must send a HID message that can be consumed by the Radio Management API.
- When the Radio Management API sends a HID message, the button or switch must receive the message and change the state of the LED accordingly.

System.Client.RadioManagement.RadioMaintainsState

Radio maintains on/off state across sleep and reboot power cycles.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The state of the wireless radio must persist across sleep, reboot, user log off, user switching and hibernate.

System.Client.RadioManagement.RadioManagementAPIHID

Wireless hardware button must communicate the change of state to the Radio Management API using HID.

Applies to	Windows 10 Client x64 Windows 10 Client x86 Windows v10.0 Mobile ARM Windows v10.0 Mobile ARM64 Windows v10.0 Mobile x86 Windows Server 2019 x64

Description

When the state of wireless radio switch changes, whether it is a slider A-B switch (with or without LED) or toggle button (with or without LED), this HID-compliant hardware switch/button must expose the HID collections to be consumed by the radio management API. Toggle button must not change the state of the device radio directly. A-B switch can be wired directly to the radios and change their state as long as it communicates the change of state to the Radio Management API using the HID driver and it changes the state in all radios present in the PC. The HID usage IDs are:

Usage ID	Usage Name	Usage Type
0x0C	Wireless Radio Controls	CA
0xC6	Wireless Radio Button	OOC
0xC7	Wireless Radio LED	OOC
0xC8	Wireless Radio Slider Switch	OOC

The collections are:

Button without LED (stateless button) – For laptops, tablets and convertibles

```
USAGE_PAGE (Generic Desktop)            05 01
USAGE (Wireless Radio Controls)         09 0C
COLLECTION (Application)                A1 01
  LOGICAL_MINIMUM (0)                   15 00
  LOGICAL_MAXIMUM (1)                   25 01
  USAGE (Wireless Radio Button)         09 C6
  REPORT_COUNT (1)                      95 01
  REPORT_SIZE (1)                       75 01
  INPUT (Data,Var,Rel)                  81 06
  REPORT_SIZE (7)                       75 07
  INPUT (Cnst,Var,Abs)                  81 03
END_COLLECTION                          C0
```

Button with LED – For laptops, tablets and convertibles that do NOT support modern standby

```
USAGE_PAGE (Generic Desktop)            05 01
USAGE (Wireless Radio Controls)         09 0C
COLLECTION (Application)                A1 01
  LOGICAL_MINIMUM (0)                   15 00
  LOGICAL_MAXIMUM (1)                   25 01
  USAGE (Wireless Radio Button)         09 C6
  REPORT_COUNT (1)                      95 01
  REPORT_SIZE (1)                       75 01
  INPUT (Data,Var,Rel)                  81 06
  REPORT_SIZE (7)                        75 07
  INPUT (Cnst,Var,Abs)                    81 03
  USAGE (Wireless Radio LED)                 09 C7
  REPORT_SIZE (1)                        75 01
  OUTPUT (Data,Var,Rel)                    91 02
  REPORT_SIZE (7)                        75 07
  OUTPUT (Cnst,Var,Abs)                     91 03
END_COLLECTION                              C0
```

Slider Switch (without LED) - For laptops, tablets and convertibles

```
USAGE_PAGE (Generic Desktop)                  05 01
USAGE (Wireless Radio Controls)                09 0C
COLLECTION (Application)                     A1 01
  LOGICAL_MINIMUM (0)                        15 00
  LOGICAL_MAXIMUM (1)                        25 01
  USAGE (Wireless Radio Slider Switch)          09 C8
  REPORT_COUNT (1)                         95 01
  REPORT_SIZE (1)                        75 01
  INPUT (Data,Var,Abs)                     81 02
  REPORT_SIZE (7)                        75 07
  INPUT (Cnst,Var,Abs)                      81 03
END_COLLECTION                              C0
```

Slider Switch with LED- Laptops, tablets and convertibles that do NOT support modern standby

```
USAGE_PAGE (Generic Desktop)                   05 01
USAGE (Wireless Radio Controls)                 09 0C
COLLECTION (Application)                      A1 01
  LOGICAL_MINIMUM (0)                          15 00
  LOGICAL_MAXIMUM (1)                          25 01
  USAGE (Wireless Radio Slider Switch)            09 C8
  REPORT_COUNT (1)                           95 01
  REPORT_SIZE (1)                          75 01
  INPUT (Data,Var,Abs)                       81 02
  REPORT_SIZE (7)                          75 07
  INPUT (Cnst,Var,Abs)                        81 03
  USAGE (Wireless Radio LED)                    09 C7
  REPORT_SIZE (1)                          75 01
  OUTPUT (Data,Var,Rel)                       91 02
  REPORT_SIZE (7)                           75 07
  OUTPUT (Cnst,Var,Abs)                        91 03
END_COLLECTION                                 C0
```

LED Only (No button or slider) - Laptops, tablets and convertibles that do NOT support modern standby

```
USAGE_PAGE (Generic Desktop)                    05 01
USAGE (Wireless Radio Controls)                  09 0C
COLLECTION (Application)                       A1 01
  LOGICAL_MINIMUM (0)                          15 00
  LOGICAL_MAXIMUM (1)                    25 01
  USAGE (Wireless Radio LED)             09 C7
  REPORT_COUNT (1)                     95 01
  REPORT_SIZE (1)                    75 01
  OUTPUT (Data,Var,Rel)                 91 02
  REPORT_SIZE (7)                      75 07
  OUTPUT (Cnst,Var,Abs)                 91 03
END_COLLECTION                           C0
```

Wireless radio LED must have a HID-compliant driver to reflect the state of the airplane mode switch located in the user interface. Wireless radio LED only uses HID for output (no input since there is no button).

When the Radio Management API sends a HID message because the global wireless state (airplane mode) has changed, the switch must consume this message and toggle the state.

For an A-B switch, the manufacturer's proprietary embedded controller must report the correct state of the switch at all times by sending a HID message to the HID driver, including every time the PC is turned on back on. Reporting the state of the A-B switch when the computer is turned back on is especially important in the case that the switch changed states while the PC was in states S3/S4/S5.

System.Client.RadioManagement.ConnectedStandby

This feature contains requirements for buttons that control the management of any radios in a laptop or Tablet/convertible PC. The radios that this requirement applies to are GPS.

System.Client.RadioManagement.ConnectedStandby.NoRadioStatusIndicatorLights

Systems that support Modern Standby must not include a light indicating the status of the radios in the system.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

In order to conserve energy, systems that support modern standby cannot include a status indicator indicating whether the radios are on.

System.Client.Sensor.Accelerometer

System.Client.Sensor.Accelerometer.Shake

If an accelerometer supports shake event, then it must report the HasShake data field

Applies to	Windows 10 Client x64 Windows 10 Client x86 Windows 10 Client ARM64

Description

Accelerometers are not required to support shake detection. If an accelerometer does support shake detection, then the HasShake data field is required to be reported. It is up to the OEM/IHV to determine what constitutes a shake event. For more information, see accelerometer data fields.

System.Client.Sensor.ActivitySensor

System.Client.Sensor.ActivitySensor.EnumerationProperties

Activity sensors are required to report supported activity types and minimum detection interval through enumeration properties

Applies to	Windows 10 Client x64 Windows 10 Client x86 Windows 10 Client ARM64

Description

The required enumeration properties for activity sensors is shown below:

Data Field	Data Type	Definition
PKEY_SensorData_SupportedActivityStates	VT_UI4	The activity states that are supported by the activity sensor. This is represented as a bitmask of ACTIVITY_STATE.
PKEY_SensorData_MinimumDetectionIntervals_Ms	VT_VECTOR | VT_UI4	A vector of minimum detection intervals, in milliseconds. The value at each index maps to the ordinal value of a state's enum value. If state is not supported, then 0 must be reported for that state.

System.Client.Sensor.AmbientLightSensor

System.Client.Sensor.AmbientLightSensor.AutoBrightnessPreferred

If an ambient light sensor is used for autobrightness, then it must be properly tagged in PnP

Applies to	Windows 10 Client x64 Windows 10 Client x86 Windows 10 Client ARM64

Description

If an ambient light sensor is intended to be used with the autobrightness feature, then the following enumeration property is required to be reported:

Data Field	Data Type	Definition
DEVPKEY_LightSensor_AutoBrightnessPreferred	VT_BOOL	Specifies if this light sensor should be the preferred light sensor used for the Windows autobrightness service.

There must only be up to one ambient light sensor reporting this property on a system.

System.Client.Sensor.AmbientLightSensor.ColorCalibration

Ambient light sensors that support color capable must be properly calibrated

Applies to	Windows 10 Client x64 Windows 10 Client x86 Windows 10 Client ARM64

Description

Ambient light sensors are no required to support color. If an ambient light sensor does support color, then it is required to be properly calibrated while a light source is aimed directly at the sensor:

- The detected ambient lux is either within 10% or 1 lux of the actual incoming light
- The detected chromaticity x and y are within 0.025 of the actual incoming light

System.Client.Sensor.AmbientLightSensor.IsValid

Ambient light sensors that report the IsValid data field must properly indicate when data is valid.

Applies to	Windows 10 Client x64 Windows 10 Client x86 Windows 10 Client ARM64

Description

Ambient light sensors are not required to report when light sensor samples are valid or not. If an ambient light sensor does support this though, then the follow requirements must be met:

The following data field must be reported:

Data Field	Data Type	Definition
PKEY_SensorData_IsValid	VT_BOOL	Indicates if the current data sample is valid.

If this value changes, a sample must be reported regardless of if the thresholds have been met. See below for examples:

Assume the lux threshold is 1 lux:

- If the last reported sample was 100 lux and the next sample is 100 lux, but the sensor is now blocked (previous sample's `PKEY_SensorData_IsValid` was true):
  - The current sample would get reported with 100 lux and `PKEY_SensorData_IsValid` set to false.
- The last reported sample was 100 lux and was blocked (previous sample's `PKEY_SensorData_IsValid` was false). The next sample is 100000 lux and the sensor is still blocked (`PKEY_SensorData_IsValid` is false):
  - No sample is reported

- The last reported sample was 0 lux and was blocked (previous sample's `PKEY_SensorData_IsValid` was false). The next sample is still 0 lux, but the sensor is now unblocked (`PKEY_SensorData_IsValid` is true):
    - The current sample would get reported as 0 lux but with `PKEY_SensorData_IsValid` set to true.

System.Client.Sensor.AmbientLightSensor.LightCalibration

Ambient light sensor that don't support color must be properly calibrated to report within 4% or at least 1 lux of the actual incoming light level.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64**

Description

The autobrightness service needs light sensors to report an accurate measurement of the light level in the environment. When the light source is aimed directly at a light sensor that doesn't support color, the reported light level is required to be within 4% or at least 1 lux of the actual incoming light level.

System.Client.Sensor.AmbientLightSensor.LightRange

Ambient light sensors are required to be able to detect a minimum of 1 lux and up to 10,000 lux

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64**

Description

The autobrightness service in Windows needs to be able to detect a reasonable range of light levels from 1 to 10,000 lux. If the range is smaller than this, then the adjusted autobrightness may not be able to match the actual brightness of the environment.

System.Client.Sensor.CustomSensor

System.Client.Sensor.CustomSensor.EnumerationProperties

Custom sensors are required to report sensor name as an enumeration property.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64**

Description

Custom sensors are required to report the following properties to PnP:

Data Field	**Data Type**	**Definition**

DEVPKEY_Sensor_Name	VT_LPWSTR	The name of the sensor.
DEVPKEY_Sensor_VendorDefinedSubType	VT_CLSID	The GUID that identifies the sensor category subtype defined by the vendor. This must be unique to the vender.
DEVPKEY_Sensor_Manufacturer	VT_LPWSTR	The manufacturer of the sensor. This must be unique to the manufacturer.

System.Client.Sensor.General.EnumerationProperties

Sensors are required to report the expected properties via PnP

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64**

Description

The required enumeration properties for all sensors are shown below:

Data Field	**Data Type**	**Definition**
DEVPKEY_Sensor_Type	VT_CLSID	A GUID that identifies the type of sensor. For more information about sensor types, see sensor type GUIDs.
DEVPKEY_Sensor_Category	VT_CLSID	The GUID that identifies the sensor category, this is required for backwards compatibility with desktop V1. For more information about sensor categories, see sensor category GUIDs.
DEVPKEY_Sensor_ConnectionType	VT_UI4	Required only for ambient light sensors and accelerometers. The senor connection type (integrated, attached, or external). For more information, see the SensorConnectionType enumeration.
DEVPKEY_Sensor_Name	VT_LPWSTR	Required only for custom sensors. The name of the sensor.
DEVPKEY_Sensor_Manufacturer	VT_LPWSTR	The manufacturer of the sensor
DEVPKEY_Sensor_Model	VT_LPWSTR	The model for the sensor.
DEVPKEY_Sensor_PersistentUniqueId	VT_CLSID	The GUID that identifies the sensor. This value must be unique for each sensor of the same model on the device.
DEVPKEY_Sensor_VendorDefinedSubType	VT_CLSID	Required only for custom sensors. The GUID that identifies the sensor category subtype defined by the vendor.

System.Client.Sensor.General.OptionalEnumerationProperties

Sensors can optionally report some enumeration properties

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64**

Description

The optional enumeration properties for all sensors are shown below:

Data Field	Data Type	Definition
DEVPKEY_Sensor_IsPrimary	VT_BOOL	Indicates if this is the primary sensor. This value defaults to false, if not set.
PKEY_Sensor_WakeCapable	VT_BOOL	Indicates if the sensor is wake capable. This must be set to VARIANT_TRUE if the sensor can wake the application processor when the FIFO buffer is full, VARIANT_FALSE otherwise.

System.Client.Sensor.General.OptionalProperties

Sensors can optionally report some sensor properties

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64**

Description

Sensors can optionally report the following sensor properties:

Data Field	Data Type	Definition
PKEY_Sensor_Power_Milliwatts	VT_R4	The power the sensor uses in milliwatts.
PKEY_Sensor_FifoReservedSize_Samples	VT_UI4	The number of events reserved for this sensor in the first-in-first-out buffer for batches. This guarantees a minimum number of events. If this value is zero, then there is no guarantee that the sensor will perform batching.

System.Client.Sensor.General.Properties

Sensors are required to report the expected sensor properties

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64**

Description

The required sensor properties for all sensors are shown below:

Data Field	Data Type	Definition
PKEY_Sensor_Type	VT_CLSID	A GUID that identifies the type of sensor. For more information about sensor types, see sensor type GUIDs.
PKEY_Sensor_State	VT_UI4	The state of the sensor. For more information about sensor states, see SENSOR_STATE.
PKEY_Sensor_MinimumDataInterval_Ms[1]	VT_UI4	The minimum time interval in milliseconds that the hardware supports for generating sensor data.
PKEY_Sensor_MaximumDataFieldSize_Bytes	VT_UI4	The maximum size returned in a ReadFile call. A ReadFile call allows the native API to allocate a buffer to hold data fields.
PKEY_Sensor_FifoMaxSize_Samples	VT_UI4	Required only if the sensor supports batching. The maximum number of events that can be batched in the FIFO buffer. If this value is zero, then batching is not supported by the sensor. The actual number of events may be smaller than this number since the buffer can be shared by multiple sensors.

Notes:

[1]For activity detection sensors, this value must be the maximum over the minimum detection intervals for the supported activities.

System.Client.Sensor.General.Wake

Sensors that support wake must be capable of waking the system from connected standby and S3

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64**

Description

Sensors are not required to support wake. If a sensor does support wake, then it is required to be able to wake the system from connected standby and S3. Additionally, the sensor must report PKEY_Sensor_WakeCapable as true and also implement the wake DDI.

System.Client.Sensor.Gyrometer

System.Client.Sensor.Gyrometer.DynamicRange

Gyrometers are required to have a dynamic range of ±720 degrees per second or more

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64**

Description

Gyrometers are required to have a sufficiently large dynamic range of ±720 degrees per second. The recommended dynamic range is ±2000 degrees per second or more.

System.Client.Sensor.Magnetometer

System.Client.Sensor.Magnetometer.DynamicRange

Magnetometers are required to have a dynamic range of ±1000 µT or more

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64**

Description

Magnetometers are required to have a sufficiently large dynamic range of ±1000 µT or more.

System.Client.Sensor.Orientation

System.Client.Sensor.Orientation.GyrometerPresent

Orientation sensors can optionally report if a gyroscope is used.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64**

Description

Orientation sensors can optionally report the following property:

Sensor Property	**Data Type**	**Definition**
PKEY_OrientationSensor_GyroscopeUsed	VT_BOOL	Indicates if a gyroscope is used in the orientation sensor.

System.Client.Sensor.Pedometer

System.Client.Sensor.Pedometer.EnumerationProperties

A Pedometer are required to report the supported step types and minimum detection interval to PnP

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64**

Description

Following sensor properties are required to be reported as enumeration properties by a Pedometer.

Data Field	Data Type	Definition
PKEY_SensorData_SupportedStepTypes	VT_UI4	The step types that are supported by the pedometer. This must be a bitmask of **PEDOMETER_STEP_TYPE.**

System.Client.Sensor.ProximitySensor

System.Client.Sensor.ProximitySensor.EnumerationProperties

A proximity sensor is required to report Proximity Type (Object Proximity or Human Proximity) as an enumeration property.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64**

Description

Proximity sensors must report the following enumeration property:

Data Field	Data Type	Definition
DEVPKEY_Sensor_ProximityType	VT_UI4	Proximity type supported by the sensor (Object Proximity or Human Proximity). Human proximity must be reported if the proximity sensor is a human presence sensor.

System.Client.Sensor.SimpleDeviceOrientation

System.Client.Sensor.SimpleDeviceOrientation.PhysicalLocation

If a system has more than one simple device orientation sensor integrated into the system, then the simple device orientation sensors must report their physical location on the system

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64**

Description

If there is more than one simple orientation sensor integrated into a system, then all simple device orientation sensors on the system must have their locations marked using ACPI PLD.

System.Client.SystemConfiguration

System.Client.SystemConfiguration.Windows10RequiredComponents

Windows 10 systems must include certain devices.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

For all other Windows 10 systems, the table below lists the minimum required components to be present in a system in order for it to be compatible for Windows 10. All components must meet the compatibility requirements and pass device compatibility testing for Windows 10.

	Storage type	Meet minimum Microsoft Windows Storage requirements
System firmware		UEFI as defined in System.Fundamentals.Firmware requirements
Networking	Ethernet or Wi-Fi	Must be either a certified Ethernet or Wi-Fi adapter
Graphics	GPU	Minimum of Direct3D 10 Feature Level 9_3 and see System.Fundamentals.Graphics.WDDM

System.Client.SystemImage

The requirements in this section describe the level two quality of HW + SW + OEM image

System.Client.SystemImage.SystemRecoveryEnvironment

System includes Windows Recovery Environment on a separate partition.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

A system must include a separate partition with a bootable Windows Recovery Environment image file (winre.wim). The GPT partition should be of type PARTITION_MSFT_RECOVERY_GUID, includes the GPT_ATTRIBUTE_PLATFORM_REQUIRED and GPT_BASIC_DATA_ATTRIBUTE_NO_DRIVE_LETTER attributes, and contains at least 50 megabytes (MB) of free space after the Windows Recovery Environment image file has been copied to it.

System.Client.SystemPartition

The requirements in this section describe the PC system partition configuration requirements.

System.Client.SystemPartition.DiskPartitioning

Systems that ship with a Windows operating system must meet partitioning requirements.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

Windows systems must ship with an active system partition in addition to the operation system partition (configured as Boot, Page File, Crash Dump, etc.). This active system partition must have at least 250 MB of free space, above and beyond any space used by required files. This additional system partition can be used to host Windows Recovery Environment (RE) and OEM tools (provided by the OEM), so long as the partition still meets the 250 MB free space requirement.

Implementation of this partition allows support of current and future Windows features such as BitLocker, and simplifies configuration and deployments.
Tools and documentation to implement split-loader configuration can be found in **Windows OEM Preinstallation Kit/Automated Installation Kit (OPK/AIK).**

System.Client.SystemPartition.OEMPartition

Windows systems with recovery & OEM partitions must meet partitioning requirements.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

If a system includes a separate partition for recovery purposes or an OEM partition for any other purpose, this separate partition must be identified with the GPT_ATTRIBUTE_PLATFORM_REQUIRED attribute. This attribute is defined as part of the PARTITION_INFORMATION_GPT (http://msdn.microsoft.com/en-us/library/aa365449(VS.85).aspx) structure.

For example:

- If this separate partition includes a bootable Windows Recovery Environment image file, the GPT partition must be of type PARTITION_MSFT_RECOVERY_GUID and include the GPT_ATTRIBUTE_PLATFORM_REQUIRED attribute.

Partitions which are identified with the GPT_ATTRIBUTE_PLATFORM_REQUIRED attribute must not be used for storing user data (such as through data backup, for example).

System.Client.ScreenRotation

System.Client.ScreenRotation.SmoothRotation

Systems with accelerometers perform screen rotation in 300 milliseconds and without any video glitches.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

All Windows systems with an accelerometer must have sufficient graphics performance to meet performance requirements for screen rotation:

- A WDDM driver is required to enumerate source modes for the integrated display. The WDDM driver must support rotated modes (0, 90, 180 and 270) for every mode that it enumerates for the integrated panel.
- The rotation is required to be supported even if the integrated panel is in a duplicate or extended topology with another display device. For duplicate mode, it is acceptable to rotate all targets connected to the rotated source. Per path rotation is allowed but not required.

Both the above mentioned requirements are optional for Stereo 3D capable resolutions.

System.Client.Tablet.Graphics

System.Client.Tablet.Graphics.SupportAllModeOrientations

Graphics drivers on Tablet systems are required to support all mode orientations.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

Graphics drivers on tablet systems are required to support all mode orientations for every resolution enumerated for the integrated panel:

- A graphics driver is required to enumerate source modes for the integrated display. For each source mode enumerated the graphics driver is required to support each orientation (0, 90, 180 and 270).
- Each orientation is required even if the integrated panel is in a duplicate or extended topology with another display device. For duplicate mode, it is acceptable to rotate all targets connected to the rotated source. Per path rotation is allowed but not required.

Both the above mentioned requirements are optional for Stereo 3D capable resolutions.

System.Client.WLAN.BasicConnectivity

System.Client.WLAN.BasicConnectivity.WlanBasicConnectivity

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description:

If present WLAN allows for untethered connectivity to networks allowing for a wide range of scenarios such as browsing the web or streaming video content. When present the WLAN device must support, at a minimum, connecting to a WPA2 psk AES ap and all associated actions to enable making that connection. This includes the following:

- Scanning for available networks
- Device Enumeration
- Capabilities check
- Radio on / off
- Querying interface properties
- Connecting to a WPA2 PSK AES ap in the specified time as stated in the Windows 10 WLAN Requirements

Timing for the above actions can be found in the Windows 10 WLAN Device requirements.

Microsoft highly recommend WLAN hardware module to support at least 802.11ac 2x2 configuration/design. This recommendation may become a requirement for the future release of the Windows Hardware Compatibility Program at Microsoft's discretion

System.Client.WLAN.HangDetectionAndRecovery

System.Client.WLAN.HangDetectionAndRecovery.WlanHangDetectionAndRecovery (WDI Drivers Only)

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64**

	Windows v10.0 Mobile ARM **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Terms: If-Implemented

Description:
Wi-Fi device firmware has been known to hang and / or get in a stuck state. Once that happens, the Lower Edge driver would either crash causing a 9F (Blue Screen) or the Wi-Fi subsystem gets into a state which requires a system reboot for the device to be functional again. In either case, the user is faced with a negative experience in their connectivity and their general system usage is disrupted. As an integral part of WDI, we have designed a mechanism to detect when the firmware gets into these states and recover the device seamlessly. This will ensure that user will see a minimal disruption in service by ensuring that the Wi-FI device stack recovers and resumes connectivity to the network without the system needing a reboot. Devices must report support for Hang Detection and Recovery in WDI_GET_ADAPTER_CAPABILITIES. Please refer to the WDI Spec for implementation details.

Requirement – Hardware / Firmware
System ACPI firmware: The System will provide the ACPI methods to PDLR the device either at a bus or at the device level.
System hardware: The system will allow for a PDLR (full device level reset). All systems must support PDLR.
System: The System will indicate support for PDLR support.
Device: The Lower Edge driver will be able to gather dumps with 25 ms and 250 Kb size
System: The system must complete the reset within 10 seconds.

System.Client.WLAN.HostedNetwork

System.Client.WLAN.HostedNetwork.WlanHostedNetwork

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Terms: If-Implemented

Description:
With this feature, a Windows computer can use a single physical wireless adapter to connect as a client to a hardware access point (AP), while at the same time acting as a software AP allowing other wireless-capable devices to connect to it.

System.Client.WLAN.WiFiDirect

System.Client.WLAN.WiFiDirect.WlanWiFiDirect

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Terms: If-Implemented

Description:
Support for Wi-Fi Direct by the Wi-Fi Driver to enable Miracast, Public APIs for Wi-Fi Direct to allow pairing to & from the PC, Accepting and Connecting to other Wi-Fi Direct Device for the GO & the Client Role. This includes support for concurrent operation over Wi-Fi Direct & Station.

System.Client.WLAN.Miracast

System.Client.WLAN.Miracast.WlanMiracast

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Terms: If-Implemented

Description:
Miracast requires both WiFiDirect support in the WLAN Adapter and support in the Graphics driver. Miracast allows the user to extend their display to a Miracast supported sync device.

System.Fundamentals.DebugPort

The ability to debug a system is crucial to supporting customers in the field and root-causing behavior in the kernel. Requirements in this area support the ability to kernel debug a Windows system.

System.Fundamentals.DebugPort.SystemExposesDebugInterface

System exposes debug interface that complies with Debug Port Specification.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

Windows 10 supports several different debug transports. They are listed below in the preferred order of implementation.

Hardware Debugging Transports

- Ethernet Network Interface Card from the supported list: https://docs.microsoft.com/en-us/windows-hardware/drivers/debugger/supported-ethernet-nics-for-network-kernel-debugging-in-windows-10https://docs.microsoft.com/en-us/windows-hardware/drivers/debugger/supported-ethernet-nics-for-network-kernel-debugging-in-windows-10

- USB 3.0 - xHCI controller compliant to xHCI debug specification.
- USB2 OTG (on supported hardware for Windows, recommend XHCI debug instead).
- USB 2.0 EHCI debug (the debug enabled port must be user accessible).

- Legacy Serial (16550 compatible programming interface).

ADDITIONAL REQUIREMENTS
FOR ALL OF THE ABOVE IMPLEMENTATIONS THE FOLLOWING MUST APPLY:

- There must be at least one user accessible debug port on the machine. It is acceptable on systems which choose to not expose a USB port or any other acceptable port from the list above to instead require a separate debugging board or device that provides the ability to debug via one (or more) of the transports above. That device/board must terminate in the same standard port as would be used for the transport if it were 'onboard' the machine. If this device is required it must be documented in the system specifications, be user serviceable, be user installable on the machine, and available for sale from the machine's vendor.
- On retail PC platforms, it is strongly recommended that machines have 2 user accessible debug ports from the above list. The secondary debug port is required to debug scenarios where the first debug port is in use as part of the scenario. Microsoft is not responsible for debugging or servicing issues which cannot be debugged on the retail platform, or reproduced on development platforms.
- SoC development or prototype platforms provided to Microsoft for evaluation must have a dedicated debug port available for debugging. If the debug port is used for any scenarios that are expected to also be used on retail shipping devices, in that case, there must be a secondary debug port available for debugging. This is to ensure that SoC development platforms can be used to test and debug all scenarios for all available transports, including USB host and function.
- All debug device registers must be memory or I/O mapped. For example, the debug device must not be connected behind a shared bus such as SPI or I2C. This would prevent other devices on the same bus from being debugged.

- When enabled, the debug device shall be powered and clocked by the UEFI firmware during preboot, before transferring control to the boot block.

For additional information, see http://go.microsoft.com/fwlink/?LinkId=237141

System.Fundamentals.EnergyEstimation

System.Fundamentals.EnergyEstimation.Discretional

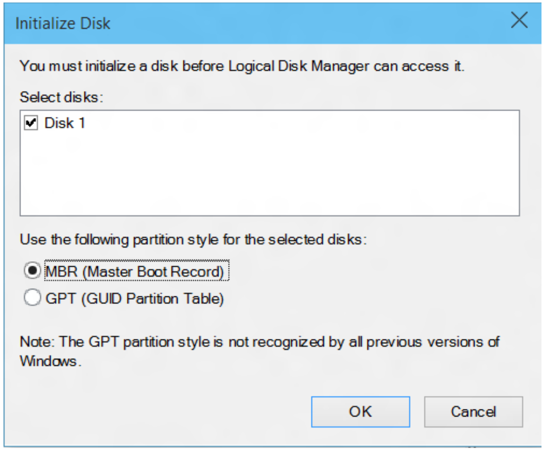
Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

There are currently three energy micro-benchmark tests in the HLK including primary storage, network, and primary display. These benchmarks are targeted to execute on any battery powered device. While in execution, the benchmarks emulate a set of steady state workloads of a particular component. At the same time, they also observe the battery drain.

- The battery must be nearly fully charged before executing a benchmark. A benchmark usually has multiple assessments. Before an assessment starts, the benchmark will estimate the expected runtime. If the remaining battery life duration is less than the time estimate required for executing the entire assessment, then the execution will immediately stop with an error message.
- Also note that some devices don't have a battery drain report correctly when it is at 100% capacity. Make sure it is less than or equal to 99% battery capacity remaining before executing a benchmark.
- Display benchmark requirements:

Display benchmark tests the battery drain during different brightness settings. Therefore the device has to be able to adjust the brightness level through software control.

  - Open a command window as administrator
  - Run the following commands to see if the brightness changes:
    - powercfg /setacvalueindex scheme_current sub_video aded5e82-b909-4619-9949-f5d71dac0bcb 10
    - powercfg /setdcvalueindex scheme_current sub_video aded5e82-b909-4619-9949-f5d71dac0bcb 10
    - powercfg /setactive scheme_current
  - If the brightness doesn't change, then the device is not suitable for this benchmark test.
- Network benchmark requirements: None
- Storage benchmark requirements:
  Storage benchmark needs to setup a fake drive get the baseline power.
  - This step needs the system with testsigning on and WTT service enabled. Once the test machine is set up through HLK controller, these should be automatically set up.
  - Open a command window as administrator, and cd to the folder of e3hlk\storhba. The storhba folder can also be found in *<controller-name>\Tests\<processor architecture>\e3hlk*.
  - cscript Scripts\Install_Storhba.wsf /storhba:1 /TestParameter:6 /LogicalUnitDiskSizeInMB:4096 /PhysicalLuns:1
  - Diskmgmt.msc (to open disk management).
  - Find the new disk with 4GB size.
  - Initialize the disk using MBR partition style.



You must initialize a disk before Logical Disk Manager can access it.

Select disks:

☑ Disk 1

Use the following partition style for the selected disks:

● MBR (Master Boot Record)

○ GPT (GUID Partition Table)

Note: The GPT partition style is not recognized by all previous versions of Windows.

  - Right click on it, select "New Simple Volume". Follow the GUI to create a volume with 4GB space and format it in NTFS.

- Remember the assigned drive letter of the new disk, and close disk manager.
- *Set\storapp_set.exe /flag –reset*
- Once finish the test, you can remove the fake drive by running

  cscript Scripts\Install_Storhba.wsf /storhba:0

  There could be some problem of removing the fake driver after reset it. To work around it, you can create another fake drive first by running "*Scripts\Install_Storhba.wsf /storhba:1 /TestParameter:6 /LogicalUnitDiskSizeInMB:4096 /PhysicalLuns:1" again, followed by "Scripts\Install_Storhba.wsf /storhba:0*".

System.Fundamentals.Firmware

System.Fundamentals.Firmware.ACPI

ACPI System Requirements

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

All systems must meet the following ACPI table requirements.

ACPI Table Requirements	
Root System Description Pointer (RSDP)	Required
Root or Extended System Description Table (RSDT or XSDT)	Required
Fixed ACPI Description Table (FADT)	Revision 5 is required for Hardware-reduced ACPI platforms and systems that support modern standby platforms
Multiple APIC Description Table (MADT)	Required
Core System Resources Description (CSRT)	Required for ARM systems if non-Standard timers or any shared DMA controllers are exposed to the OS
Debug Port Table (DBGP)	Required. DBG2 table is required instead for Hardware-reduced ACPI platforms and systems that support modern standby platforms.
Differentiated System Description Table (DSDT)	Required

DSDT Requirements

As per ACPI 4.0a, all devices in the ACPI namespace must include:

- A vendor-assigned, ACPI-compliant Hardware ID (_HID object).
- A set of resources consumed (_CRS object).

In addition, the following conditional requirements apply:

- If any devices in the namespace share the same Hardware ID, then each is required to have a distinct Unique Identifier (_UID object).
- If any device in the namespace is enumerated by its parent bus (Plug and Play buses), the address of the device on its parent bus (_ADR object) is required.
- If any device in the namespace is compatible with a Microsoft-provided driver, the Compatible ID (_CID object) defined for that device type is required.

General-Purpose Input/Output (GPIO) on an System that Supports Modern Standby

GPIO Controllers for pins used by Windows drivers or ASL control methods must appear as devices in the ACPI namespace.

Devices in the namespace that are connected to GPIO pins on an enumerated controller device must:

- Include GPIO IO Connection resource descriptors in their _CRS for any GPIO I/O pins connected. Include GPIO Interrupt Connection resource descriptors in their _CRS object for any GPIO interrupt pins connected.

Simple Peripheral Bus (SPB) on an System that supports Modern Standby

SPB Controllers for connections used by Windows drivers or ASL control methods must appear as devices in the ACPI namespace.

Devices in the namespace that are connected to an enumerated SPB controller device (UART, I2C, SPI) must include SPB Connection resource descriptors in their _CRS for the SPB Connection(s) used.

Power Button

The power button, whether implemented as an ACPI Control Method Power Button or as part of the Windows-compatible Button Array, must:

- Be able to cause the system to power-up when required.
- Generate the Power Button Override Event (Section 4.7.2.2.1.3 of the ACPI 4.0a specification) when held down for 4 seconds.

Control Method Power Button

Systems dependent on built-in (or connected) keyboards/mice for input must conform to the ACPI Control Method

Power Button (Section 4.7.2.2.1.2 of the ACPI 4.0a Specification). In addition, systems that support modern standby must:

- Implement the ACPI Control Method Power Button (Section 4.7.2.2.1.2 of the ACPI 4.0a Specification) using a dedicated GPIO interrupt pin to signal button press events.
- Configure the power button's GPIO interrupt pin as a non-shared, wake-capable (ExclusiveAndWake) GPIO interrupt connection resource.
- List the Power Button's GPIO interrupt connection resource in the ACPI Event Information (_AEI object) of the GPIO controller device to which it is connected.
- Provide the event method (_Lxx or _Exx object) for the power button event under the GPIO controller device in the ACPI namespace.

NOTE: For systems that require a separate driver to handle power button presses, it is acceptable to have that driver evaluate a control method that performs a Notify(
) on the Control Method Power Button device instead of using the GPIO-based solution above.

Button Array-based Power Button

Touch-first (keyboard-less) systems must:

- Implement the Windows-compatible Button Array device.
- Connect the power button to a dedicated GPIO interrupt pin.
- Configure the power button's GPIO interrupt pin as a non-shared, wake-capable (ExclusiveAndWake), Edge-triggered (Edge) GPIO interrupt connection resource, capable of interrupting on both edges (ActiveBoth).
- List the power button's GPIO Interrupt connection resource first in the Button Array device's _CRS object.

NOTE: For systems that require a separate driver to handle power button presses, it is acceptable to have that driver call the 5-Button array driver's power button event interface instead of using the GPIO-based solution above.

Time and Alarm Device

All battery-powered systems which are not capable of supporting Modern Standby are required to implement the Alarm capabilities of the ACPI Time and Alarm control method device.
Any system that supports Modern Standby that sets the "CMOS RTC Not Present" bit in the IAPC_BOOT_ARCH flags field of the FADT must implement the device's Time capabilities.

System.Fundamentals.Firmware.FirmwareSupportsBootingFromDVDDevice

System firmware supports booting from DVD device as defined by the El Torito specification

Applies to	Windows Server 2019 x64

Description

The system firmware must support booting the system DVD if the system includes a DVD. The system firmware or option ROM must support the No-Emulation mode in the "El Torito" Bootable CD-ROM Format Specification, Version 1.0, for installing Windows® from optical media, such as bootable DVD media. The primary optical device must be bootable. This requirement applies to the primary optical storage and the primary bus to which the device is attached.

System.Fundamentals.Firmware.FirmwareSupportsUSBDevices

System firmware provides USB boot support for USB keyboards, mouse, and hubs

Applies to	**Windows Server 2019 x64**

Description

If the system includes support for USB keyboards and pointing devices, then the system firmware must: Support USB keyboards and pointing devices during system boot, resume from hibernate, and operating system setup and installation.
Support USB input devices at least three levels of physical hubs below the host controller.
Support composite input devices by the boot protocol as defined in HID.
For Windows Server systems, it is acceptable to enumerate, but not initialize all devices. If the device is accessed, it must be fully initialize before proceeding.
The USB controller and USB devices must be fully enumerated when:
• Anything other than the Windows Boot Manager is at the top of the system boot order
• A boot next variable has been set to boot to something other than the Windows Boot Manager
• On a system where the Windows Boot Manager is at the top of the list, an error case has been hit, such that the firmware fails over from the Windows Boot Manager to the next item in the list
• Resuming from hibernate, if the system was hibernated when booted from USB
• Firmware Setup is accessed.

System.Fundamentals.Firmware.HardwareMemoryReservation

System.Fundamentals.Firmware.HardwareMemoryReservation

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

This requirement limits the amount of memory that is reserved by the hardware (including drivers or firmware) and not available to the OS or user applications on a system. Taking into consideration the changes required to meet this requirement, it will be introduced in a phased manner. <=2GB systems – max of 3% + 25MB of 2GB (86.5MB)

- 2-3GB systems – max of 3% of 3GB + 25MB (117.2MB)
- For all other systems, a max of 120MB
- If screen resolution exceeds 1366x768, an additional 8 bytes per pixel will be allowed. Note: The budgets above are intended to cover 2 full screen video memory reservations for graphics drivers at 1366x768 at 32 bytes per pixel – 8MB. The adjustment above takes into consideration machines with higher resolutions.

RAM Size	Screen resolution	Threshold
1GB	1366x768	86.5MB
2GB	1366x768	86.5MB
2GB	1920x1080	86.5MB + 8MB
3GB	1366x768	117.2MB
3GB	1920x1080	117.2MB + 8MB
4GB	Any	120MB

Applies to Windows Client OS SKUs only

Design Notes:

- Hardware memory reservation is computed as the difference between the physical memory that is mapped as visible to the Windows OS (excluding all device/firmware reservations) compared to the installed RAM on the machine.

Installed memory is queried via Query GetPhysicallyInstalledSystemMemory() and OS visible memory is queried via GlobalMemoryStatusEx() – ullTotalPhys.

System.Fundamentals.Firmware.HSTI

The Hardware Security Testability Interface provides a standardized mechanism for reporting the results of Security Configuration Self-Tests

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

HSTI is defined by a specification available publicly on MSDN (https://msdn.microsoft.com/en-us/library/windows/hardware/mt712332). The current version of HSTI is 1.1a.

Mandatory: Effective July 28, 2018, Systems must implement and accurately report the results of HSTI 1.1a or greater.

Mandatory: Effective Oct 1, 2020, Systems must implement and accurately report the results of HSTI 2.0 or greater.

System.Fundamentals.Firmware.NoExternalDMAOnBoot

All external DMA ports must be off by default until the OS explicitly powers them through related controller(s).

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

The firmware must protect physical memory from unauthorized DMA. Refer to the "**Windows DMA Protection Specification**" for details.

System.Fundamentals.Firmware.UEFIBitLocker

A system with TPM that supports wired LAN in pre-OS must support the UEFI 2.3.1 EFI_DHCP4_PROTOCOL protocol and the UEFI 2.3.1 EFI_DHCP6_PROTOCOL (and the corresponding service binding protocols).

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

Systems which support TPM and wired LAN networking must support EFI_DHCP4_protocol, EFI_DHCP4_SERVICE_BINDING_PROTOCOL, EFI_DHCP6_protocol, and EFI_DHCP6_SERVICE_BINDING_PROTOCOL for wired LAN as defined in UEFI 2.3.1.

At pre-boot, BitLocker must be able to discover its Network Unlock provider on a Windows Deployment Server (WDS) via DHCP, and unlock the OS volume after retrieving a secret from WDS.

Details
All UEFI systems with TPM present and a wired LAN port must support BitLocker Network Unlock . This requires full DHCP support for wired LAN during preboot through a UEFI DHCP driver. Specifically, there must be UEFI driver implementations for EFI_DHCP4_protocol, EFI_DHCP4_SERVICE_BINDING_PROTOCOL , EFI_DHCP6_protocol, and EFI_DHCP6_SERVICE_BINDING_PROTOCOL for wired LAN, as defined in UEFI 2.3.1.

This requirement is "If Implemented" for Server systems and applies only if a Server system is UEFI capable

System.Fundamentals.Firmware.UEFIBootEntries

UEFI firmware honors software control over load option variables.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

UEFI systems must allow the Operating System to create both generic and device specific boot entries with Messaging Device path, specifically USB Class Device Path (UEFI version 2.3 main specification section 9.3.5.9). The firmware must respect these settings and not modify them once the OS has changed them. Furthermore, the firmware must accurately report the boot entries to the OS.

Functional Notes:

If the device corresponding to a boot entry is not found, it is preferable for the system to proceed to the next boot entry silently (without presenting an error message or requiring user intervention).

If the system is booted from an internal USB device and there is a USB class entry at the top of the boot order, the system should first attempt to boot from external USB devices before attempting internal USB boot devices.

Design Notes:

The UEFI specification requires that the software bootmanager be allowed to do the boot order programming (UEFI v. 2.3 Section 3.1.1 "Boot Manager Programming").

The firmware should interpret load options and device paths as specified in Section 9 "Protocols - Device Path Protocol."

The UEFI specification describes the variables that must be modifiable at runtime in Section 3.2, table 10.

The UEFI specification is available at http://www.UEFI.org.

This requirement is "If Implemented" for Server systems and applies only if a Server system is UEFI capable.

System.Fundamentals.Firmware.UEFICompatibility

System firmware must meet Windows Compatibility requirements.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

All systems which ship with a UEFI-compatible OS must be compatible with the following sections of the UEFI 2.3.1 specification:

2.3, 3.1, 4.3, 6.1 ~ 6.5, 7.1~7.5, 8.1, 8.2, 9.1, 9.5, 11.2 ~ 11.4, 11.8, 11.9, 12.4, 12.7, 12.8, 12.9, 18.5, 21.1, 21.3, 21.5, 27.1~27.8.

Additional guidance listed in "UEFI Support and Requirements: Microsoft Windows Server 2008" document (available at http://www.microsoft.com/whdc/system/platform/firmware/uefireg.mspx), if any, shall also be required.

If the system includes any device which has a UEFI driver that uses run-time memory after the operating system boots, then a Memory Attributes Table must be included. The Memory Attributes Table must conform to the format described in the UEFI 2.6 specification version, unless the version of the system's UEFI implementation is a later revision, in which case the Memory Attributes Table must use the format specified for that version.

All Windows 8 systems must boot in UEFI mode by default. Other requirements may add additional sections of compatibility to this list, but this is the baseline.

All systems, except servers, must be certified in UEFI mode without activating CSM. If a system is available with 32bit and/or 64bit UEFI, both configurations must be tested for certification. For server, certification in UEFI mode is only required if UEFI is implemented.

OEMs may ship with CSM mode activated and the enterprise or government customer's licensed OS selection when requested.

System.Fundamentals.Firmware.UEFIDefaultBoot

All client systems must be able to boot into UEFI boot mode and attempt to boot into this mode by default.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The System firmware must be able to achieve UEFI mode boot by default. Such a system may also support fallback to legacy BIOS mode boot for deploying OS images which do not support UEFI, if the user explicitly selects that option in the pre-boot UEFI BIOS menu.
This requirement is "If Implemented" for Server systems.

System.Fundamentals.Firmware.UEFILegacyFallback

System firmware must not fall back to legacy BIOS mode without explicit user action.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

If the system ships with a UEFI-compatible OS, system firmware must be implemented as UEFI and it must be able to achieve UEFI boot mode by default. Such a system may also support fallback to legacy BIOS boot on systems with OS which do not support UEFI, but only if the user selects that option in a pre-boot firmware user interface. Legacy option ROMs also may not be loaded by default.
"Explicit User Action" means that end user (or in case of enterprise customer, the IT pro) must manually access the pre-boot firmware configuration screen and change the setting. It may not ship in the BIOS mode by default and programmatic methods which can be attacked by malware are not acceptable.
All systems with Class 2 UEFI must not fall back to legacy BIOS mode nor load legacy Option ROM's without explicit user action within the pre-boot UEFI configuration UI."
An OEM may not ship a 64 bit system which defaults to legacy BIOS or loads legacy option ROMs if that system ships with a UEFI-compatible OS.
When Secure Boot is Enabled, Compatibility Support Modules (CSM) must NOT be loaded. Compatibility Support

Modules are always prohibited on systems that support modern standby.
This requirement is "If Implemented" for Server systems and applies only if a Server system is UEFI capable.

System.Fundamentals.Firmware.UEFISecureBoot

All client systems must support UEFI Secure boot.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

Note: These requirements are "If Implemented" for Server systems and apply only if a Server system supports UEFI Secure Boot.

1. Secure Boot must ship enabled with minimum of UEFI 2.3.1 Errata C.
2. For the purposes of UEFI Secure Boot, the platform shall expose an interface to Secure Boot, whereby the system firmware is compliant with the following sections and sub-sections of UEFI version 2.3.1 Errata C:
   - 7.1
   - 7.2
   - 7.2.1
   - 27.2
   - 27.5 - 27.8 (as further profiled below).
3. UEFI Version 2.3.1 Errata C variables must be set to SecureBoot=1 and SetupMode=0 with a signature database (EFI_IMAGE_SECURITY_DATABASE) necessary to boot the machine securely pre-provisioned, and include a PK that is set and a valid KEK database. The system uses this database to verify that only trusted code (for example: trusted signed boot loader) is initialized, and that any unsigned image or an image that is signed by an unauthorized publisher does not execute. The contents of the signature database are determined by the OEM, based on the required native and third- party UEFI drivers, respective recovery needs, and the OS Boot Loader installed on the machine. The following Microsoft-provided EFI_CERT_X509 signature shall be included in the signature database: "CN=Microsoft Windows Production PCA 2011" and "Cert Hash(sha1): 58 0a 6f 4c c4 e4 b6 69 b9 eb dc 1b 2b 3e 08 7b 80 d0 67 8d" which shall use the following SignatureOwner GUID: {77fa9abd-0359-4d32- bd60-28f4e78f784b}, must also be included in the form of either an EFI_CERT_X509_GUID or EFI_CERT_RSA2048_GUID type:
   - Note: Must NOT contain the following certificate: "CN=Microsoft Windows PCA 2010" and "Cert Hash(sha1): c0 13 86 a9 07 49 64 04 f2 76 c3 c1 85 3a bf 4a 52 74 af 88"
   - Note II: Windows Server systems may ship with Secure Boot disabled, but all other provisions of this sub-requirement must be met
4. When Secure Boot is Enabled, Compatibility Support Modules (CSM) must NOT be loaded.
5. The initial UEFI signature databases (db) shall be created with the EFI_VARIABLE_TIME_BASED_AUTHENTICATED_WRITE_ACCESS attribute stored in firmware flash and may be updated only with an OEM-signed firmware update or through UEFI authenticated variable write.
6. Support for the UEFI "forbidden" signature database (EFI_IMAGE_SECURITY_DATABASE1) must be implemented.

7. The platform shall ship with a "forbidden" signature database (EFI_IMAGE_SECURITY_DATABASE1) created with the EFI_VARIABLE_TIME_BASED_AUTHENTICATED_ACCESS attribute. When a signature is added to the forbidden signature database, upon reboot, any image certified with that signature must not be allowed to initialize/execute.
8. Secure Boot must be rooted in a protected or ROM-based Public Key. Secure Boot must be rooted in an RSA public key with a modulus size of at least 2048 bits, and either be based in unalterable ROM or otherwise protected from alteration by a secure firmware update process, as defined below.
9. Secure firmware update process. If the platform firmware is to be serviced, it must follow a secure update process. To ensure the lowest level code layer is not compromised, the platform must support a secure firmware update process that ensures only signed firmware components that can be verified using the signature database (and are not invalidated by the forbidden signature database) can be installed. UEFI Boot Services variables must be hardware-protected and preserved across flash updates. The Flash ROM that stores the UEFI BIOS code must be protected. Flash that is typically open at reset (to allow for authenticated firmware updates) must subsequently be locked before running any unauthorized code. The firmware update process must also protect against rolling back to insecure versions, or non-production versions that may disable Secure Boot or include non-production keys. A physically present user may however override the rollback protection manually. In such a scenario (where the rollback protection is overridden), the TPM must be cleared. Further, it is recommended that manufacturers writing BIOS code adhere to the NIST guidelines set out in NIST SP 800-147 (http://csrc.nist.gov/publications/nistpubs/800-147/NIST-SP800-147-April2011.pdf), BIOS Protection Guidelines, which provides guidelines for building features into the BIOS that help protect it from being modified or corrupted by attackers. For example, by using cryptographic digital signatures to authenticate BIOS updates.
10. Signed Firmware Code Integrity Check. Firmware that is installed by the OEM and is either read-only or protected by a secure firmware update process, as defined above, may be considered protected. Systems shall verify that all unprotected firmware components, UEFI drivers, and UEFI applications are signed using minimum RSA-2048 with SHA-256 (MD5 and SHA-1 are prohibited), and verify that UEFI applications and drivers that are not signed as per these requirements will fail to run (this is the default policy for acceptable signature algorithms). If an images signature is not found in the authorized database, or is found in the forbidden database, the image must not be started, and instead, information about it shall be placed in the Image Execution Information Table.
11. UEFI firmware and driver implementations must be resistant to malicious input from untrusted sources. Incomplete input validation may result in buffer overflows, integer and pointer corruption, memory overwrites, and other vulnerabilities, compromising the runtime integrity of authenticated UEFI components.
12. Verify Signature of all Boot Apps and Boot Loaders. Upon power-on, the platform shall start executing boot firmware and use public key cryptography as per algorithm policy to verify the signatures of all images in the boot sequence up-to and including the Windows Boot Manager.
13. Microsoft Key Encryption Key (KEK) is provisioned A valid Microsoft-provided KEK is included in the KEK database. Microsoft provides the KEK in the form of either an EFI_CERT_X509_GUID or EFI_CERT_RSA2048_GUID type signature. The Microsoft KEK signature uses the following SignatureOwner GUID: {77fa9abd-0359-4d32-bd60-28f4e78f784b}.
14. PKpub verification. The PKpub key is owned by the OEM and stored in firmware flash. The private-key counterpart to PKpub is PKpriv, which controls Secure Boot policy on all OEM-manufactured devices, and its protection and use must be secured against un-authorized use or disclosure. PKpub must exist and the operating system must be able to read the value and verify that it exists with proper key length.
15. No in-line mechanism is provided whereby a user can bypass Secure Boot failures and boot anyway. Signature verification override during boot when Secure Boot is enabled is not allowed. A physically present user override is not permitted for UEFI images that fail signature verification during boot. If a user wants to boot an image that does not pass signature verification, they must explicitly disable Secure Boot on the target system.
16. UEFI Shells and related applications. UEFI Modules that are not required to boot the platform must not be signed by any production certificate stored in "db", as UEFI applications can weaken the security of Secure Boot. For example, this includes and is not limited to UEFI Shells as well as manufacturing, test, debug, RMA, &

decommissioning tools. Running these tools and shells must require that a platform administrator disables Secure Boot.

17. Secure Boot Variable. The firmware shall implement the SecureBoot variable as documented in Section 3.2 "Globally Defined Variables' of UEFI Specification Version 2.3.1 Errata C"
18. For devices which are designed to always boot with a specific Secure Boot configuration, the two requirements below to support Custom Mode and the ability to disable Secure Boot are optional.
19. (Optional for systems intended to be locked down) The platform MUST implement the ability for a physically present user to select between two Secure Boot modes in firmware setup: "Custom" and "Standard". Custom Mode allows for more flexibility as specified in the following:
    A. It shall be possible for a physically present user to use the Custom Mode firmware setup option to modify the contents of the Secure Boot signature databases and the PK. This may be implemented by simply providing the option to clear all Secure Boot databases (PK, KEK, db, dbx), which puts the system into setup mode.
    B. If the user ends up deleting the PK then, upon exiting the Custom Mode firmware setup, the system is operating in Setup Mode with SecureBoot turned off.
    C. The firmware setup shall indicate if Secure Boot is turned on, and if it is operated in Standard or Custom Mode. The firmware setup must provide an option to return from Custom to Standard Mode which restores the factory defaults.
20. (Optional for systems intended to be locked down) Enable/Disable Secure Boot. A physically present user must be allowed to disable Secure Boot via firmware setup without possession of PKpriv. A Windows Server may also disable Secure Boot remotely using a strongly authenticated (preferably public-key based) out-of-band management connection, such as to a baseboard management controller or service processor. Programmatic disabling of Secure Boot either during Boot Services or after exiting EFI Boot Services MUST NOT be possible.
21. If the firmware is reset to factory defaults, then any customized Secure Boot variables are also factory reset. If the firmware settings are reset to factory defaults, all custom-set variables shall be erased and the OEM PKpub shall be re-established along with the original, manufacturer-provisioned signature databases.
22. OEM mechanism exists to remediate failed EFI boot components up to and including the Windows OS loader (bootmgr.efi). Images in the EFI boot path that fail Secure Boot signature verification MUST not be executed, and the EFI_IMAGE_EXECUTION_INFO_TABLE entry for that component shall be updated with the reason for the failure. The UEFI boot manager shall initiate recovery according to an OEM-specific strategy for all components up to and including Windows bootmgr.efi.
23. A working Windows RE image must be present on all Windows client systems The Windows Recovery image must be present in the factory image on every Secure Boot capable system. To support automated recovery and provide a positive user experience on Secure Boot systems, the Windows RE image must be present and enabled by default. As part of the Windows Trusted Boot work enhancements have been made to Windows RE to allow optimized recovery from signature verification failures in Secure Boot. OEMs must include Windows RE as part of their factory image on all Windows client systems.
24. Firmware-based backup and restore. If the OEM provides a mechanism to backup boot critical files (for example: EFI drivers and boot applications), it must be in a secure location only accessible and serviceable by firmware. The OEM may provide the capacity via firmware or other backup store to store backup copies of boot critical files and recovery tools. If such a store is implemented, the solution must also have the capability to restore the target files onto the system without the need for external media or user intervention. This is a differentiator for the OEM in failover protection, used if the Windows OS loader (bootmgr.efi) or other boot critical components fail, preventing Windows native recovery solutions to execute.
25. Firmware-based backup synchronization. Backup copies of boot critical components (for example: EFI drivers and boot applications) stored in firmware must be serviced in sync with updates to same files on the system If the system has the capability to store a backup copy of the Windows OS loader (bootmgr.efi), and potentially other critical boot components, then the files must be serviced on the same schedule as their counterparts in use on the

live system. If the Windows OS loader is updated by Windows Update, then the backup copy of bootmgr.efi stored in firmware must be updated on the next boot.

26. All Windows client systems must support a secondary boot path. For all Windows systems configured for Secure Boot, there must be an alternate boot path option that is followed by the firmware in the event that the primary Windows OS loader fails. The second boot path may point either to the default shadow copy installed by Windows to the system backup store (<EFI System Volume>\EFI\Boot\boot<platform>.efi), or to a copy stored by the OEM firmware-based mechanism. This alternate path could be a file in executable memory, or point to a firmware-based remediation process that rolls a copy out of the OEM predetermined backup store.
27. All Windows client systems must support a USB boot path for recovery purposes. For all Windows systems configured for Secure Boot, there is a last resort of booting from USB.
28. Supporting GetVariable() for the EFI_IMAGE_SECURITY_DATABASE (both authorized and forbidden signature database) and the SecureBoot variable.
29. Supporting SetVariable() for the EFI_IMAGE_SECURITY_DATABASE (both authorized and forbidden signature database), using an authorized KEK for authentication.
30. Reserved Memory for Windows Secure Boot UEFI Variables. A total of at least 128 KB of non-volatile NVRAM storage memory must be available for NV UEFI variables (authenticated and unauthenticated, BS and RT) used by UEFI Secure Boot and Windows, and the maximum supported variable size must be at least 64 KB. There is no maximum NVRAM storage limit. Note that this is an increase from Windows 10, version 1703 requirements of 64 KB total and 32 KB variable size. This requirement will become enforced in the next release cycle, after April 2018.
31. During normal firmware updates the following must be preserved:
    - The Secure Boot state & configuration (PK, KEK, db, dbx, SetupMode, SecureBoot)
    - All UEFI variables with VendorGuid {77fa9abd-0359-4d32-bd60-28f4e78f784b}
    - A physically-present user who authenticates to the firmware may change, reset, or delete these values
32. The platform shall support EFI variables that are:
    a. accessible only during the boot services or also accessible in the runtime phase;
    b. non-volatile; and
    c. Possible to update only after proper authorization, for example, being properly signed.
33. The platform must support EFI variables with any valid combination of the following UEFI 2.3.1 variable attributes set:

    Copy

    EFI_VARIABLE_NON_VOLATILE

    EFI_VARIABLE_BOOTSERVICE_ACCESS

    EFI_VARIABLE_RUNTIME_ACCESS

    EFI_VARIABLE_AUTHENTICATED_WRITE_ACCESS

    EFI_VARIABLE_APPEND_WRITE

    EFI_VARIABLE_TIME_BASED_AUTHENTICATED_WRITE_ACCESS

34. Microsoft UEFI CA key MUST be included in SecureBoot DB unless the platform, by design, blocks all the 3rd party UEFI extensions.
35. All Windows client systems must ship with up-to-date DBX content out-of-the-box.
36. Platform MUST expose dbDefault, dbxDefault, KEKDefault, & PKDefault to be accessible for read by the OS.
37. [If Implemented] If platform ships with support for Customized Deployment of Secure boot (Revision 1263, Section 30.3 of UEFI 2.7), then the device MUST ship in deployed mode. Devices may be shipped in User Mode for custom orders from enterprise customers.

38. [If Implemented] If platform ships with support for HTTP Boot (Revision 1214, Section 23.7 of UEFI 2.7), then the client connection to the server must be based on a strong server authentication. In case of HTTP it must be HTTPS with minimum of EV SSL authentication or the equivalent.
39. [If Implemented] If platform ships with support for Platform Recovery (Revision 1227, Section 23.7 of UEFI 2.7), then platform MUST also support HTTP Boot as mentioned above.
40. [If Implemented] If platform ships with support for Customized Deployment of Secure Boot (Revision 1263, Section 30.3 of UEFI 2.7), then the Platform MUST provide consistent Secure Boot workflows as specified in the "Windows Consistent Secure Boot Workflows" document available on CONNECT.
41. Confidential & replay-protected storage: External memory for non-volatile storage of all UEFI variables and security-sensitive BIOS settings MUST include protections of that data to ensure confidentiality and integrity of the data and to mitigate against rollback attacks. This is generally accomplished by encrypting the data, applying a Message Authentication Code, and storing the resulting record in replay-protected storage such as Replay Protected Memory Block or Replay Protected Monotonic Counter.

    RPMC for non-discrete TPMs is a requirement for 2020

    RPMC for UEFI is a requirement for 2020

System.Fundamentals.Firmware.UEFITimingClass

System firmware must expose timing and class information.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

- During POST, the firmware shall measure its own timing and record the duration of post, rounded to the nearest mSec.
- These timings shall measure tEnd of reset sequence (Timer value noted at beginning of BIOS initialization - typically at reset vector) Handoff to OS Loader.

System.Fundamentals.Firmware.Update

System firmware must meet the requirements in order to support system and/or device firmware updates using firmware driver package.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

These requirements must be met by any system that updates system and/or device firmware using the Windows firmware driver package mechanism.
- The ESRT table must define at least one firmware resource (ESRE) in the resource list, which must include a system firmware resource.
- Only one system firmware resource can be defined in the ESRT.
- No two resources in the ESRT table are permitted to have the same firmware class GUID.
- ESRE must provide appropriate status code including success or failed firmware update attempt, on the subsequent boot, to the OS.
- Firmware for every resource defined by the ESRT must be upgradable to a newer version
- Firmware version of a particular resource must not break compatibility with firmware versions of other resources.
- Firmware must provide the lowest supported firmware version using the field "LowestSupportedFirmwareVersion" in the ESRE table. Firmware must not allow rollback to any version lower than the lowest supported version. Whenever a security related update has successfully been made, this field must be updated to match the "FirmwareVersion" field in the ESRE. When the lowest firmware version does not match the current firmware version, firmware must allow rollbacks to any version between the current version and the lowest supported version (inclusive).
- Firmware must seamlessly recover from failed update attempts if it is not able to transfer control to the OS after an update is applied.

System.Fundamentals.Firmware.Boot

This section describes boot requirements for all client systems.

System.Fundamentals.Firmware.Boot.EitherGraphicsAdapter

System firmware must be able to boot a system with onboard or integrated graphics and with multiple graphics adapters.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

Systems with GPUs on the system board and mobile systems that can use a docking station with PCI slots must provide a means in the system firmware setup utility to compel the system to use the onboard graphics device to boot. This capability is required so the onboard graphics device can be used in a multiple-monitor configuration and for hot undocking a mobile system.

If the system includes PCI, AGP, or PCI Express expansion slots, the system firmware must be able to boot a system with multiple graphics adapters. The system BIOS must designate one device as the VGA device and disable VGA on all other adapters. A system with an integrated graphics chipset and one or more discrete graphics adapters must be able to disable the integrated graphics chipset if the integrated graphics chipset cannot function as a non-VGA chipset.

System.Fundamentals.Firmware.Boot.SystemWithBootDeviceGreaterThan

Systems with a boot device with a capacity greater than 2.2 terabytes must comply with requirements.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

Systems with a boot device with a capacity greater than 2.2 terabytes must comply with the following requirements:

- The system must be 64-bit.
- The system must comply with the UEFI requirements in the section system.fundamentals.firmware.
- The system must comply with Advanced Configuration and Power Interface (ACPI) Specification version 4.0. Specifically, the system must be able to support legacy or Operating System-directed configuration and Power Management (OSPM)/ACPI mode.

System.Fundamentals.Firmware.CS

System.Fundamentals.Firmware.CS.CryptoCapabilities

System that support Modern Standby must include cryptographic capabilities to meet customer expectations on platform speed and performance.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

Since all components in the boot path as well as many performance-critical OS subsystems will invoke cryptographic functions, run-time performance of these functions is critical. The following requirements have been drafted to help ensure sufficient cryptographic capabilities are in place to meet customer expectations on platform speed and performance:

- The platform must meet cryptographic performance requirements as stated in Table 1. The platform may meet these requirements through any combination of hardware or software. The following general remarks apply to all algorithms in Table below:

  a. Target performance must be achieved in a multi-threaded test. The number of threads will be determined by querying the property named L"HardwareThreads" on the BCrypt provider through the CNG BCryptGetProperty interface. The provider is required to return a DWORD value in response. If the provider does not support this property, the test will run single-threaded.

  b. When cryptographic acceleration engines are used: Due to the overhead involved in dispatching requests to hardware acceleration engines, it is recommended that small requests be handled in software. Similarly, it is recommended that vendors consider using CPU-based cryptography to improve throughput when all cryptographic acceleration engines are fully utilized, idle capacity is available on the CPU, and the device is in a high-performance mode (such as when connected to AC power).

- ARM based platforms must implement the EFI_HASH_PROTOCOL from UEFI Industry Group, Unified Extensible Firmware Interface Specification version 2.3.1 Errata B. The EFI_HASH_PROTOCOL implementation must be accessible from Windows pre-Operating System code (i.e. in the Boot Services phase of platform boot). Both the UEFI hash protocols EFI_HASH_ALGORITHM_SHA1_NOPAD_GUID and EFI_HASH_ALGORITHM_SHA256_NOPAD_GUID must be supported, and the implementation must support passing a Message at least 10 Mbytes long (Note: No padding must be applied at any point to the input data).

- To make entropy generation capabilities available to Windows pre-Operating System code, the platform shall support the EFI_RNG_PROTOCOL for pre-Operating System read of at least 256 bits of entropy in a single call (i.e. 256 bits of full entropy from a source with security strength of at least 256 bits). The protocol definition can be found in Microsoft Corporation, "UEFI Entropy-Gathering Protocol,"[2].

- All cryptographic capabilities in accordance with Table 1 shall be accessible from the runtime OS in kernel mode, through the interface specified in Microsoft Corporation, "BCrypt Profile for SoC Acceleration," [2] .

- **OPTIONAL.** It is recommended that the platform's cryptographic capabilities also be accessible from the runtime OS in user mode, through the interface previously referenced in Requirement 4.

- The OS interface library shall be implemented in such a way that when an unprivileged process is operating on a given key in a given context, it shall not be able to access the key material or perform key operations associated with other contexts.

- **OPTIONAL**. It is highly recommended that the RNG capability of the platform be exposed through an OS entropy source through the interface specified in Microsoft Corporation, "BCrypt Profile for SoC Acceleration," previously referenced in Requirement 4.

- **OPTIONAL.** (Applies when a cryptographic acceleration engine is used) It should be possible to maintain and perform cryptographic operations on at least three distinct symmetric keys or two symmetric keys and one asymmetric key simultaneously in the acceleration engine.

Table: Algorithm-specific requirements. The "Category" column classifies algorithms as mandatory to support at the software interface as per requirement 4 (M), or optional (O). Note that all algorithms that are accelerated in hardware must also be exposed through the software interface.

Algorithm	Category	Modes	Mandatory Supported Key Size(s)	Remarks
3-DES	O	ECB, CBC, CFB8	112, 168	
AES	M	ECB, CBC, CFB8, CFB128, CCM, CMAC, GCM, GMAC	128, 192, 256	Performance >= 60 MBytes/s for AES-128-CBC and AES-128-ECB encryption and decryption as measured at the CNG kernel-mode BCrypt interface when processing 32 kByte blocks.
	O	CTR, XTS, IAPM	128, 192, 256	
RSA	O	PKCS #1 v1.5, PSS, OAEP	512 to 16384 in 8-byte increments	Public key performance for 2048-bit keys (and public exponent F4 (0x10001)) when verifying PKCS#1v1.5 padded signatures, measured at the kernel mode BCrypt interface <=0.6 ms/verification.
ECC	O	ECDSA, ECDH	256	If implemented, must support Elliptic curve P-256 defined in National Institute for Standards and Technology, "Digital Signature Standard," FIPS 186-3, June 2009.
SHA-1	O			Performance >60 Mbytes/s as measured at the CNG kernel-mode BCrypt interface when processing 4kByte blocks.
HMAC-SHA1	O			
SHA-256	O			Performance >60 Mbytes/s as measured at the CNG kernel-mode BCrypt interface when processing 4kByte blocks.
HMAC SHA-256	O			

RNG	M	Entropy source with optional FIPS 800-90-based DRBG	Security strength must be at least 256 bits[1]. Note that exposing this functionality through the UEFI Entropy-Gathering Protocol is required (see Req 3) and exposing it as an OS entropy source is recommended (see Req 7).

[1] The Modern Standby vendor shall supply documentation indicating, and allowing Microsoft to estimate, the quality of the entropy source. The entropy shall be assessed using the min-entropy method of Appendix C of National Institute for Standards and Technology, "Recommendation for Random Number Generation using Deterministic Random Bit Generators," FIPS 800-90, March 2007 and must surpass or be equal to 256 bits before the runtime OS starts.

[2] This specification must be requested explicitly from Microsoft. To request the current version, please contact http://go.microsoft.com/fwlink/?LinkId=237130.

System.Fundamentals.Firmware.CS.UEFISecureBoot.ConnectedStandby

All client systems that support Modern Standby must support UEFI Secure Boot.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

1. Modern standby systems must meet all of the requirements cited in this section and under System.Fundamentals.Firmware.Uefisecureboot section. In addition MUST meet the following requirement.
2. Boot Integrity. Platform uses on-die ROM or One-Time Programmable (OTP) memory for storing initial boot code and initial public key (or hash of initial public key) used to provide boot integrity, and provides power-on reset logic to execute from on-die ROM or secure on-die SRAM.
3. Secure Boot launch of Windows 8 BootMgr must not require use of an Allowed DB entry other than the Microsoft-provided EFI_CERT_X509 signature with "CN=Microsoft Windows Production PCA 2011" and "Cert Hash(sha1): 58 0a 6f 4c c4 e4 b6 69 b9 eb dc 1b 2b 3e 08 7b 80 d0 67 8d.
4. The policy for acceptable signature algorithms (and padding schemes) shall be possible to update. The exact method for updating the policy is determined by each authority (for example: Microsoft determines policies for binaries it is responsible for; SOC vendor for firmware updates). It is recognized that the initial ROM code need not have an ability to update the initial signature scheme.

5. The platform shall maintain and enforce a policy with regards to signature authorities for firmware and pre-Operating System components; the policy (and hence the set of authorities) shall be possible to update. The update must happen either as a result of actions by a physically present authorized user or by providing a policy update signed by an existing authority authorized for this task.
6. Upon power-on, the platform shall start executing read-only boot firmware stored on-die and use public key cryptography as per algorithm policy to verify the signatures of all images in the boot sequence up- to the Windows Boot Manager.
7. Protection of physical memory from unauthorized internal DMA (for example: GPU accessing memory outside of video-specific memory) and no unauthenticated DMA access to the SOC. The firmware shall enable this protection as early as feasible, preferably within the initial boot firmware.
8. Optional: The memory containing the initial boot firmware (executing in SRAM) may be made inaccessible upon jumping to the next validated stage of the boot sequence. The initial boot firmware may remain inaccessible until power-on-reset is triggered.
9. The platform shall enforce policy regarding the replacement of firmware components. The policy must include protection against rollback. It is left to the platform vendor to define the exact method for policy enforcement, but the signature verification of all firmware updates must pass and the update must be identified in such a manner that a later version of a component cannot, without proper authorization (for example: physical presence), be replaced by an earlier version of the component where earlier and later may be defined by a (signed) version number, for example.
10. Optional: The platform shall offer at least 112 logical eFuse bits to support platform firmware revision control in accordance with the above requirement.
11. Physical Security Requirements. In retail parts, once the platform is configured for Production mode, the hardware must disable all external hardware debug interfaces such as JTAG that may be used to modify the platform's security state, and disable all hardware test modes and disable all scan chains. The disabling must be permanent unless re-enablement unconditionally causes all device-managed keys that impact secure boot, TPM, and storage security to be rendered permanently erased.
12. Platforms shall be UEFI Class three (see UEFI Industry Group, Evaluating UEFI using Commercially Available Platforms and Solutions, version 0.3, for a definition) with no Compatibility Support Module installed or installable. BIOS emulation and legacy PC/AT boot must be disabled.
13. Each device is required to leave manufacturing provisioned with all cryptographic seeds and keys that are necessary to prevent attacks against the device’s Secure Boot, TPM and secure persistent storage implementations. Seeds and symmetric keys shall be immutable, per-device-unique, and non- predictable (random with sufficient length to resist exhaustive search; see NIST 800-31A for acceptable key sizes).
14. The platform is required to implement the Hardware Security Testability Interface and share documentation and tools as specified in System.Fundamentals.Firmware.HSTI.
15. All Security Features marked as Implemented in HSTI must report as Successfully Verified.

System.Fundamentals.Firmware.TPR

This feature includes requirements specific to system firmware with eDrive support.

System.Fundamentals.Firmware.TPR.UEFIEncryptedHDD

Systems which ship with a self-encrypting hard drive as a storage device must support the UEFI 2.3.1 EFI_STORAGE_SECURITY_COMMAND_PROTOCOL protocols and shall contain a non-OS partition that can be used to store WinRE.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

If self-encrypted drive support is implemented it must have a UEFI-compatible OS and contain system firmware both conforming to system firmware logo requirements as defined in System.Fundamentals.Firmware and also contain a separate WINRE partition.

BitLocker shall support self-encrypting drivers that conform to the eDrive Device Guidelines available on WHDC at http://msdn.microsoft.com/en-us/library/windows/hardware/br259095

UEFI – Trusted Command Support in UEFI 2.3 + UEFI Mantis change number 616 or UEFI 2.3.1

Standard v2.3 + errata Bv2 www.uefi.org

Mantis Change Number 616 www.uefi.org (This is not part of v2.3)

All necessary partitions have to be created, managed individually pre/post encryption. The WINRE partition must always be separate and outside of the OS/encryption partition.

If WinRE is on the system partition, the size is 350 MB. If it's not the system partition, then it's 300MB. This is assuming MBR layout. (For GPT, WinRE is always separate from the ESP, therefore 300 MB.)

This requirement is "If Implemented" for Server systems and applies only if a Server system is UEFI capable.

System.Fundamentals.Graphics

System.Fundamentals.Graphics.FirmwareSupportsLargeAperture

32-bit and 64-bit system firmware supports large aperture graphic adapters.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The system firmware (BIOS/UEFI) must support large aperture graphics adapters. The 32-bit system firmware (BIOS/UEFI) must be able to support at least 256 MB aperture. On 64-bit systems the firmware (BIOS/UEFI) must be able to support at least 1GB aperture.
A system that supports multiple graphics adapters must ensure sufficient resources for each adapter. For example on a 32bit system with 4 graphics adapters, each adapter must receive at least 256 MB memory resources each on the PCI bus.

System.Fundamentals.Graphics.MicrosoftBasicDisplayDriver

System is compatible with the Microsoft Basic Display Driver.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The System must boot in a mode where the frame buffer used by the Microsoft basic display driver is displayed whenever the Microsoft display driver writes to the frame buffer. No other driver is involved to accomplish this output. The frame buffer must be linear and in BGRA format.

System.Fundamentals.Graphics.NoRebootUpgrade

Graphics drivers must be upgradable without a reboot of the system.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The WDDM driver model has supported rebootless upgrade since Windows Vista. For Windows all systems must support the upgrade of graphics driver package without requiring the system to reboot.
For example
the graphics driver package includes the graphics driver and all associated utilities and services.

System.Fundamentals.Graphics.DisplayRender

The requirements in this section are enforced on any graphics device implementing display and render portion of the WDDM.

System.Fundamentals.Graphics.DisplayRender.StableAndFunctional

Display device functions properly and does not generate hangs or faults under prolonged stress.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86**

	Windows 10 Client ARM64 **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The system must run under prolonged stress without generating hangs or faults.

System.Fundamentals.Graphics.HybridGraphics

Hybrid Graphics Feature

System.Fundamentals.Graphics.HybridGraphics.MultiGPU

Hybrid Graphics

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

New systems shipping in Windows 10 that expect to be hybrid capable must adhere to the following requirements:

- A Microsoft supported hybrid system can only be composed as one integrated GPU (iGPU) and one discrete GPU (dGPU)
- Cannot have more than two GPUs
- Both GPU's must be DX11.0 or higher
- Both GPU's driver must be WDDM 2.0 or higher
- Both GPUs must implement the standard allocation type added to the KM and associated UM DDIs to support cross adapter shared surfaces.
- If each GPU has separate standard drivers, then they must be independent of each other and able to be updated independently without breaking hybrid functionality
- The dGPU must be equal or higher performance than the iGPU
- The dGPU adapter is the one that sets the discrete hybrid cap

All other multi-GPU configurations do not get Microsoft hybrid support. They will be treated the same way as defined by the "System.Fundamentals.Graphics.MultipleOperatingMode" requirement.

D-list requirements

This is the list of applications maintained by the dGPU IHV for choosing a GPU for an app to run in hybrid mode or not:

- The D-list DLL can be loaded into a process and queried at most once during D3D initialization
- The DLL size must be under 200KB
- The DLL must be able to return the GPU selection choice within 4ms

Power Management Requirements

Following are the power management requirements for the discrete GPU participating in a hybrid configuration:

- The driver is required to register for runtime power management.
- The driver needs to register certain power components based on the following scenarios.

Device does not require D3 transitions	**DXGK_POWER_COMPONENT_ENGINE component for each GPU engine (node)** **A DXGK_POWER_COMPONENT_D3_TRANSITION component with one F state**
Device requires D3 transitions and has no self-refresh memory	A DXGK_POWER_COMPONENT_D3_TRANSITION component with two F states DXGK_POWER_COMPONENT_ENGINE component for each GPU engine (node) A DXGK_POWER_COMPONENT_MEMORY component for each memory segment. If TransitionalLatency of this component is > 200us, component must also have DXGK_POWER_COMPONENT_FLAGS::DriverCompletesFStateTransition flag set
Device requires D3 transitions and has self-refresh memory	A DXGK_POWER_COMPONENT_D3_TRANSITION component with two F states DXGK_POWER_COMPONENT_ENGINE component for each GPU engine (node) A DXGK_POWER_COMPONENT_MEMORY component for every memory segment and with the DXGK_POWER_COMPONENT_FLAGS::ActiveInD3 flag set. This component must report 2 F States and TransitionalLatency of F1 state must be 0 One DXGK_POWER_COMPONENT_MEMORY_REFRESH component for the adapter. Also, the driver must leave space in dependency array for all device engines

- Transitional Latency reported for each component must not be greater than max. Latency tolerance for that component is specified in the table below.

	Latency tolerance
Engine (monitor ON)	
Initial state	0.08 ms
After 200 ms of idle time	15 ms
No context on the engine	30 ms
Engine (monitor OFF)	
Initial state	2 ms
After 200 ms of idle time	50 ms
No context on the engine	100 ms
Memory	
Active context exists	15 ms
No active context exists	30 ms

Memory refresh	
Initial state	0.08 ms
No active context exists	30 ms
Monitor off and no active context exists	80 ms
D3 transition	
Initial state	0.08 ms
After 10 s of all engines idle time	15 ms
No active context	200 ms
Monitor off and (no active context or all engines idle for 60 s)	250 ms

System.Fundamentals.Graphics.InternalDisplay

Base for Graphics on Systems

System.Fundamentals.Graphics.InternalDisplay.NativeResolution

Systems with integrated displays must use native resolution by default.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

A system with an integrated display must support the native resolution of the display and use native resolution as the default.

An "integrated" display is any display that is built into the system. A laptop lid is an example of an integrated display.

Windows is designed to work best in native resolution.
This requirement applies to systems that use UEFI or BIOS.

System.Fundamentals.Graphics.MultipleDevice

Requirements which apply to systems with more than one graphics device.

System.Fundamentals.Graphics.MultipleDevice.Configure

On a system with multiple graphics adapters, system firmware will allow the user to configure the usage of the adapters.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

	Windows Server 2019 x64

Description

On a system with multiple graphics adapters, the system firmware (BIOS, UEFI, etc), must provide the user with the ability to modify the following settings:

- Enable/Disable any adapters:
  - The firmware must offer the user the ability to select which adapter is enabled or disabled
  - At any given time at least one adapter, that supports POST, must be enabled
  - If the user enables an adapter, and the system only supports one active adapter at a time, then all other adapters must be disabled
  - If the only enabled adapter is not detected, the firmware will, fallback to the integrated adapter. If there is no integrated adapter, then fallback to the first adapter found on the first bus

- Select the adapter to be used as POST device
  - Firmware must only allow the user to select one adapter as the POST device.
  - A System with an integrated adapter is allowed to POST only on an adapter that cannot be physically removed from the system
  - At any given time at least one adapter, that supports POST, must be enabled
  - If multiple adapters that support POST are enabled, the firmware must provide the user an option to select which one will be used for POST

System.Fundamentals.Graphics.MultipleDevice.SubsystemDeviceID

Hybrid/Switchable Graphics systems that support multiple discrete graphics adapters or chipset combination must use the same Subsystem ID.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

Multiple GPU Graphics configurations that support multiple discrete graphics adapters or chipset combination must use the same Subsystem ID for each device in the configuration.

Multiple GPU Graphics systems are permitted to have heterogeneous graphics solutions in certain circumstances, thus allowing different VEN IDs.
The Multiple GPU configurations which combine GPUS from different vendors must have the same SUBSYS ID to indicate the driver packages intended for a Multiple GPU system. Should the same device be used as a single device

in another system, that instance of the device must use a different unique 4part PNPid
.

This does not apply to systems that implement Microsoft Hybrid solution, this solution is expected to have distinct HWID’s.

Examples:

1. The integrated GPU and the Discrete GPU may have different VEN ID and DEV ID, but must have the same SSID. For example:

```
---------------
Display Devices
---------------
Card name: InField GFX
Manufacturer: OutStanding
Chip type: RUOK Family
DAC type: Integrated RAMDAC
Device Key: Enum\PCI\VEN_AAAA&DEV_EEEE&SUBSYS_9025104D&REV_A1
---------------
Display Devices
---------------
Card name: Rocking Fast GFX
Manufacturer: Awesome Chips
Chip type: 10Q Family
DAC type: Internal
Device Key: Enum\PCI\VEN_BBBB&DEV_DDDD&SUBSYS_9025104D&REV_07
```

2. The GPUs that is used in a Switchable machine must use a different SSID if also used in a non-switchable machine. For example:

```
---------------
Display Devices
---------------
Card name: InField GFX
Manufacturer: OutStanding
Chip type: RUOK Family
DAC type: Integrated RAMDAC
Device Key: Enum\PCI\VEN_AAAA&DEV_EEEE&SUBSYS_9999104D&REV_A1
```

Note that the OutStanding InField GFX in #1. Is the same as the one stated in #2; however, although they are the same hardware, they must have a different SSID.

System.Fundamentals.Graphics.RenderOnly

Requirements which apply to a graphics device only implementing WDDM Render DDI's.

System.Fundamentals.Graphics.RenderOnly.MinimumDirectXLevel

Render Only device on client or server system must be Direct3D 10 capable or greater.

Applies to	Windows 10 Client x64 Windows 10 Client x86 Windows 10 Client ARM64 Windows v10.0 Mobile ARM Windows v10.0 Mobile ARM64 Windows v10.0 Mobile x86 Windows Server 2019 x64

Description

If a client or server system includes a render only device, the device must be Direct3D 10 capable or greater. This device can only be supported by a WDDMv1.2 Render Only Driver. Render Only devices are not allowed as the primary graphics device on client systems. All Windows client systems must have a full graphics WDDM v1.3 device as the primary boot device.

System.Fundamentals.HAL

This feature defines Hardware Abstraction Layer (HAL) requirements for systems.

System.Fundamentals.HAL.IfCSRTPresent

Signed HAL extensions are required for timers and DMA controllers that are not supported in-box

Applies to	Windows v10.0 Mobile ARM Windows v10.0 Mobile ARM64

Description

For platforms that don't implement the ARM defined Generic Interval Timer (GIT), the platform should have CSRT table with resource groups that describe the timer resources. In addition, The OS image on the platform must contain Microsoft signed HAL extensions that are properly linked to the entries in the CSRT, and these HAL extensions must register the following minimum timer resources required by Windows:

- a timer (minimum resolution of one millisecond),
- a counter (Minimum resolution 1 usec),
- an always on timer (must also be registered with a resolution of at least one millisecond), and
- an always on counter (registered with a resolution of a least 1 millisecond)

If the platform includes a system (shared) DMA controller, the CSRT must include the entries to describe this controller. In addition, the OS image on the platform must contain Microsoft signed HAL extensions that are properly linked to these entries in the CSRT, and these HAL extensions must register the DMA resources required by Windows: at least one DMA Controller, and all DMA Channels for each registered DMA Controller.

Additional Information

Business Justification	The information in the tables helps Windows identify the HAL extension module(s) that need to be loaded to support the hardware implemented on the platform. The HAL

	extension gets information from these tables on how the core system resources are implemented and configured on this platform, to accommodate any variations among platforms.

System.Fundamentals.HAL.HPETRequired

System provides a high-precision event timer

Applies to	Windows Server 2019 x64

Description

Systems must implement a High Precision Event Timer (HPET) that complies with the following points of the Intel Architecture Personal Computer (IA-PC) HPET Specification:

- The main counter frequency must be greater than or equal to 10 MHz and less than or equal to 500 MHz
- The main counter must monotonically increase, except on a roll-over event.
- The main counter and comparators must be at least 32 bits wide.
- The main counter must have at least three comparators.
- All of the comparators must be able to fire aperiodic, "one-shot" interrupts.
- At least one of the comparators must be able to fire periodic interrupts.
- Each comparator must be able to fire a unique and independent interrupt.
- HPET must support edge triggering interrupts.
- Timer interrupts must not be shared in LegacyIRQRouting mode.

System.Fundamentals.Input

Requirements in this section apply to HID devices that are integrated in the system.

System.Fundamentals.Input.I2CDeviceUniqueHWID

I2C connected HID devices must have a Unique HWID along with a HID compatible ID.

Applies to	Windows 10 Client x64 Windows 10 Client x86 Windows v10.0 Mobile ARM Windows v10.0 Mobile ARM64 Windows v10.0 Mobile x86

Description

All I2C connected HID devices must have a unique HWID and a HID compatible ID that will allow WU to identify the device (when needed) and allow drivers to be loaded from WU.

Design Notes:

See Microsoft published HID I2C protocol specification.

System.Fundamentals.Input.PS2UniqueHWID

All PS/2 connected devices (such as internal keyboards) must have a unique hardware ID.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

All PS/2 connected devices (such as touchpads and keyboards) must have a unique hardware ID that enables the third party driver to ship with WU.

Design Notes:

See Microsoft unique hardware ID whitepaper http://www.microsoft.com/whdc/device/input/mobileHW-IDs.mspx.

System.Fundamentals.MarkerFile

A marker file is used to help associate WER data with specific computer models. Requirements in this section describe the syntax for the "marker file.

System.Fundamentals.MarkerFile.SystemIncludesMarkerFile

System includes marker file

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The marker file gives additional information regarding the maker of the PC system and model. This information is used to collect and distribute On-line Crash Analysis information. The marker file is a text file with a .mrk extension. The .MRK filename must be under 256 characters in length including the path. The characters must be letters, numbers, periods, hyphens, commas and parentheses.
The marker file format is:
For companies with PCI Vendor IDs:
VendorID_CompanyName_Division_Marketing Model Name_other
info.MRK

For companies without a PCI Vendor ID
CompanyName_Division_Marketing Model Name_other info.MRK

Each column is separated by the underscore '_' character. The values in each column are
VendorID
 = The PCI vendor ID for the PC manufacturer.
CompanyName = Name of the company go here. This should be consistent for each marker file.
Division = this represents the division within the company. If your company doesn't not have divisions please put 'na.'
Marketing Model Name = product name the system will be shipped as. This should be the same as the marketing name entered at the time of logo submission.
Other info = optional ad can be added by putting more underscores. The additional fields may be used for identifying any other critical information about the system.
Optionally, the _I field can be used as a part number that can be used to link the marketing model name to.

<u>Design Notes:</u>
The marker file goes in the c:\windows\system32\drivers folder.

System.Fundamentals.Network

These are system level requirements that may impact the integration with a type of network device.

System.Fundamentals.Network.NetworkListOffloads

Wireless LAN networking device on systems that support Modern Standby must support NDIS 6.30 and support offloads.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following requirements apply to wireless LAN devices. WLAN Devices must support the following features.

Feature	Requirement
No Pause on Suspend	Required
D0 offload	Required
USB Selective Suspend	Required- If USB based
Network List offload	Required
Wi-Fi PSM	Required
Wi-Fi Direct	Required
Radio Management	Required

WPS 2.0	Required
WoWLAN	Required

Systems that support Modern Standby require the use of an NDIS 6.30 Ethernet driver. The device must support the features listed below.

Feature	Required
Wakeup on LAN	Yes
D0 & D3 Protocol Offloads (Protocols Jun. 26, 2013)	Yes
Interrupt Moderation	Yes
OS-programmable packet filtering	Yes

System.Fundamentals.Network.PowerRequirements

All physical network devices in a system (inclusive of docking stations) must meet device certification criteria for power management requirements.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

Support of this feature is required. All physical network devices included in a system (inclusive of docking stations) must meet the device-level power management requirements for that specific device type. Example: If an Ethernet device is included in a Modern Standby capable system or associated dock, that Ethernet device must meet the power management requirements for Modern Standby regardless of whether the individual device certification was achieved when tested on a Modern Standby capable system or not.

System.Fundamentals.NX

System.Fundamentals.NX.SystemIncludesNXProcessor

Systems must ship with processors that support NX and include drivers that function normally when NX is enabled

Applies to	**Windows Server 2019 x64**

Description

To ensure proper device and driver behavior in systems all drivers must operate normally with Execution Protection. Specifically, drivers must not execute code out of the stack, paged pool and session pool. Additionally, drivers must not fail to load when Physical Address Extension (PAE) mode is enabled, a requirement for operation of NX.In addition, the system firmware must have NX on and data execution prevention (DEP) policy must not be set to “always off."

System.Fundamentals.PowerManagement

Power management is a feature that turns the PC off or into a lower power state. Requirements in this section describes requirements around power management.

System.Fundamentals.PowerManagement.DockUndock

System supports docking and undocking across a hibernate transition.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

For systems which ship with a dock, the system must be able to hibernate and resume when changing from the docked to undocked state or the undocked to the docked state. This is not limited to, but should include that the memory map should not change when docking or undocking the system.

System.Fundamentals.PowerManagement.MultiPhaseResume

Storage subsystem supports multi-phase resume from Hibernate

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

The driver and hardware subsystems for the boot storage device must support multi-phase resume from Hibernate. In order to do this, the system must be able to maintain the system's ability to identify definitively all of the memory needed on resume. This is not limited to, but should include that:

- Any crashdump filters/minifilters that must support read
- No WHEA pshed plugins are installed
- Hypervisor is not enabled

System.Fundamentals.PowerManagement.PCSupportsLowPowerStates

Systems support S4 and S5 and either S0 low power idle or S3, states.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86**

	Windows v10.0 Mobile ARM **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

A desktop or mobile system installed with a client operating system must support the S4 (Hibernate) and S5 (Soft-off) states and either S0 low power idle, or S3 (Sleep). Systems that support Modern Standby must also support S4 (Hibernate). Every system must support wake from all implemented sleep states. Wake from S5 is only required from the power button.

Systems which support S0 low power idle must report that behavior by setting the following bits in the FACP flags.

FACP - Field	Bit Len.	Bit Offset	Description
LOW_POWER_S0_IDLE_CAPABLE	1	21	This flag indicates if the system supports low power idle states in the ACPI S0 state. A value of one (1) indicates that the platform supports sufficiently low S0 idle power such that transitions to the S3 state are not required. OSPM may interpret a one in a manner that it favors leaving the platform in the S0 state with many devices powered off over the S3 state when the user is no longer interacting with the platform.
Reserved	10	22	*Reserved for future use.*

If a USB host controller is implemented on the system, then at least one external port on the controller must support wake-up capabilities from S3. If the system contains multiple USB host controllers, all host controllers integrated on the system board (that is, not add-on cards) must support wake-up from S3. USB host controllers are not required to support wake-up when a mobile system is running on battery power.

Server systems are not required to implement S0 idle, S3, S4, or S5 states. If a server system does implement any of these behaviors, they must work correctly.

Power Management is an important aspect of good user experience. The system should be able to control what devices to put into a sleep state when not being used. All devices must comply with the request from the system to go into a sleep state and not veto the request thereby putting an additional drain on the power source.

System.Fundamentals.PowerManagement.PowerProfile

System must report form factor via power management profile.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM**

	Windows v10.0 Mobile ARM64 **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The Preferred_PM_Profile in the FADT table must be set to one of the values based on the form factor of the system as outlined in the ACPI specification version 5.0. This value shall not be unspecified (0).

Design Notes:

For more information see page 119 of the ACPI specification version 5.0.

System.Fundamentals.PowerManagement.ModernStandby

Power management is a feature that turns the PC off or into a lower power state. Requirements in this section describes requirements around power management for systems that support modern standby.

System.Fundamentals.PowerManagement.ModernStandby.Quality

Systems that support S0 low power idle must meet reliability standards for Runtime Power Management.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Client ARM64** **Windows v10.0 Client ARM**

Description

Systems that support Modern Standby must meet minimal reliability standards as tested for this requirement. The test associated with this requirement will exercise minimum criteria to achieve reasonable performance and reach systems power floor during Modern Standby.

Design Notes:

To help ensure the reliability of a system that supports modern standby, the system will be subjected to the following tests:

Modern Standby Basic Requirement Test

This test will be run with a simulated battery and software power button. Success criteria is based on meeting the following metrics:

- MS exit latency of < 1 second*
- Software DRIPS achieved >= 80%
- Divergence between Software and Hardware DRIPS <= 10%

**A device with rotational hard disk drive (HDD) as its primary boot drive is excused from exit latency requirement*

System.Fundamentals.PXE

System.Fundamentals.PXE.PXEBoot

Remote boot support for PXE complies with BIOS Boot Specification 1.01 or EFI boot manager

Applies to	Windows Server 2019 x64

Description

All systems are required to be PXE capable. The system must support booting from the network as defined in BIOS Boot Specification, Version 1.01, Appendix C, or as controlled by the EFI boot manager. This requirement is exempt for systems that are configured with Wireless LAN only.
Systems shipping with a UEFI compatible operating system and supporting PXE boot must support IPV4 PXE and IPV6 PXE booting as defined in UEFI 2.3.1.
UNDI must support :

- a DUID-UUID per IEFT draft
- (http://tools.ietf.org/html/draft-narten-dhc-duid-uuid-01)
- DHCP6, DUID-UUID, IPv6 IPV4 multicast

Design Notes:
Microsoft recommends that the implementation of accessing PXE be consistent with BIOS Boot Specification, Version 1.01, and Appendix C.

System.Fundamentals.Reliability

System.Fundamentals.Reliability.SystemReliability

Drivers in a system must be reliable.

Applies to	Windows 10 Client x64 Windows 10 Client x86 Windows 10 Client ARM64 Windows v10.0 Mobile ARM Windows v10.0 Mobile ARM64 Windows v10.0 Mobile x86 Windows Server 2019 x64

Description

All drivers in a system must pass all requirements under **Device.DevFund.Reliability**. All systems will need to pass Common Scenario stress:

- Enable/Disable with IO before and after
- Sleep stress with IO before and after

System.Fundamentals.Security

This requirement outlines the system capabilities and firmware tables required to support virtualization based security features. These requirements are applicable to all editions of Windows – Windows Home, Windows Professional, Windows Enterprise, Windows Education, and Windows Server.

System.Fundamentals.Security.CryptoOffloadHardware

Systems must ensure BitLocker / device encryption does not impact system performance

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows Server 2019 x64**

Description:

Systems must meet the security and performance needs to support BitLocker encryption and file encryption on the fly without impacting the user experience, including battery life. For those systems that would instead use a 3rd party encryption solution, BitLocker can be turned off as described in this document.

1. MUST have storage controller with inline crypto engine with AES-XTS capability
   OR
2. MUST have AES crypto acceleration instructions (either AES-NI or ARMv8 AES instructions)

System.Fundamentals.Security.DeviceEncryption

Systems that support modern standby must support device encryption.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

Systems that support modern standby must meet the security requirements to support enablement of Device Encryption. OEMs must not block the enablement of Device Encryption when deploying the OS images unless the device is pre-provisioned with a third-party disk encryption solution. Device Encryption will be enabled on these systems to ensure that user data is protected. As pre-requisites for Device Encryption, modern standby systems must meet requirements for TPM and Secure Boot as outlined in System.Fundamentals.TPM20 and System.Fundamentals.Firmware.CS.UEFISecureBoot.ConnectedStandby. Systems must meet the security and performance needs to support BitLocker encryption and file encryption on the fly without impacting the user experience, including battery life. For those systems that would instead use a 3rd party encryption solution, BitLocker can be turned off as described in this document. Either one of these requirements must be met:

1. MUST have storage controller with inline crypto engine (JESD220C UFS version 2.1) with AES-XTS capability

OR

2. MUST have AES crypto acceleration instructions (either AES-NI or ARMv8 AES instructions)

System.Fundamentals.Security.NoTDIFilterAndLSP

No TDI filters or LSPs are installed by the driver or associated software packages during installation or usage.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

There can be no use of TDI filters or LSPs by either kernel mode software or drivers, or user mode software or drivers.

System.Fundamentals.Security.PlayReadyModule

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

PlayReadyModule, when available on a device in secure firmware in conjunction with a compatible graphics driver, enables hardware-based content protection for media. If implemented, this module provides hardware-rooted protection of device keys, content keys and media content/samples that flow through a media pipeline. It will enable the device to have access to high definition (1080p and above) premium content. OEMs shipping on chipsets/SoCs that have a PlayReadyModule available (in the form of secure firmware available from the chipset vendor) must include PlayReadyModule on devices with screen resolutions of 1080p or higher.

System.Fundamentals.Security.SecureBiometrics

Secure biometric requirements for systems

Applies to	**Windows 10 Client x64** **Windows 10 Client ARM64** **Windows Server 2019 x64**

Terms: If-Implemented

Description:

The following shows the hardware, firmware and software requirements for secure biometrics on new platforms, new chassis.

1. MUST meet all criteria for Virtualization Based Security (VBS) support as described in System.Fundamentals.Security.VirtualizationSupport.
2. MUST have secure biometric trustlet configuration registry keys set.
3. Secure Boot MUST be supported as described in System.Fundamentals.Firmware.UEFISecureBoot.
4. MUST have specific supported IR Camera and/or fingerprint hardware.

Camera requirements:

1. Support for the following firmware table is required:
    a. Secure Devices Table (ACPI version 6.2, section 5.2.26)
2. Camera must meet all criteria described under System.Client.Camera.CameraControls
3. Camera must meet all criteria described under System.Client.Camera.SensorCapture
4. Camera must meet all criteria described under System.Client.Camera.PhysicalLocation
5. Camera must meet all criteria described under System.Client.Camera.Device
6. Camera must meet all criteria described under Device.Streaming.Camera.Base.Sharing.FaceAuthMode.
7. If a vendor DMFT is provided, it must not touch the contents of the frames.
8. If the camera is a USB streaming video camera, it must use the Microsoft USB Video class driver (USBVideo.sys) as required by Device.Streaming.Camera.UVC,
9. If the camera is a MIPI camera, WDF secure drivers must be used with the camera.
10. Camera firmware must be updateable using a hardened mechanism or sensor must not support in field firmware updates.
11. Camera must not support any means to replay a previously captured frame.

It is recommended that the IR camera be exposed independently from the RGB camera.

Fingerprint requirements:

1. Fingerprint module must meet all criteria described under Device.FingerPrintReader.Base.
2. Fingerprint module must meet all of the following additional criteria:

- Fingerprint sensor must support capability for the secure connection protocol and encryption capability.
- Fingerprint sensor must support all WBDI IOCTLS required for the secure connection protocol.
- Engine adapter must support all methods for enrolling and identifying securely.
- Fingerprint sensor must contain a Microsoft issued certificate with an ECDSA-capable public key. The certificate is issued to an IHV after it has gone through a certification process to show that its sensor meets all security requirements.
- Fingerprint sensor must support a form of secure boot. The sensor must have a non-updateable bootloader capable of hashing the executable firmware on the device.
- Fingerprint sensor must have a private key that is unique per device. This key must only be accessible to the non-updateable bootloader.
- The bootloader must generate an ephemeral ECDH key pair on every boot, which must be made available to the device firmware.

System.Fundamentals.Security.VirtualizationSupport

Systems with applicable processor generations must ship with hardware virtualization extensions enabled by default in the BIOS, and available for exclusive use by the operating system.

Applies to	Windows 10 Client x64 Windows 10 Client x86 Windows v10.0 Mobile ARM Windows v10.0 Mobile ARM64 Windows v10.0 Mobile x86 Windows Server 2019 x64

Description

The following system capabilities required to properly support Microsoft's Virtualization Based Security (VBS) platform. VBS supports a range of OS protections and security features (e.g. Device Guard, Credential Guard, Exploit Guard, System Guard). Windows will enable VBS and HVCI by default only if all the requirements below are met. Manual enablement of VBS will still be possible on systems with only a subset of these requirements via the Windows Defender Security Center UI (WDSC), however system performance or compatibility may have issues.

- Virtual machine extensions (Intel VT-X, AMD-V) with extended page tables (second level page tables).
- Per-page attribute controls in the second level page table which allow the operating system to set execute permissions separately for user and supervisor mode accesses (e.g. Mode Based Execution Control or MBEC for Intel platforms)
    - This capability must be present in order for Windows to enable VBS by default.
- All I/O devices must be behind an IOMMU/SMMU (Intel VT-D, AMD-Vi, ARM64 SMMUs).
- If system firmware provides the ability to control the exposure of platform virtualization extensions, including processor virtualization technology and system IOMMUs, to system software, these controls must be in the "enabled" state by default.
- The OS must have exclusive use and control of the physical processor's hardware virtualization extensions, with no other virtual machine monitor or hypervisor assuming control of these functions and showing virtualized facsimiles to the operating system.
- Systems must have a minimum of 4GB of system memory.
- UEFI Memory Reporting - UEFI firmware must adhere to the following memory map reporting format and memory allocation guidelines in order for firmware to ensure compatibility:
    - UEFI v2.6 Memory Attributes Table (MAT) - Firmware must cleanly separate EFI runtime memory ranges for code and data, and report this to the operating system. Proper segregation and reporting of EFI runtime memory ranges allows VBS to apply the necessary page protections to EFI runtime services code pages within the VBS secure region. Conveying this information to the OS is accomplished using the EFI_MEMORY_ATTRIBUTES_TABLE.
    - The entire EFI runtime must be described by this table. All appropriate attributes for EfiRuntimeServicesData and EfiRuntimeServicesCode pages must be marked. These ranges must be aligned on page boundaries (4KB), and cannot overlap.
    - EFI Page Protections - All entries must include attributes EFI_MEMORY_RO, EFI_MEMORY_XP, or both. All UEFI memory that is marked executable must be read only. Memory marked writable must not be executable. Entries may not be left with neither of the attributes set, indicating memory that is both executable and writable.
- Windows SMM Security Mitigations ACPI Table (WSMT) – System firmware must adhere to the recommendations for hardening SMM code described in the Windows SMM Security Mitigations Table (WMST) specification. Firmware must implement the protections described in the WSMT specification, and set the corresponding protection flags as described in the specification to report compliance with these requirements to the operating system.
  Note: This sub-requirement is If-implemented for Windows Server 2019

- Secure MorLock Rev 2 must be enabled , details here
- Ensure all system drivers have been tested and verified to be compatible with hypervisor-enforced code integrity (HVCI).

System.Fundamentals.Security.DGCG

For Device Guard and Credential Guard, Intel TXT fully works when enabled and operates in parallel with these feature sets.

System.Fundamentals.Security.DGCG.CredentialGuard

This feature checks for Credential Guard.

Applies to	**Windows 10 Client x86** **Windows 10 Client ARM64** **Windows Server 2019 x64**

Terms: If-Implemented

Description:

The following table shows the hardware, firmware and software requirements for Credential Guard.

1. MUST meet all Device Guard requirements as described in System.Fundamentals.Security.DeviceGuard (except for the need of HVCI compatible drivers and Firmware UEFI NX Protection)
2. MUST meet the additional requirements as described in the table below:

Requirement	Description
Trusted Platform Module (TPM) version 1.2 or 2.0	TPM 1.2 and 2.0 provides protection for encryption keys that are stored in the firmware. Either discrete or firmware TPMs will suffice.
Firmware security patch for Secure MOR Implementation	Secure MOR Revision 2 bit prevents certain memory attacks and is necessary for Credential Guard. This will further enhance security of Credential Guard.

System.Fundamentals.Security.DGCG.DeviceGuard

Device Guard requirement for systems

Applies to	**Windows 10 Client x86** **Windows 10 Client ARM64** **Windows Server 2019 x64**

Terms: If-Implemented

Description:

Windows 10 has an optional feature called Device Guard that gives organizations the ability to lock down devices in a way that provides advanced malware protection against new and unknown malware variants as well as Advanced Persistent Threats (APTs). The following table shows the hardware, firmware and software requirements for Device Guard.

1. MUST meet all HVCI Compatible Driver requirements as described in "Filter.Driver.DeviceGuard.DriverCompatibility".
2. MUST meet the additional requirements as described in the table below:

Requirement	Description
Windows 10 OS SKUs	Windows 10 Enterprise, Windows 10 Education, Windows Server 2019, Windows 10 IoT Enterprise
x64 architecture	Virtualization-based security (VBS) features require the Windows hypervisor, which is only supported on 64-bit processors
UEFI firmware version 2.3.1.c or higher with UEFI Secure Boot and Platform Secure Boot	UEFI Secure Boot ensures that the device boots only authorized code. Additionally, Boot Integrity (aka Platform Secure Boot) must be supported following the requirement in Hardware Compatibility Specification for Systems for Windows 10: System.Fundamentals.Firmware.UEFISecureBoot System.Fundamentals.Firmware.CS.UEFISecureBoot.ConnectedStandby (this includes Hardware Security Test Interface)
Secure firmware update process	Like UEFI software, UEFI firmware can have security vulnerabilities. It is essential to have the capability to immediately patch such vulnerabilities when found through firmware updates. UEFI firmware must support secure firmware update as described in System.Fundamentals.Firmware.UEFISecureBoot.
Firmware BIOS lockdown	Required BIOS capabilities: BIOS password or stronger authentication supported to ensure that only the authenticated Platform BIOS administrator can change BIOS settings Protected BIOS option to configure a list of permitted boot devices and the boot device order, which overrides the BOOTORDER modification made by the OS, for example, to boot only from an internal hard drive. Ability of OEM to add ISV, OEM, or Enterprise Certificate in Secure Boot DB at manufacturing time. Required Configurations: Microsoft UEFI CA must be removed from Secure Boot DB. Support for 3rd-party UEFI modules is permitted but should leverage ISV-provided certificates or OEM certificate for the specific UEFI software. BIOS options related to security and boot options must be secured to prevent other operating systems from starting and to prevent changes to the BIOS settings.

	BIOS authentication must be set. For example, the BIOS password must be set.
Virtualization extensions	The following virtualization extensions are required to support virtualization-based security: 1. Intel VT-X or AMD-V 2. Second Level Address Translation (Intel Extended Page Tables, AMD Rapid Virtualization Indexing)
VT-D or AMD Vi IOMMU (Input/output memory management unit)	In Windows 10, an IOMMU can be used to enhances system resiliency against memory attacks. For more information, see ACPI description tables.
VBS enablement of NX protection for UEFI runtime services	VBS will enable No-Execute (NX) protection on UEFI runtime service code and data memory regions. UEFI runtime service code must support read-only page protections, and UEFI runtime service data must not be executable. UEFI runtime services must meet these requirements: • Implement the UEFI 2.6 EFI_MEMORY_ATTRIBUTES_TABLE. All UEFI runtime service memory (code and data) must be described by this table. • PE sections need to be page-aligned in memory (not required in non-volatile storage). • The Memory Attributes Table needs to correctly mark code and data as RO/NX for configuration by the OS: o All entries must include attributes EFI_MEMORY_RO, EFI_MEMORY_XP, or both. o No entries may be left with neither of the above attributes, indicating memory that is both executable and writable. Memory must be either readable and executable or writeable and non-executable. **Note:** this only applies to UEFI runtime service memory, and not UEFI boot service memory. **Note:** this protection is applied by VBS on OS page tables. Please also note the following: • Do not use sections that are both writable and executable • Do not attempt to directly modify executable system memory • Do not use dynamic code
Firmware support for SMM protection	The Windows SMM Security Mitigations Table (WSMT), Revision 1, April 18, 2016 specification contains details of an Advanced Configuration and Power Interface (ACPI) table that was created for use with Windows operating systems that support Windows virtualization-based security (VBS) features. • For more information, see the Windows SMM Security Mitigations Table (WMST) specification.

System.Fundamentals.Security.SystemGuard

This feature includes requirements specific to the enablement of a dynamic root of trust for protecting and hardening VBS and the Hypervisor

System.Fundamentals.Security.SystemGuard

Systems must meet the following requirements

Applies to	**Windows 10 Client x64** **Windows 10 Client ARM64**

Term: if-implemented

Description

The platform must meet all baseline requirements for Device Guard, Credential Guard and Virtualization Based Security

- **For Intel® vPro™ processors starting with Intel® Coffeelake, Whiskeylake, or later silicon**
    - Platforms must meet the Windows DMA Protection Specification, please reference the System.Fundamentals.Firmware.NoExternalDMAOnBoot requirement for more details.
    - Platforms must support d/TPM , integrated TPM or f/TPM is not supported
    - Platforms must have all SMM communication buffers implemented in:
        - EfiRuntimeServicesData ,EfiRuntimeServicesCode , EfiACPIMemoryNVS, or EfiReservedMemoryType memory types
    - Platforms must have all SMM page tables as follows:
        - Do NOT contain any mappings to EfiConventionalMemory (e.g. no OS/VMM owned memory)
        - Do NOT contain any mappings to code sections within EfiRuntimeServicesCode
        - Do NOT have execute and write permissions for the same page
        - Platforms must allow ONLY that TSEG pages can be marked executable and the memory map must report TSEG EfiReservedMemoryType
    - Platforms must provide mechanism to protect the SMM page tables from modification:
        - BIOS SMI handler must be implemented such that SMM page tables are locked on every SMM entry
    - Platforms must support Modern/Connected Standby (S3 will not be in scope in the future for this feature)
    - Platform must set up a AUX index with index, attributes, and policy that exactly corresponds to the AUX index specified in the TXT DG with a data size of exactly 104 bytes (for SHA256 AUX data). (NameAlg = SHA256)
        - Platforms must set up a PS (Platform Supplier) index with:
            - Exactly the "TXT PS2" style Attributes on creation as follows:
                - AuthWrite |
                - PolicyDelete |
                - WriteLocked |
                - WriteDefine |
                - AuthRead |
                - NoDa |

        - Written |
        - PlatformCreate
      - A policy of exactly PolicyCommandCode(CC = TPM2_CC_UndefineSpaceSpecial) (SHA256 NameAlg and Policy)
      - Size of exactly 70 bytes
      - NameAlg = SHA256
      - In addition, it must have been initialized and locked (TPMA_NV_WRITTEN = 1, TPMA_NV_WRITELOCKED = 1) at time of OS launch.
    - PS index data DataRevocationCounters, SINITMinVersion, and PolicyControl must all be 0x00
  - Required AUX policy must be as follows:
    - A = TPM2_PolicyLocality (Locality 3 & Locality 4)
    - B = TPM2_PolicyCommandCode (TPM_CC_NV_UndefineSpecial)
    - authPolicy = {A} OR {{A} AND {B}}
    - authPolicy digest = 0xef, 0x9a, 0x26, 0xfc, 0x22, 0xd1, 0xae, 0x8c, 0xec, 0xff, 0x59, 0xe9, 0x48, 0x1a, 0xc1, 0xec, 0x53, 0x3d, 0xbe, 0x22, 0x8b, 0xec, 0x6d, 0x17, 0x93, 0x0f, 0x4c, 0xb2, 0xcc, 0x5b, 0x97, 0x24
  - Platform firmware must carry all code required to execute an Intel® Trusted Execution Technology secure launch:
    - Intel SINIT ACM must be carried in the OEM BIOS
    - Platforms must ship with a production ACM signed by the correct production Intel ACM signer for the platform
  - System firmware is recommended to be updated via UpdateCapsule in Windows Update

- **For Qualcomm processors with SD850 or later chipsets:**
  - All Monitor Mode communication buffers must be implemented in either EfiRuntimeServicesData (recommended), data sections of EfiRuntimeServicesCode as described by the Memory Attributes Table, EfiACPIMemoryNVS, or EfiReservedMemoryType memory types
  - All Monitor Mode page tables must:
    - Do NOT contain any mappings to EfiConventionalMemory (e.g. no OS/VMM owned memory)
    - They must **NOT** have execute and write permissions for the same page
    - Platforms must only allow Monitor Mode pages marked as executable
    - The memory map must report Monitor Mode as EfiReservedMemoryType
    - Platforms must provide mechanism to protect the Monitor Mode page tables from modification
  - Platforms must support Modern/Connected Standby (S3 will not be in scope in the future for this feature)
  - Platform firmware must carry all code required to perform a launch
  - Platform firmware must be updated via UpdateCapsule and deliverable via Windows Update

System.Fundamentals.SignedDrivers

This feature checks for signed drivers.

System.Fundamentals.SignedDrivers.BootDriverEmbeddedSignature

Boot drivers must be self-signed with an embedded signature.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86**

	Windows v10.0 Mobile ARM **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

All boot start drivers must be embedded-signed using a Software Publisher Certificate (SPC) from a commercial certificate authority. The SPC must be valid for kernel modules. Drivers must be embedded-signed through self-signing before the driver submission.

Design Notes:
For more information about how to embedded-sign a boot start driver, see "Step 6: Release-Sign a Driver Image File by Using an Embedded Signature" at the following website:

http://www.microsoft.com/whdc/winlogo/drvsign/kmcs_walkthrough.mspx
After the file is embedded-signed, use SignTool
to verify the signature. Check the results to verify that the root of the SPC's certificate chain for kernel policy is "Microsoft Code Verification Root." The following command line verifies the signature on the toaster.sys file:

```
    Signtool verify /kp
 /v amd64\toaster.sys

    Verifying: toaster.sys
    SHA1 hash of file: 2C830C20CF15FCF0AC0A4A04337736987C8ACBE3
    Signing Certificate Chain:
    Issued to: Microsoft Code Verification Root
    Issued by: Microsoft Code Verification Root
    Expires: 11/1/2025 5:54:03 AM
    SHA1 hash: 8FBE4D070EF8AB1BCCAF2A9D5CCAE7282A2C66B3
    ...
    Successfully verified: toaster.sys
    Number of files successfully Verified: 1
    Number of warnings: 0
    Number of errors: 0
```

In the Windows Hardware Lab Kit, this requirement will be tested by using the Embedded Signature Verification test.

System.Fundamentals.SignedDrivers.DigitalSignature

System must contain compatible qualified devices.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

All buses, devices and other components in a system must meet their respective Windows Compatible Hardware Requirements and use drivers that either are included with the Windows operating system installation media or are digitally signed by Microsoft through the Windows Hardware Compatibility Program that match the Windows OS version being submitted for and shipping with.

For example, if a logo qualifying a system for Windows 10, then all drivers on the system must be signed by Microsoft for Windows 10 or be drivers that ship on the Windows 10 media. All devices in the system would also need to be logo qualified or certified for Windows 10. This requirement applies to all versions of Microsoft Windows.

All devices and drivers need to be fully installed, and does not contain any problem codes.

Systems must meet the following dependent device-level requirements.

- **Device.DevFund.INF.DDInstall.CoInstallers**
- **Device.DevFund.DriverSecurity.DriverPackage**
- **Device.DevFund.Reliability.ProperINF**
- **Device.DevFund.CDA.Application (If applicable)**

All drivers and firmware servicing must use Windows Update.

System.Fundamentals.SMBIOS

System Management BIOS (SMBIOS) requirements defines data structures in the system firmware which allows a user or application to store and retrieve information about the computer.

System.Fundamentals.SMBIOS.SMBIOSSpecification

System firmware support for SMBIOS complies with the SMBIOS specification.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The system firmware must implement support for SMBIOS that complies with System Management BIOS Reference Specification, Version 3.0 or later version, as needed to correctly and uniquely identify the system using the mandated structures and data below. The SMBIOS implementation must follow all conventions and include all required structures and fields as indicated in the SMBIOS Specification, Section 6.2, “Required structures and data”, and follow all conformance requirements as indicated in ANNEX A (Informative). Bit 2 in the BIOS Characteristics Extension Byte 2 field must be set (Section 3.3.1.2.2 of the specification). The length of the Type 1 (System Information) table must be at least 1Bh bytes (includes SKU Number and Family fields from Version 3.0 or later of the specification).

Additionally, the following fields must have non-Null values that accurately describe the computer system or computer system component, with no "generic", "universal", indefinite or other non-specific values or strings in the below structures that would preclude unique identification of a system:

- (Table 0, offset 04h) BIOS Vendor
- (Table 0, offset 08h) BIOS Release Date
- (Table 0, offset 14h) BIOS Major Release Version[1]
- (Table 0, offset 15h) BIOS Minor Release Version[1]
- (Table 1, offset 04h) System Manufacturer[2]
- (Table 1, offset 05h) System Product Name[2]
- (Table 1, offset 07h) Serial Number[4]
- (Table 1, offset 08h) Universal Unique ID number
- (Table 1, offset 19h) System SKU Number[2]
- (Table 1, offset 1Ah) Family[2]
- (Table 2, offset 05h) Base Board Product[2]
- (Table 3, offset 05h) Type[2]

Microsoft recommends that the following fields have non-Null values that accurately describe the computer system or computer system component:

- (Table 0, offset 05h) BIOS Version
- (Table 0, offset 16h)Embedded Controller Major Release Version[3]
- (Table 0, offset 17h) Embedded Controller Minor Release Version[3]
- (Table 1, offset 06h) System Version
- (Table 1, offset 1Bh) System Family[2]
- (Table 2, offset 04h) Base Board Manufacturer
- (Table 2, offset 05h) Base Board Product
- (Table 2, offset 06h) Base Board Version

[1]These fields must not have values equal to 0FFh.

[2]These fields gain prominence as fields which will be used for identifying unique system configurations for telemetry and servicing. The Manufacturer, Product Name, SKU Number, Family, Base Board Product and System Enclosure fields must not be longer than 64 characters in length. Avoid leading or trailing spaces or other invisible characters. The Type field value must be from the "System Enclosure or Chassis Types" table.

[3]If the system has a field upgradeable embedded controller firmware; these values should not be equal to 0FFh.

[4] For Windows Server, this field is optional, i.e., If Implemented.

Design Notes:

Inputs to the identified SMBIOS fields are to remain consistent by avoiding variations in punctuation, abbreviations, spacing, capitalization, and spelling errors.

Company must ensure updates to firmware do not modify the values for the "Manufacturer", "Family", "Product Name", "Baseboard Product", "SKU Number" and "Enclosure Type" fields defined in the SMBIOS specification

As new form factors are developed in partnership with Distributed Management Task Force, Inc. ("DMTF") to provide new byte values for new "enclosure type" fields. Company must begin to accurately report the new byte value for new "enclosure type" field for new Product Name systems to which the new form factor applies within one-hundred and twenty (120) days of the new byte value being made available.

System.Fundamentals.StorageAndBoot

This section summarizes the requirements for storage and boot devices.

System.Fundamentals.StorageAndBoot.BootPerformance

Boot Devices in systems that support Modern Standby must meet these requirements.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following requirements apply to Boot Devices in systems that support Modern Standby.

The Windows platform supports SATA, USB, NVMe, eMMC SD and UFS based storage. The table below shows which bus types can be used for the boot device.

Storage Type	Boot	Data Disk
SATA	Yes	Yes
USB	No	Yes
NVMe	Yes	Yes
eMMC 4.5+	Yes	Yes
SD 2.0+	No	Yes
UFS 2.0+	Yes	Yes

ACPI interfaces must specify whether the storage device is internal or external and whether or not it is removable or fixed.

_RMV must be defined in ACPI namespace for any embedded devices attached to an SD host controller, where 0 is defined as non-removable. _RMV may optionally be defined for external slots as 1.

The following parameters must be defined within the "Storage Class-Specific Information" to be returned by the ACPI _DSM method for an SD/eMMC Storage Controller:

- Number of Sockets
- Socket Addresses

Support GPIO card detection on SD/eMMC Storage Controller.

When using eMMC as the primary boot device, the eMMC memory must be hardware partitioned such that the boot critical portion of the EFI Firmware resides in an area of the device that is not accessible by Windows.

The CPU Vendor and/or Firmware Provider must furnish the software tools needed to maintain and update the firmware.

The following requirements are applicable to solid state (SATA SSD, NVMe, eMMC and UFS) boot storage media and are tested with the smaller of 2% or 1GB free space.

Feature	Span Size	Specification
Power		
Max Idle Power	-	<= 5 mW
Random Performance		
4KB Write IOPs	1 GB	>= 200
	*5 GB	>= 50
	†10 GB	>= 50
64KB Write IOPs	1 GB	>= 25
4KB Read IOPs	*5 GB	>= 2000
	†10 GB	>= 2000
4KB 2:1 read/write mix IOPs	1 GB	>= 500
	* 5GB	>= 140
	†10 GB	>= 140
Sequential Performance		
Write speed (64KB I/Os)	*5 GB	>= 40 MB/s
	†10 GB	>= 40 MB/s
Write speed (1MB I/Os)	*5 GB	>= 40 MB/s
	†10 GB	>= 40 MB/s
Read speed (64KB I/Os)	*5 GB	>= 60 MB/s
		‡>= (120 MB/s)
	†10GB	>= 60 MB/s
		‡>= (120 MB/s)
Device I/O Latency		
Max Latency	-	< 500 milliseconds

*Applies only to devices with 16 GB of internal storage or lower.

†Applies only to devices with greater than 16 GB of internal storage.

‡Applies only if the device is HS200 capable.

Additional I/O Latency requirement:

Maximum of **20 seconds** sum-total of user-perceivable I/O latencies over any **1 hour** period of a user-representative workload, where a user-perceivable I/O is defined as having a latency of at least 100 milliseconds.

The following requirements are applicable to SATA HDD boot storage media

Feature	Specification
Max Standby Power	<= 250 mW

System.Fundamentals.StorageAndBoot.EncryptedDrive

Systems which ship with a Encrypted Drive as a boot storage device must support security command protocols in order to make sure the data at rest is always protected.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

The following requirements apply if Encrypted Drive (**System.Fundamentals.StorageAndBoot.EncryptedDrive**) support is implemented for a UEFI based client system or server systems:

a. The system MUST have a TPM 1.2 or TPM 2.0.

b. The system MUST implement the EFI_STORAGE_SECURITY_COMMAND_PROTOCOL from either:

  o Trusted Command Support in UEFI 2.3 + UEFI Mantis change number 616 or

  o UEFI 2.3.1

c. The implementation of the Trusted Computing Group Platform Reset Attack Mitigation Specification (http://www.trustedcomputinggroup.org/resources/pc_client_work_group_platform_reset_attack_mitigation_specification_version_10) MUST unconditionally issue TPer Reset (OPAL v2.0 in section 3.2.3) for all scenarios whenever memory is cleared.

d. The EFI_STORAGE_SECURITY_COMMAND_PROTOCOL and the TPer Reset command MUST be included in the base UEFI image (not in a separate image of a UEFI driver).

e. The system MUST enumerate all Encrypted Drives and TPer Reset MUST be issued prior to executing any firmware code not provided by the platform manufacturer in the base UEFI image.

f. The TPer Reset MUST be issued regardless of whether the TPM has had ownership taken or not.

Note: The TPer Reset action will occur later in the boot process than the memory clear action because it has a dependency on the EFI_STORAGE_SECURITY_COMMAND_PROTOCOL.

System.Fundamentals.StorageAndBoot.SATABootStorage

System with SATA boot storage must meet requirements.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

AHCI Host Controllers using Windows for boot support must be compliant with the AHCI specification.

Host Controller Interface	Revision
AHCI	1.1, 1.2, 1.3

System with SATA controller must enable AHCI mode support.
Externally connected SATA devices (eSATA) are not supported for boot storage.

When SATA is used as the primary boot device, to ensure reliability and prevent inadvertent erasure of the firmware that may cause the device to become inoperable, the boot critical portion of the UEFI firmware must reside on a separate storage device that is not accessible by the host Operating System. The CPU Vendor and/or Firmware Provider must furnish the software tools needed to maintain and update the firmware.

When used in systems that support modern standby, the SATA device must meet the power requirements stated in the section for **System.Fundamentals.StorageAndBoot.BootPerformance**.

System.Fundamentals.StorageClassMemory

System.Fundamentals.StorageClassMemory

System.Fundamentals.StorageClassMemory

Applies to	Windows Server 2019 x64

Description:

- Platforms supporting the use of Storage Class Memory devices must implement the relevant portions of ACPI 6.1 (or newer), specifically:
    - NVDIMM Firmware Interface Table (NFIT)
    - NVDIMM Root Device reported under the _SB namespace in Differentiated System Description Table (DSDT) or Secondary System Description Table (SDDT)
    - NVDIMM Device reported under the NVDIMM Root Device in the DSDT or SSDT for every module in the system
    - NVDIMM Root Device Notification value of 0x81 (Unconsumed Uncorrectable Memory Error Detected)
    - NVDIMM Devie Notification value of 0x81 (NFIT Health Event Notification)
    - Persistent memory regions reported in the Memory Affinity Structure(s) in the System Resource Affinity Table (SRAT)
    - Continuously running Address Range Scrub (ARS)
    - Heterogeneous Memory Attribute Table (HMAT)

- Firmware shall not map any Storage Class Memory devices to the 4GB region starting at address 0xFFFF00000000 in system address space.
- Platforms must support Asynchronous DRAM Refresh (ADR) on Intel-based systems.
- Platform must only present 1 namespace per physical device. If there are more than one namespace on a physical device, only a single namespace will be usable.

System.Fundamentals.StorageClassMemory.1GibMappings

The starting address of all byte addressable persistent memory regions is mapped at 1GiB granularity.

Applies to	Windows Server 2019 x64

Description

SCM-capable platforms must map the starting address of byte addressable persistent memory regions at 1GiB granularity.

Note: If this granularity is not provided, the Windows SCM stack will not load.

System.Fundamentals.StorageClassMemory.INVDIMM.DSMCompliance

System.Fundamentals.StorageClassMemory.INVDIMM.DSMCompliance

Applies to	Windows Server 2019 x64

Description:

- Platforms supporting the use of INVDIMM devices need to comply with the _*DSM* specification with version 1.7 or newer located here: http://pmem.io

System.Fundamentals.StorageClassMemory.INVDIMM.Label

System.Fundamentals.StorageClassMemory.INVDIMM.Label

Applies to	Windows Server 2019 x64

Description:

- Platforms supporting the use of INVDIMM devices need support for Labels with BTT support, with BTT implementation compliant with UEFI 2.7 or newer.
- Platforms must support creating and removing namespaces which span the entirety of the available persistent memory region attached to a memory controller or socket.
    - Multiple namespaces per device or per interleave set are not supported.

System.Fundamentals.StorageClassMemory.NVDIMMN.DSMCompliance

System.Fundamentals.StorageClassMemory.NVDIMM-N.DSMCompliance

Applies to	Windows Server 2019 x64

Description:

Platforms supporting the use of NVDIMM-N devices have to comply with the *Microsoft _DSM for JEDEC Byte-Addressable Energy-Backed Interface NVDIMMs* specification, located here:

- https://msdn.microsoft.com/en-us/library/windows/hardware/mt604741(v=vs.85).aspx

Note: NVDIMM-N devices are identified through the Firmware's NFIT table as defined in ACPI 6.1, or a newer revision.

System.Fundamentals.StorageClassMemory.NVDIMMN.Label

System.Fundamentals.StorageClassMemory.NVDIMMN.Label (if implemented)

Applies to	**Windows Server 2019 x64**

Description:

- Platforms supporting the use of NVDIMM-N devices may support the use of Labels. If implemented, Labels must be compliant with UEFI 2.7

System.Fundamentals.StorageClassMemory.NVDIMMN.Persistence

System.Fundamentals.StorageClassMemory.NVDIMM-N.Persistence

Applies to	**Windows Server 2019 x64**

Description:

Platforms supporting NVDIMM-N devices must appropriately trigger save / restore operations across planned and unplanned power cycles of the system. It is expected that data will be persisted upon power loss, provided the device indicated to be armed and ready for a back-up at the time of power loss.

Note: It is highly recommended that persistence is achieved by implementing ADR support in the platform.

System.Fundamentals.SystemAudio

System.Fundamentals.SystemAudio.Audio

Systems contain audio devices that conform to Windows Logo requirements.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

Systems need to conform to all **Device.Audio** requirements.

System.Fundamentals.SystemAudio.MicrophoneLocation

Microphone Location Reporting Requirement

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

- All active onboard fixed-position single element microphones and onboard fixed-position microphone arrays (multiple combined elements) on a system must be available for independent capture.
- Systems with no onboard fixed-position microphone arrays, but with multiple onboard fixed-position microphones (e.g. Front/Back), AND no combined microphone, must have exactly one with GeoLocation = "Front" (which will be set as the default microphone on that system).
- Systems with multiple onboard fixed-position microphone arrays must have exactly one with GeoLocation = "Front."
- Mic arrays with "n" elements must deliver RAW audio to the system. The RAW format must have "n" channels, and data must come directly from the mic elements, free of signal processing.
- If a microphone and a camera are physically co-located onboard then stated location information for each must match.
- For devices with multiple onboard fixed-position microphones or multiple arrays, the names of these endpoints should be unique on the system. To specify a unique name, there are a few different methods using KSPROPERTY_PIN_NAME, IPinName and .inf pin description name GUID registration.

System.Fundamentals.SystemAudio.SystemUsesHDAudioPinConfigs

System uses the HD Audio device pin configuration registers to expose logical devices supported by the Windows UAA HD Audio class driver.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

If the PnP ID of an HD Audio device matches as compatible with any of the audio class drivers packaged with Windows, the device must provide basic functionality for all of its endpoints when using that driver. Audio device must follow Microsoft HD Audio pin configuration programming guidelines and expose devices divided into areas based on audio device hardware functionality resources.

See the Pin Configuration Guidelines for High Definition Audio Devices white paper at http://go.microsoft.com/fwlink/?LinkId=58572.

System.Fundamentals.SystemPCIController

System.Fundamentals.SystemPCIController.PCIRequirements

System devices and firmware meet PCI requirements

Applies to	**Windows Server 2019 x64**

Description
All PCI Express devices must comply with the PCI Base Express Specification 1.1 or later unless specified otherwise below.

Reverse bridge implementations as defined in Appendix A of the PCI Express to PCI/PCI-X Bridge Specification are not supported in Windows
A reverse bridge will not be supported if it adheres to the guidelines and recommendations as defined in Appendix A of the PCI Express to PCI/PCI-X Bridge Specification, Revision 1.0.

System firmware disables the extended (non-VC0) virtual channels in PCI Express devices.
The system firmware sets the VC enable bit (PCI Express Base Specification, Revision 1.0a, Section 7.11.7, "VC Resource Control Register: bit 31") to 0 for all extended (non-VC0) virtual channels in all PCI Express devices. This requirement does not apply to PCI Express High Definition Audio controllers, which use class code 04 and subclass code 03.Because extended support for VC hardware is optional, this requirement addresses the scenario in which incompatible VC hardware implementations might cause system reliability, stability, and performance issues. Hardware vendors are encouraged to work with Microsoft to define the future direction of extended virtual channel support.

System firmware for PCI-X Mode 2 capable and PCI Express systems implements MCFG table for configuration space access. PCI-X Mode 2-capable and PCI Express systems must implement the MCFG ACPI table in PCI Firmware. Specification, Revision 3.0.The configuration space of PCI-X Mode 2 and PCI Express devices must be accessible through the memory-mapped configuration space region defined in this table.

PCI-to-PCI bridges comply with PCI-to-PCI Bridge Architecture Specification
All PCI-to-PCI bridges must comply with PCI-to-PCI Bridge Architecture Specification, Revision 1.2.

Virtual bridges that comply with PCI Express also comply with PCI-to-PCI Bridge Architecture Specification, Revision 1.1. In addition, VGA 16-bit decode (Section 3.2.5.18, "Bridge Control Register, bit 4") and SSID and SSVID (Section 3.2.5.13) from PCI-to-PCI Bridge Architecture Specification, Revision 1.2, must also be supported.
SSID and SSVID support is not required until January 1, 2011. If implemented, SSID and SSVID must meet the specification. SSVID is not required for PCIe to PCI/PCI-X bridges.

x64-based system provides 64-bit support in PCI subsystem. For x64-based systems, all PCI bridges on the system board must support dual-access cycle (DAC) for inbound access, and DAC-capable devices must not be connected below non-DAC-capable bridges, such as on adapter cards.

All 64-bit adapters must be DAC capable. This DAC requirement does not apply to outbound accesses to PCI devices. However, for systems in which DAC is not supported on outbound accesses to PCI devices, the system firmware must not claim that the bus aperture can be placed above the 4-GB boundary.

System.Fundamentals.SystemUSB

This section contains requirements for systems with USB host controllers.

System.Fundamentals.SystemUSB.ExternalUSBonCSisEHCIorXHCI

External USB ports on system that support modern standby must be EHCI or XHCI

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

USB host controllers on systems that support Modern Standby must implement xHCI (eXtensible Host Controller Interface) or EHCI (Enhanced Host Controller Interface). Legacy companion controllers (UHCI/OHCI) are not supported.

All exposed ports must support all speeds slower than the maximum speed of the host controller, to enable support of legacy devices including keyboards and mice.

Required Speed Support	EHCI Port (USB 2.0)	XHCI Port (USB 3.x)
Low-Speed	Yes	Yes
Full-Speed	Yes	Yes
Hi-Speed	Yes	Yes
Super-Speed	No	Yes

Transaction translators (TTs), integrated with the EHCI host controller, are not standardized, but the Windows EHCI driver supports serveral implementations of a controller- integrated TT. The supported integrated TT implementation must be identified in ACPI using the _HRV hardware revision for the USB controller. Please contact the USB team to determine if your implementation is supported and for more information about which _HRV value should be reported.

If the USB EHCI controller does not feature an integrated TT, any externally exposed ports must be routed through an embedded rate-matching hub.

For improved power efficiency and performance, USB Host Controllers on systems that support Modern Standby are recommended to be at least USB 3.x compatible, with an XHCI controller integrated into the SoC or chipset. The operating system supports standard EHCI and XHCI controllers including debug registers.

USB Host Controller Interface	Recommendation

UHCI/OHCI Companion Controllers	Not-supported
EHCI	Supported
XHCI (including debug capability)	Supported and Recommended

System.Fundamentals.SystemUSB.SuperSpeedCapableConnectorRequirements

Each exposed SuperSpeed capable connector supports SuperSpeed, high, full and low speed USB devices routed through its xHCI controller.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

xHCI Controllers are backwards compatible with SuperSpeed, high, full, and low speed USB devices. Backwards compatible is defined as all USB devices enumerate and function at their intended speeds. More than one xHCI controller may be present on a system as long as the SuperSpeed capable ports are correctly routed. EHCI controllers may also be present on the system; however, SuperSpeed capable ports should not be routed through them.

In general, it is a best practice to route SuperSpeed, high, full, and low-speed device connections through the same xHCI controller. However, it is permitted to route the SuperSpeed connections to one xHCI controller and high, full, and low speed connections to a second xHCI controller. The high, full and low speed connections shall not be routed to a non-xHCI controller, and the port routing shall not change in normal operation, for example: system reboot, hibernate, or disable/enable of the controller.

System.Fundamentals.SystemUSB.SystemExposesUSBPort

Systems are recommended to expose at least one user-accessible USB port.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

Systems are recommended to expose at least one external USB host port. If a system exposes such port(s), the following requirement applies.

USB ports must be correctly described in ACPI with the _UPC (USB Port Capabilities) package type parameter as defined in the ACPI 6.1 specification, section 9.14. This information allows Windows to determine when a USB-C port is exposed, or when a micro-A/B port is exposed (meaning ID pin detection is necessary).

If the system's form factor is too thin to expose a standard USB A port, it is recommended to expose a Type-C port and acceptable to expose a micro-A/B port. See the table below for the complete list of options.

While USB 2.0 capable controllers are acceptable, USB 3.1 XHCI host controllers are preferred. The USB ports must fully comply with the USB 3.1 or USB 2.0 specification. USB 3.1 connectors must properly support 900mA USB 3.1 devices, and 500 mA USB 2.0 and 1.1 devices. USB 2.0 ports must properly support 500 mA USB 2.0 and 1.1 devices.

It is optional to include an adapter that converts the port from micro USB or USB Type-C to USB A. If you bundle an adapter, the adapter capabilities must match that of the exposed connector of the USB host controller.

External USB Ports	Recommendation
Standard USB A Port(s)	Recommended
USB Type-C Port(s)	Recommended
Standard USB A Port(s) + USB Type-C Port(s)	Recommended
Micro-USB A/B Port + 1 or more Standard USB A Port	Supported
Micro-USB A/B (Host + Function debug) Port	Supported
Micro-USB B Port + 1 or more Standard USB A Port	Supported
Proprietary Docking Port with USB Host and/or debug Functionality	Supported
Mini-USB A, A/B or B Port	Not Supported
Proprietary USB Host Port	Not Supported

A Standard-A-to-A cable defined as defined by the USB 3.1 specification can be used to expose XHCI host debug transport from a Standard USB-A port. These ports must tolerate being back-powered and it is strongly recommended that the standard USB A port provide built-in protection against a short on the VBus line., which can occur if the USB port is connected to another host when it is not properly configured in debug mode. Type-C ports that expose XHCI host debug can use the same mechanism as Standard-A ports by connecting a C-to-A-receptacle adapter to the Type-C port first.

If a system exposes multiple Dual Role capable ports, only one port should in function mode at any given time. If the micro-USB B port provides no additional functionality beyond debugging, it must be hidden in the battery compartment or behind a easily removable cover. In order to comply with USB-IF requirements, VBUS must not be asserted on the micro-A/B port until the resistance to ground of the ID pin of the micro-USB A/B port is less than 10 Ohms. This will prevent a short-circuit when a user connects a micro-USB B cable to another USB host, such as a desktop. Alternatively, the port can implement short protection circuitry for VBus.

System.Fundamentals.SystemUSB.TestedUsingMicrosoftUsbStack

Systems with xHCI Controllers must be tested with Microsoft's xHCI Stack installed.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

Systems with Extensible Host Controller Interface (xHCI) Controllers must be tested with Microsoft's xHCI Stack installed and enabled.

Any system using xHCI must ship using Microsoft’s inbox xHCI stack. Additionally if a system ships with dock that has an xHCI controller, that dock must use Microsoft’s xHCI stack.

System.Fundamentals.SystemUSB.USBDevicesandHostControllersWorkAfterPowerCycle

All USB devices and host controllers work properly upon resume from sleep, hibernation or restart without a forced reset of the USB host controller.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

All USB devices and host controllers work properly upon resume from sleep, hibernation or restart without a forced reset of the USB host controller.

Design Notes:

Registry key ForceHCResetOnResume documented at the KB below is not needed for devices to function properly upon resume in Windows 7 or newer.
http://support.microsoft.com/kb/928631
Note that a known set of currently existing devices do require a forced reset upon resume, these devices should be covered in a list kept by the OS which will reset these devices upon resume. The goal of this requirement is to ensure that this list of devices which need a reset to appear after resume does not grow and that devices can properly handle sleep state transitions without being reset.
A reset of the entire USB Host Controller results in significantly increased time that it takes for all USB devices to become available after system resume since there could be only one device at address 0 at a time, this enumeration has to be serialized for all USB devices on the bus. We have also seen that resetting the host controller can lead to an illegal SE1 signal state on some host controllers, which in turn can cause some USB devices to hang or drop off the bus. Moreover, devices cannot maintain any private state across sleep resume as that state will be lost on reset.

System.Fundamentals.SystemUSB.USBC

System.Fundamentals.SystemUSB.USBC.USBTypeCCharging

USB Type-C Charging cases are supported

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

If a System contains a USB Type-C port that can be used to charge the system, that port must support the following requirements addition to the USB Type-C and PD specs:

- If the system ships with or is sold with a Type-C charger, the system must be able to charge from a dead battery using that charger.
- For multiple USB Type-C port systems, it is recommended that all USB Type-C ports on the system can be used to charge the system to reduce user confusion.

System.Fundamentals.SystemUSB.USBC.USBTypeCCertifiedCables

USB Type-C Systems and Devices that ship with Cables ship with certified cables

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

If a system or device is USB Type-C and ships with a USB Type-C cable or an adapter, the cable and/or adapter must be USB-IF certified.

In addition, if the USB Type-C cable or adapter is used for an Alternate Mode Standard and the industry group that owns that Standard has a corresponding certification, the cable or adapter must get that certification.

System.Fundamentals.SystemUSB.USBC.USBTypeCUCM

USB Type-C systems must support UCM

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

This requirement applies to systems that support Power Delivery or Dual Role or Alternate Modes.

Systems with local USB-C ports (e.g. directly on the system compared to on a detachable or separate device or dock) that do not implement UCSI or UcmTcpci must ship with a 3rd-party UcmCx client driver.

3rd-party UcmCx client drivers must be implemented as per the following MSDN documentation:

- https://msdn.microsoft.com/en-us/library/windows/hardware/mt188011(v=vs.85).aspx

The UcmCx client driver is required to implement the following APIs:

- UcmInitializeDevice
- UcmConnectorCreate
- UcmConnectorTypeCAttach
- UcmConnectorTypeCDetach
- UcmConnectorTypeCCurrentAdChanged
- UcmConnectorChargingStateChanged

If the system or controller supports Power Delivery, the following additional APIs must be implemented:

1. UcmConnectorPowerDirectionChanged
2. UcmConnectorPdSourceCaps
3. UcmConnectorPdPartnerSourceCaps
4. UcmConnectorPdConnectionStateChanged

If the system or controller exposes dual role ports, the following additional APIs must be implemented:

- UcmConnectorDataDirectionChanged

System.Fundamentals.SystemUSB.USBC.USBTypeCUCMTCPCI

USB Type-C systems that support UCMTCPCI must implement it correctly

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Terms: If-Implemented

Description

This requirement applies to systems that support Power Delivery or Dual Role or Alternate Modes.

Systems with local USB-C ports that have Type-C Port Controller(s) but do not have Type-C Port Manager silicon that provides the Type-C policy engine and protocol layer should implement a UcmTcpciCx client driver.

If the system implements UcmTcpci, the UcmTcpciCx client driver is required to implement the following APIs:

1. UcmTcpciPortControllerCreate
2. UcmTcpciPortControllerSetHardwareRequestQueue
3. UcmTcpciPortControllerStart
4. UcmTcpciPortControllerAlert

If the system has a battery, supports PD charging, and implements UcmTcpci, it must have silicon that handles PD charging before the OS has started.

System.Fundamentals.SystemUSB.USBC.USBTypeCUCSI

USB Type-C Systems that support UCSI must implement USCI correctly

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86**

Description

This requirement applies to systems that support Power Delivery or Dual Role or Alternate Modes.

Systems with local USB-C ports (e.g. directly on the system compared to on a detachable or separate device or dock) that have an Embedded Controller which implements PD policy should implement UCSI.

If the system implements UCSI, it must implement UCSI v1.0 (or later). It must specify the UCSI version number that is implemented in the VERSION field of the UCSI data structure. In addition, the system must implement the following optional features from the UCSI spec.

<u>Commands</u>

- GET_ALTERNATE_MODES
- GET_CAM_SUPPORTED
- GET_PDOS
- GET_CABLE_PROPERTY
- SET_NOTIFICATION_ENABLE
  - The system or controller must support the following notifications within this command:
    - Supported Provider Capabilities Change
    - Negotiated Power Level Change
    - Supported CAM Change
- GET_CONNECTOR_STATUS
  - The system or controller must support the following Connector Status Changes within this command:
    - Supported Provider Capabilities Change
    - Negotiated Power Level Change
    - The system or controller must support the following fields in GET_CONNECTOR_STATUS Status structureProvider Capabilities Limited Reason
    - Request Data Object

System.Fundamentals.SystemUSB.XhciBiosHandoffFollowsSpec

xHCI BIOS handoff follows specification

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

For all xHCI controllers exposed to the OS, the system firmware must follow the BIOS handoff procedure defined in section 4.2.2.1 of the XHCI specification.

System.Fundamentals.SystemUSB.XHCIControllersMustHaveEmbeddedInfo

Systems with xHCI controllers must have embedded ACPI information for port routing.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

Please reference ACPI specification version 6.1.

The ACPI namespace hierarchy for USB devices should exactly match the devices hierarchy enumerated by Windows operating system.

All connectable USB ports are required to have a _PLD object. In addition, two fields in the _PLD object: Group token (Bit 86:79) and Group Position (Bit 94:87) should be correctly defined for all USB connection points, including those that are not visible externally (which should be indicated by setting bit 64 to zero).

No two USB connection points should have identical combination of Group token and Group Position. If two ports are sharing a connection point, they should have identical _PLD objects. If the connection point is a Type C connector, the _PLD specified for that connector under the UCSI node must match the _PLD specified under the USB controller node.

If the USB controller is a dual role controller that uses the inbox USB Role Switch (URS) driver, then the same _PLD object for the connector should be specified under both USB Host and USB Function.

This information helps define the mapping of USB ports to uniquely identifiable connection points. The Windows USB 3.x stack will use this information to determine which ports are tied to the same connection points. Any USB port that does not have a _PLD object will be assumed to be not connectable and not visible (i.e. it is not being used at all). The definition of connectable port as per ACPI 6.1 spec (section 9.14), is a port on which either a user can connect a device OR there is an integrated device connected to it.

Please see design notes for additional information on how to implement this requirement.

Design Notes:
Example
This example is based on xHCI Spec (Version .95) Appendix D. The hardware configuration is exactly the same as in that Appendix. The ACPI representation of that hardware configuration differs in this example; those differences are highlighted.
The following is an example of the ACPI objects defined for an xHCI that implements a High-speed and SuperSpeed Bus Instance that are associated with USB2 and USB3 Protocol Root Hub Ports, respectively. The xHCI also supports an integrated High-speed hub to provide Low- and Full-speed functionality. The External Ports defined by the xHC implementation provide either a USB2 data bus (i.e. a D+/D- signal pair) or a SuperSpeed (or future USB speed) data bus (i.e. SSRx+/SSRx- and SSTx+/SSTx-signal pairs).
Where:

- The motherboard presents 5 user visible connectors C1 - C5:
  - Motherboard connectors C1 and C2 support USB2 (LS/FS/HS) devices.
  - Motherboard connectors C3, C4 and C5 support USB3 (LS/FS/HS/SS) devices.
- The xHCI implements a High-speed Bus Instance associated with USB2 Protocol Root Hub ports, e.g. HCP1 and HCP2 are High-speed only, i.e. they provide no Low- or Full-speed support.
- The xHCI presents 7 External Ports (P1 - P7):
  - External Port 1 (P1) is HS only and is not visible or connectable.
  - External Ports 2 - 5 (P2 - P5) support LS/FS/HS devices:
    - P2 is attached to motherboard USB2 connector C1.
    - P3 is attached to motherboard USB2 connector C2.
    - P4 is attached to the USB 2.0 logical hub of the Embedded USB3 Hub on the motherboard. The USB 2.0 logical hub supports the LS/FS/HS connections for 2 ports (EP1 - EP2)
    - The USB 2.0 connections of motherboard hub ports EP1 and EP2 are attached to motherboard connectors C3 and C4 respectively, providing the LS/FS/HS support for the USB3 connectors.
  - P5 is attached to motherboard connector C5, providing the LS/FS/HS support to the motherboard USB3 connector C5.
  - External Port 6 (P6) is attached to the SuperSpeed logical hub of the Embedded USB3 Hub on the motherboard. The SuperSpeed logical hub supports the SS connections of 2 ports (EP1 - EP2).
  - The SuperSpeed connections of motherboard hub ports EP1 and EP2 are attached to motherboard connectors C3 and C4 respectively, providing the SS support for the USB3 connectors.
  - External Port 7 (P7) is attached to motherboard connectors C5, providing the SS support for the USB3 connector.
- The xHCI implements 4 internal HS Root Hub ports (HCP1 - HCP4), 2 High-speed and 2 SuperSpeed:
  - Internal Port 1 (HCP1) maps directly to External Port 1 (P1).

    - Internal Port 2 (HCP2) is attached to a HS Integrated Hub. The Integrated Hub supports 4 ports (IP1 - IP4):

        - Ports 1 to 4 (IP1-IP4) of the Integrated Hub attach to External Ports 2 to 5 (P2-P5), respectively.

    - Internal Ports 3 and 4 (HCP3, HCP4) attach to External Ports 6 and 7 (P6, P7), respectively.

- All connectors are located on the back panel and assigned to the same Group.
- Connectors C1 and C2 are USB2 compatible and their color is not specified. Connectors C3 to C5 are USB3 compatible and their color is specified.
- External Ports P1 - P5 present a USB2 data bus (i.e. a D+/D- signal pair). External Ports P6 and P7 present a SuperSpeed data bus (i.e. SSRx+/SSRx- and SSTx+/SSTx- signal pairs).

```
Scope( \_SB ) {

        Device( PCI0 ) {

// Host controller ( xHCI )
Device( USB0 ) {
// PCI device#/Function# for this HC. Encoded as specified in the ACPI
// specification
Name( _ADR, 0xyyyyzzzz )
// Root hub device for this HC #1.
Device( RHUB ) {
Name( _ADR, 0x00000000 ) // must be zero for USB root hub
// Root Hub port 1 ( HCP1 )
Device( HCP1 ) {// USB0.RHUB.HCP1
Name( _ADR, 0x00000001 )
// USB port configuration object. This object returns the system
// specific USB port configuration information for port number 1
Name( _UPC, Package() {
0x01,// Port is connectable but not visible
0xFF,// Connector type (N/A for non-visible ports)
0x00000000,// Reserved 0 - must be zero
0x00000000} )// Reserved 1 - must be zero
} // Device( HCP1 )
// Root Hub port 2 ( HCP2 )
Device( HCP2 ) {// USB0.RHUB.HCP2
Name( _ADR, 0x00000002 )
Name( _UPC, Package() {
0xFF,// Port is connectable
0x00,// Connector type - (N/A for non-visible ports)
0x00000000,// Reserved 0 - must be zero
0x00000000} )// Reserved 1 - must be zero
// Even an internal connection point should have a _PLD and
// provide a valid Group Token and Position
Name( _PLD, Buffer( 0x10) {
0x00000081,// Revision 1,
// color width height ignored for non-visible connector
```

```
0x00000000,// connector type ignored for non-visible connector
0x00808000,// Not User visible, Panel, position shape ignored,
// Group Token = 1, Group Position = 1
// This is the group of all internal connectors.
// Each connector should have a unique position in this
// group
0x00000000} )// Ignored for non-visible connectors
//
// There is no separate node for the integrated hub itself
//
// Integrated hub port 1 ( IP1 )
Device( IP1 ) {// USB0.RHUB.HCP2.IP1
// Address object for the port. Because the port is
// implemented on integrated hub port #1, this value must be 1
Name( _ADR, 0x00000001 )
Name( _UPC, Package() {
0xFF,// Port is connectable
0x00,// Connector type - Type 'A'
0x00000000,// Reserved 0 - must be zero
0x00000000} )// Reserved 1 - must be zero
// provide physical connector location info
Name( _PLD, Buffer( 0x10) {
0x00000081,// Revision 1, Ignore color
// Color (ignored), width and height not
0x00000000,// required as this is a standard USB 'A' type
// connector
0x00800c69,// User visible, Back panel, Center, left,
// shape = vert. rect, Group Token = 0,
// Group Position 1 (i.e. Connector C1)
0x00000003} )// ejectable, requires OPSM eject assistance
} // Device( IP1 )
// Integrated Hub port 2 ( IP2 )
Device( IP2 ) {// USB0.RHUB.HCP2.IP2
// Address object for the port. Because the port is
// implemented on integrated hub port #2, this value must be 2
Name( _ADR, 0x00000002 )
Name( _UPC, Package() {
0xFF,// Port is connectable
0x00,// Connector type - Type 'A'
0x00000000,// Reserved 0 - must be zero
0x00000000} )// Reserved 1 - must be zero
// provide physical connector location info
Name( _PLD, Buffer( 0x10) {
0x00000081,// Revision 1, Ignore color
// Color (ignored), width and height not
0x00000000,// required as this is a standard USB 'A' type
// connector
0x01000c69,// User visible, Back panel, Center, Left,
// Shape = vert. rect, Group Token = 0,
// Group Position 2 (i.e. Connector C2)
0x00000003} )// ejectable, requires OPSM eject assistance
} // Device( IP2 )
// Integrated Hub port 3 ( IP3 )
Device( IP3 ) { // USB0.RHUB.HCP2.IP3
// Address object for the port. Because the port is implemented
// on integrated hub port #3, this value must be 3
Name( _ADR, 0x00000003 )
// Must match the _UPC declaration for USB0.RHUB.HCP3 as
// this port shares the connection point
Name( _UPC, Package() {
0xFF,// Port is not connectable
0x00,// Connector type - (N/A for non-visible ports)
0x00000000,// Reserved 0 - must be zero
0x00000000} )// Reserved 1 - must be zero
// Even an internal connection point should have a _PLD and
// provide a valid Group Token and Position.
// Must match the _PLD declaration for USB0.RHUB.HCP3 as
// this port shares the connection point
Name( _PLD, Buffer( 0x10) {
0x00000081,// Revision 1,
// color width height ignored for non-visible connector
0x00000000,// connector type ignored for non-visible connector
0x01008000,// Not User visible, Panel, position shape ignored,
// Group Token = 1, Group Position = 2
// This is the group of all internal connectors.
// Each connector should have a unique position in this
// group
0x00000000} )// Ignored for non-visible connectors
//
// There is no separate node for the embedded hub itself
//

// Motherboard Embedded Hub 2.0 Logical Hub port 1 ( EP1 )
Device( EP1 ) {// USB0.RHUB.HCP2.IP3.EP1
Name( _ADR, 0x00000001 )
// Must match the _UPC declaration for
// USB0.RHUB.HCP3.EP1 as this port provides
// the LS/FS/HS connection for C3
Name( _UPC, Package() {
0xFF,// Port is connectable
0x03,// Connector type - USB 3 Type 'A'
0x00000000,// Reserved 0 - must be zero
0x00000000} )// Reserved 1 - must be zero
// provide physical connector location info
Name( _PLD, Buffer( 0x10) {
0x0072C601,// Revision 1, Color valid
// Color (0072C6h), width and height not
0x00000000,// required as this is a standard USB
// 'A' type connector
0x01800c69,// User visible, Back panel, Center,
// Left, shape = vert.
// rect, Group Token = 0,
// Group Position 3
//(i.e. Connector C3)
0x00000003} )// ejectable, requires OPSM eject
// assistance
} // Device(EP1)
// Motherboard Embedded Hub 2.0 Logical Hub port 2 ( EP2 )
Device( EP2 ) {// USB0.RHUB.HCP2.IP3.EP2
Name( _ADR, 0x00000002 )
// Must match the _UPC declaration for
// USB0.RHUB.HCP3.EHUB.EP2 as this port provides
// the LS/FS/HS connection for C4
Name( _UPC, Package() {
0xFF,// Port is connectable
0x03,// Connector type - USB 3 Type 'A'
0x00000000,// Reserved 0 - must be zero
0x00000000} )// Reserved 1 - must be zero
// provide physical connector location info
Name( _PLD, Buffer( 0x10) {
0x0072C601,// Revision 1, Color valid
// Color (0072C6h), width and height not
0x00000000,// required as this is a standard USB
// 'A' type connector
0x02000c69,// User visible, Back panel, Center,
// Left, Shape = vert.
// rect, Group Token = 0,
// Group Position 4 (i.e. Connector C4)
0x00000003} )// ejectable, requires OPSM eject
//assistance
} // Device( EP2 )
} // Device( IP3 )

// Integrated hub port 4 ( IP4 )
Device( IP4 ) { // USB0.RHUB.HCP2.IP4
Name(_ADR, 0x00000004)
// Must match the _UPC declaration for USB0.RHUB.HCP4 as
// this port provides the LS/FS/HS connection for C5
Name( _UPC, Package() {
0xFF,// Port is connectable
0x03,// Connector type - USB 3 Type 'A'
0x00000000,// Reserved 0 - must be zero
0x00000000} )// Reserved 1 - must be zero
// provide physical connector location info
Name( _PLD, Buffer(0x10) {
0x0072C601,// Revision 1, Color valid
// Color (0072C6h), width and height not
```

```
0x00000000,// required as this is a standard USB 'A' type
// connector
0x02800c69,// User visible, Back panel, Center, Left,
// Shape = vert. rectangle, Group Token = 0,
// Group Position 5 (i.e. Connector C5)
0x00000003} )// ejectable, requires OPSM eject assistance
} // Device( IP4 )
} // Device( HCP2 )

// Root Hub port 3 ( HCP3 )
Device( HCP3 ) {
Name( _ADR, 0x00000003 )
// Must match the _UPC declaration for USB0.RHUB.HCP2.IP3 as
// this port shares the connection point
Name( _UPC, Package() {
0xFF,// Port is connectable
0x00,// Connector type - (N/A for non-visible ports)
0x00000000,// Reserved 0 - must be zero
0x00000000} )// Reserved 1 - must be zero
// Even an internal connection point should have a _PLD and
// provide a valid Group Token and Position.
// Must match the _PLD declaration for USB0.RHUB.HCP2.IP3 as
// this port shares the connection point
Name( _PLD, Buffer( 0x10) {
0x00000081,// Revision 1,
// color width height ignored for non-visible connector
0x00000000,// connector type ignored for non-visible connector
0x01008000,// Not User visible, Panel, position shape ignored,
// Group Token = 1, Group Position = 2
// This is the group of all internal connectors.
// Each connector should have a unique position in this
// group
0x00000000} )// Ignored for non-visible connectors
//
// There is no separate node for the embedded hub itself
//
// Motherboard Embedded Hub SS Logical Hub port 1 ( EP1 )
Device( EP1 ) {// USB0.RHUB.HCP3.EP1
Name( _ADR, 0x00000001 )
// Must match the _UPC declaration for
// USB0.RHUB.HCP2.IHUB.IP3.EHUB.EP1 as this port
// provides the SS connection for C3
Name( _UPC, Package() {
0xFF,// Port is connectable
0x03,// Connector type - USB 3 Type 'A'
0x00000000,// Reserved 0 - must be zero
0x00000000} )// Reserved 1 - must be zero
// provide physical connector location info
Name( _PLD, Buffer( 0x10) {
```

```
0x0072C601,// Revision 1, Color valid
// Color (0072C6h), width and height not
0x00000000,// required as this is a standard USB
// 'A' type connector
0x01800c69,// User visible, Back panel, Center,
// Left, shape = vert.
// rect, Group Token = 0,
// Group Position 3
//(i.e. Connector C3)
0x00000003} )// ejectable, requires OPSM eject
// assistance
} // Device(EP1)
// Motherboard Embedded Hub SS Logical Hub port 2 ( EP2 )
Device( EP2 ) {// USB0.RHUB.HCP2.EP2
Name( _ADR, 0x00000002 )
// Must match the _UPC declaration for
// USB0.RHUB.HCP3.IP3.EP2 as this port
// provides the SS connection for C4
Name( _UPC, Package() {
0xFF,// Port is connectable
0x03,// Connector type - USB 3 Type 'A'
0x00000000,// Reserved 0 - must be zero
0x00000000} )// Reserved 1 - must be zero
// provide physical connector location info
Name( _PLD, Buffer( 0x10) {
0x0072C601,// Revision 1, Color valid
// Color (0072C6h), width and height not
0x00000000,// required as this is a standard USB
// 'A' type connector
0x02000c69,// User visible, Back panel, Center,
// Left, Shape = vert.
// rect, Group Token = 0,
// Group Position 4 (i.e. Connector C4)
0x00000003} )// ejectable, requires OPSM eject
// assistance
} // Device( EP2 )
} // Device( HCP3 )
// Root Hub port 4 ( HCP4 )
Device( HCP4 ) {// USB0.RHUB.HCP4
Name( _ADR, 0x00000004 )
// Must match the _UPC declaration for USB0.RHUB.HCP2.IP4 as
// this port provides the SS connection for C5
Name( _UPC, Package() {
0xFF,// Port is connectable
0x03,// Connector type - USB 3 Type 'A'
0x00000000,// Reserved 0 - must be zero
0x00000000} )// Reserved 1 - must be zero
// provide physical connector location info
Name( _PLD, Buffer( 0x10) {
```

```
0x0072C601,// Revision 1, Color valid
// Color (0072C6h), width and height not
0x00000000,// required as this is a standard USB 'A' type
// connector
0x02800c69,// User visible, Back panel, Center, Left,
// Shape = vert. rect, Group Token = 0,
// Group Position 5 (i.e. Connector C5)
0x00000003} )// ejectable, requires OPSM eject assistance
} // Device( HCP4 )
} // Device( RHUB )

} // Device( USB0 )
//
// Define other control methods, etc.

} // Device( PCIO )

} // Scope( \_SB )
```

System.Fundamentals.SystemUSB.XhciSupportsMinimum31Streams

xHCI controller must support at least 31 primary streams per endpoint.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

Refer to the eXtensible Host Controller Interface specification, section 4.12.2.

This requirement is for the MaxPSASize in the HCCPARAMS to be set to 4 at the minimum to enable ultimate data transfer rate with UAS devices.

Storage devices based on the USB Attached SCSI Protocol (UASP) will utilize streams to achieve faster data transfer rates. To enable the best experience with these devices, every xHCI controller will need to support at least 31 primary streams.

System.Fundamentals.TPM20

System.Fundamentals.TPM20.TPM20

All systems as specified below must contain an HLK certified TPM 2.0 device

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Mandatory: All systems must contain a TPM 2.0, and the TPM 2.0 must be both available to the system and enabled in the shipping configuration.

Recommended: The System should not provide a mechanism to put the TPM in a state where it is visible to Windows but disabled or with hierarchies disabled.

Mandatory: The TPM 2.0 must be a model and firmware certified under Device.TrustedPlatformModule.TPM20.

Mandatory: The TPM 2.0 must have an associated EK Certificate compliant with Device.TrustedPlatformModule.TPM20.EKCert

Recommended: The TPM Interrupt PIN should be connected to an Interrupt Controller and the System should configure this Interrupt Controller to allow Interrupts. This requirement applies to discrete TPM devices only.

For Server Only: These requirements are **If Implemented** and **Strongly Recommended** on Server x64. Any Server system with a TPM 2.0 must meet all requirements in System.Fundamentals.TPM20, but Server systems are not required to contain a TPM 2.0. On October 1, 2021 these requirements become **Mandatory** for server systems.

System.Fundamentals.TPM20.PlatformSpecifications

All platforms which contain a TPM 2.0 must meet these functionality requirements for proper operation of the TPM.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

1. The platform shall include a trusted execution environment supporting the command set defined in “TCG PC Client Platform Firmware Profile Specification for TPM Family 2.0 Level 00 Revision 00.21” dated March 30, 2016 along with “Errata for PC Client Specific Platform Firmware Profile Specification Version 1.0, Revision 0.21”.
2. The platform is required to measure data into PCR [7] as specified in “TCG PC Client Platform Firmware Profile Specification for TPM Family 2.0 Level 00 Revision 00.21” dated March 30, 2016.
3. The platform shall comply with Trusted Computing Group “TCG EFI Protocol Specification” for Family “2.0”, denoted “Level 00 Revision 00.13”, dated March 30, 2016 including Errata Version 0.5
4. The platform shall comply with the requirements defined in Trusted Computing Group, "TCG ACPI Specification”, “Level 00 Revision 00.37” dated December 19, 2014.

5. The platform must comply with the Trusted Computing Group "Physical Presence Interface Specification", Version 1.30, Revision 00.52. Dated July 28, 2015.
6. The platform must comply with the Trusted Computing Group. "Platform Reset Attack Mitigation Specification", Version 1.00. Dated May 15, 2008.

System.Fundamentals.TPM20.PlatformConfiguration

All platforms which contain a TPM 2.0 must meet these functionality requirements for proper operation of the TPM.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows 10 Client ARM64** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

1. During the boot sequence, the boot firmware/software shall measure all firmware and all software components it loads after the core root of trust for measurement is established. The measurements shall be logged as well as extended to platform configuration registers in a manner compliant with the requirements in System.Fundamentals.TPM20.PlatformSpecifications.
2. The measurements must be implemented such that they reliably and verifiably allow a third party to identify all components in the boot process up until the point either the boot finished successfully or when software with an exploited vulnerability was loaded.
   a) For example, if the third component loaded includes an exploited vulnerability, then values for the first, second, and third component in the trusted boot log correctly reflect the software that loaded but any values after that may be suspect.
   b) To achieve this, the trusted execution environment must provide a mechanism of signing the values of the registers used for Trusted Boot. See the "TCG PC Client Platform Firmware Profile" specification referenced in System.Fundamentals.TPM20.PlatformSpecifications for details.
3. The UEFI firmware update process must protect against rolling back to insecure firmware versions, or non-production versions, that may disable secure boot or include non-production keys. A physically present user may however override the rollback protection manually. In such a scenario (where the rollback protection is overridden), the TPM must be cleared. See NIST SP 800-147 for details.
4. Platform firmware must ensure invariance of PCRs 0, 2, and 4 across power cycles in the absence of changes to the platform's static core root of trust for measurements (SRTM). Platform firmware must ensure invariance of PCR[7] across power cycles in the absence of changes to the platform's static core SRTM. Attaching a (non-bootable) USB to the platform or attaching the platform to an officially supported docking station shall not cause changes to the SRTM measurements.
5. If the platform is in any state, such as a "manufacturing mode", "debug mode" or other state which puts PCR[7] bound assets at risk, allows for memory dumps, is intended for debugging, manufacturing use, or engineering device use, the platform shall extend PCR[7] to reflect such a state.
6. The platform must be configured to use SHA-256 boot log (PCR) measurements in the shipping configuration.
   a) A platform with a single PCR bank which can be switched between SHA1 and SHA-256 modes is acceptable.
7. Crypto agile event logs must be supported as specified in the "TCG EFI Protocol Specification" referenced in System.Fundamentals.TPM20.PlatformSpecifications.
8. PPRequiredForClear should be FALSE.
   a) In earlier versions of PPI (prior to 1.3) this variable was called "NoPPIClear" and had opposite polarity. The equivalent setting for NoPPIClear is True. The meaning of this requirement that the default configuration must not require the user to accept a prompt to clear the TPM when the Clear command is sent from the OS using PPI.

b) A system may contain a UEFI option to allow end-users or admins to change this setting, and/or be compatible with a tool to automate changing this setting.

9. PPRequiredForTurnOn must be FALSE.
10. PPRequiredForTurnOff must be TRUE.
11. PPRequiredForChangeEPS must be TRUE.
12. PPRequiredForChangePCRs must be FALSE.
13. Per Section 8.1.1 of "TCG PC Client Platform Firmware Profile Specification", Family "2.0", Level 00, Revision 00.21 dated March 30, 2016, the TPM ACPI Object must contain:
    a) A _CID matching "MSFT0101"
    b) An _HID which correctly identifies the TPM Vendor and Model number, in such a manner as specified by the TPM manufacturer.
14. If the memory for the TPM is a System rather than TPM component, it must not lose access to NV before ExitBootServices. The System must be delivered to the end user with the TPM un-provisioned, and without ownership taken.
    a. If during manufacturing any actions are taken which may take ownership of the TPM or provision it, the TPM should be cleared during the final steps of manufacturing.
15. **Mandatory:** Platform manufacturers must provide in-field firmware updates for security related TPM firmware updates.
16. **Recommended:** Platform manufacturers should deliver security related TPM firmware updates to devices via Windows Update in a timely fashion.
17. **Mandatory:** Effective October 1, 2019 platform manufacturers must release security related TPM firmware updates, via Windows Update, to certified devices within 90 days of the date that the TPM manufacturer releases a fix.
    a) If the TPM part is Common Criteria or FIPS certified and the firmware update must go through recertification, the update must be made available within either 90 days of TPM manufacturer release or 14 days of recertification, whichever is later.
    b) This requirement does not apply to Server devices
18. The TPM ACPI Object must correctly report if Interrupt based communication is supported.
19. **Recommended**: This bullet item is currently optional and will not be enforced until October 1, 2020, when it becomes **Mandatory**, except when required by other "If Implemented" Requirements.
    a) Confidential & replay-protected storage: If a TPM uses external memory for non-volatile storage of TPM state (including seeds, proof values, & dictionary attack variables), movement of the TPM state to and from the NV memory MUST include protections of that data to insure confidentiality and integrity of the data and to mitigate against rollback attacks. This is generally accomplished by encrypting the data, applying a Message Authentication Code, and storing the resulting record in replay-protected storage such as Replay Protected Memory Block or Replay Protected Monotonic Counter.

System.Fundamentals.USBBoot

The feature and requirements are about being able to boot from a USB device.

System.Fundamentals.USBBoot.BootFromUSB

System firmware supports booting from all exposed USB 1.x, 2.x, and 3.x ports

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64**

	Windows v10.0 Mobile x86 **Windows Server 2019 x64**

Description

System BIOS or UEFI firmware must by default:

- Support booting through USB 1.x on OHCI controllers
- Support booting through USB 2.x on EHCI controllers
- Support booting through USB 1.x, 2.x, and 3.x on XHCI controllers.
- Support these on all exposed USB ports up to a hub depth of 3.

The system must also support booting Windows PE images from a USB 2.0 device by using extended INT 13 or UEFI native interface in less than 90 seconds.

Design Notes:
OEMs are encouraged to test the boot functionality by creating a bootable USB flash drive with WinPE. See the OPK for details. Vendors may license WinPE (at no charge). For information, send an e-mail to licwinpe@microsoft.com.

System.Fundamentals.USBBoot.SupportSecureStartUpInPreOS

Systems support secure startup by providing system firmware support for writing to and reading from USB flash devices in the pre-operating system environment.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

On all UEFI systems and all systems that implement a TPM, the system must support BitLocker recovery and strong authentication scenarios. This is accomplished by enabling enumeration and full-speed reading/ writing of data (such as key backup and recovery information) from and to a USB mass storage class device, and the UEFI firmware will provide an instance of the block I/O protocol for access to these USB devices.

Design Notes:
See the USB Mass Storage Class Bulk-Only Transport and the USB Mass Storage Class UFI Command specifications, downloadable from http://go.microsoft.com/fwlink/?LinkId=58382.

System.Fundamentals.USBDevice

These requirements apply to USB devices that are integrated into a system.

System.Fundamentals.USBDevice.SelectiveSuspend

All internally connected USB devices must support selective suspend by default.

Applies to	Windows 10 Client x64 Windows 10 Client x86 Windows 10 Client ARM64 Windows v10.0 Mobile ARM Windows v10.0 Mobile ARM64 Windows v10.0 Mobile x86 Windows Server 2019 x64

Description

Selective suspend is an important power saving feature of USB devices. Selective suspension of USB devices is especially useful in portable computers, since it helps conserve battery power.

If a USB device is internally connected, the device driver must enable selective suspend by default. Every USB device driver must place the device into selective suspend within 60 seconds of no user activity. This timeout should be as short as possible while maintaining a good user experience. The selective suspend support can be verified by reviewing the report generated by the powercfg -energy command.

Implementation Notes:
When devices enter selective suspend mode, they are limited to drawing a USB specification defined 2.5mA of current from the USB port. It is important to verify that devices can quickly resume from selective suspend when they are required to be active again.

For example, when selectively suspended, a USB touchpad must detect be able to detect a user's touch and signal resume without requiring the user to press a button. Some devices can lose the ability to detect a wake event when limited to the selective suspend current, 500 microamps per unit load, 2.5mA max. These devices, such as a USB Bluetooth enabled module, must be self-powered, not relying solely on the USB bus for power. By drawing power from another source, the device can detect wake events

For more information about enabling selective suspend for HID devices, please refer to this MSDN article http://msdn.microsoft.com/en-us/library/ff538662(VS.85).aspx

For more information about how to implement selective suspend in a driver, please refer to this white paper: http://www.microsoft.com/whdc/driver/wdf/USB_select-susp.mspx

To specify a port that is internal (not user visible) and can be connected to an integrated device, the ACPI properties _UPC.PortIsConnectable byte must be set to 0xFF and the _PLD.UserVisible bit must be set to 0. More details are available on MSDN.

System.Fundamentals.Video

System.Fundamentals.Video.HDRStreamingDisplayCharacteristics

All system with an 8-bit, SDR integrated display that is designed to support HDR video streaming must be provisioned with the display characteristics required by Windows to enable the feature.

Applies to	Windows 10 Client x64

	Windows 10 Client x86 **Windows 10 Client ARM64**

Description

Details of the requirement

Starting with Windows 10, version 1703, Windows support HDR video content playback and streaming on high-end systems with SDR integrated displays with a peak brightness of 300 nits or greater. To enable this feature, OEM must provision the system with the brightness and color characteristics of the integrated SDR panel on the device. The following characteristics must be *accurately* provisioned by the OEM so they are available the OS to enable the feature:

1. Max Luminance // 10% screen area
2. Min Luminance // black level
3. Max Full Frame Luminance // e.g. max 'paper white'
4. Chromaticities of Primaries (i.e., red, green, and blue primaries)
5. Chromaticity of white point // default D65

The colorimetry data reported to the OS deviate from the actual panel color characteristics by no more than 1.0 CIE Delta E 2000 (DE00); this applies for all reported values.

In Windows 10, version 1709, OEM can provision these display colorimetric values by choosing from one of three methods:

1. EDID or DisplayID data blocks [least preferred] - The traditional method for describing a display's color characteristics is in the firmware/ROM. The sink sets the chromaticity and white point values in the EDID color characteristics block (see A.2.7 Color Characteristics in CEA-861-F). In addition, the sink sets the HDR MinCLL, MaxCLL, and MaxFALL luminance parameters (assuming 5-10% screen area) in the CEA 861.3 extension data block.
2. Driver override using the DxgkDdiQueryAdapterInfo DDI - WDDM 2.2 and above provide a mechanism for the display driver to report display colorimetry data to the OS via the DxgkDdiQueryAdapterInfo DDI. OEMs provide the display measurements to the display driver via IHV-specific mechanisms. OEMs should work with their IHV for more information.
3. Advanced color ICC profile [most preferred] - International Color Consortium (ICC) profiles provide a standardized way to store color information about a computer display; the latest version of the spec is ICC.1:2010/ISO 15076-1:2010. ICC profiles are files with the .icm or .icc extension.
   Some of the required color characteristics are defined in existing public ICC tags (data blocks). Windows 10, version 1709 defines a new vendor specific data block – named "MHC2" – to store the remaining characteristics. A properly formatted ICC profile containing an MHC2 tag is referred to as an "advanced color ICC profile" to distinguish it from other types of ICC profile which have been supported by Windows for many years.
   The recommended method for installing an advanced color ICC profile is via a monitor INF which can reference the profile as a resource in the INF package. Monitor INFs can be preinstalled in the OS image (for an integrated display), automatically downloaded via Windows Update, or supplied via another software delivery mechanism.

Please see HDR and WCG Ecosystem Guidance for Windows documents for complete details of these three options.

System.Fundamentals.WatchDogTimer

A watchdog timer is a device that provides basic watchdog support to a hardware timer exposed by the Microsoft hardware watchdog timer resource table.

System.Fundamentals.WatchDogTimer.IfWatchDogTimerImplemented

If a Watch Dog Timer is implemented and exposed through a WDRT (supported for versions prior to Windows 8) or WDAT (required for Windows 8 and later versions), it must meet Windows compatibility and functionality requirements.

Applies to	**Windows 10 Client x64** **Windows 10 Client x86** **Windows v10.0 Mobile ARM** **Windows v10.0 Mobile ARM64** **Windows v10.0 Mobile x86** **Windows Server 2019 x64**

Description

Hardware watchdog timer monitors the OS, and reboots the machine if the OS fails to reset the watchdog. The watchdog must meet the requirements and comply with the specification in http://MSDN.microsoft.com/en-us/windows/hardware/gg463320.aspx.

System.Server.Assurance

This feature shows the requirements that need to be met by a server to get the Hardware Assurance AQ

System.Server.Assurance.EnhancedPlatformIntegrityProtection

Server supports hardware- and firmware-based enhanced platform integrity protection

Applies to	**Windows Server 2019 x64**

Description

This is an "If-Implemented", optional system requirement for a system providing enhanced security for Windows Server. The server platform must support;

UEFI 2.3.1c or later as defined in the following Requirements, and tested by the respective Tests;

System.Fundamentals.Firmware.TPR.UEFIEncryptedHDD

System.Fundamentals.Firmware.UEFIBitLocker

System.Fundamentals.Firmware.UEFIBootEntries

System.Fundamentals.Firmware.UEFICompatibility

System.Fundamentals.Firmware.UEFIDefaultBoot

System.Fundamentals.Firmware.UEFILegacyFallback

System.Fundamentals.Firmware.Update

SecureBoot as defined in the following Requirements, and tested by the respective Tests;

System.Fundamentals.Firmware.UEFILegacyFallback

System.Fundamentals.Firmware.UEFISecureBoot

The processors in the system are capable of IOMMU, as defined in the following Requirements, or tested by the respective Tests;

System.Server.Virtualization.ProcessorVirtualizationAssist

If the processor supports microcode updates then it must require signed microcode updates as defined in the following requirement, validated by the respective tests;

System.Fundamentals.Security.DeviceGuard

The system supports TPM 2.0, as defined in the following Requirements, and tested by the respective Tests;

System.Fundamentals.TPM20.EKCerts

System.Fundamentals.TPM20.TPM20

The platform is required to implement hardware security test interface and share documentation and tools as specified in the 'Hardware Security Test Interface Specification' document, available at this location, https://msdn.microsoft.com/en-us/library/windows/hardware/dn879006.aspx. This requirement is IF IMPLEMENTED for Server, but REQUIRED for the Hardware Assurance Additional Qualification.

All the components in the system, such as storage, network or graphics adapters or circuitry, or other components that are the default configuration of the system, or components which a customer may order from the vendor with the system, must support Secure Boot. For example, all drivers must be signed to comply with Secure Boot and the network card needs to support PXE Boot when the system is configured for Secure Boot.

For systems to be awarded the Assurance AQ, the UEFI flag NoPPIClear must be set to TRUE by default. In addition, the NoPPIProvision flag must be set to TRUE by default. There must be a mechanism in UEFI to confirm the settings of these variables and change them. This requirement is in place to allow for total remote management of TPMs out of the box without additional configuration.

For systems to be awarded the Assurance AQ, the UEFI implementation must be compliant with the needs of code integrity. Specifically;

Data pages must be separate from code pages.

Code and Data pages are at page level granularity for alignment.

The same page will not contain both Data [Read or Write] and executable Code.

The memory mappings for what pages are code and data are correct i.e., it is not the case that the whole image is marked as data or code.

This will be accomplished using the correct build options for creating the UEFI binaries. The system must include the GUID the firmware can set to claim compliance with this requirement.

The platform is required to implement hardware security test interface and share documentation and tools as specified in the Hardware Security Test Interface Specification document, available at http://aka.ms/wmic

This requirement is IF IMPLEMENTED for Server system designs not based on Intel® Xeon® processor Intel64 Family 6 Model 85 Stepping X, or later – where X will vary, nor AMD® Opteron® AMD64 Family 23 Model 1 Stepping 1 or later processor, for Windows Server systems seeking the Hardware Assurance Additional Qualification.

This requirement will be REQUIRED for Server system designs that are based on Intel® Xeon® processor Intel64 Family 6 Model 85 Stepping X, or later – where X will vary, or AMD® Opteron® AMD64 Family 23 Model 1 Stepping 1 or later processor, for Windows Server systems seeking the Hardware Assurance Additional Qualification.

System.Server.AzureStack

System.Server.AzureStack.Base

Basic requirements that must be supported by any server used in a Microsoft Azure Stack solution

Applies to	**Windows Server 2019 x64**

Description
Requirements for a server used in a Microsoft Azure Stack solution are captured in the following table.

Feature	Requirement
System.Fundamentals.Firmware	System.Fundamentals.Firmware.FirmwareSupportsUSBDevices
	System.Fundamentals.Firmware.UEFIBitLocker
	System.Fundamentals.Firmware.UEFIBootEntries
	System.Fundamentals.Firmware.UEFICompatibility
	System.Fundamentals.Firmware.UEFIDefaultBoot
	System.Fundamentals.Firmware.UEFILegacyFallback
	System.Fundamentals.Firmware.UEFISecureBoot
	System.Fundamentals.Firmware.Update
System.Server.Virtualization	System.Server.Virtualization.ProcessorVirtualizationAssist

In addition to the above, the server must have:

- CPU that is a dual socket system with Intel® Xeon® Processor E5 v3 Family or better

- A minimum of 256GB RAM

System.Server.AzureStack.BMC

System.Server.AzureStack.BMC.Base

Baseboard Management Controller requirements for Microsoft Azure Stack

Applies to	**Windows Server 2019 x64**

Description

The BMC feature requirement for a Microsoft Azure Stack solution is captured in the following table.

Feature	Requirement	Azure Stack Certification
System.Server.BMC	System.Server.BMC.OutOfBandRemoteManageability	Required
System.Server.Manageability.Redfish	System.Server.Manageability.Redfish.Basic	If Implemented

In addition to the above, the BMC should implement LDAP-based authentication.

System.Server.AzureStack.BMC.Reliability

Baseboard Management Controller reliability requirements for Microsoft Azure Stack

Applies to	**Windows Server 2019 x64**

Description

The IPMI functionality below will be tested from a reliability perspective since it is critical for a successful deployment and continued access to an Azure Stack solution. The following powershell cmdlets will be used with the '-ManagementProtocol IPMI' parameter to exercise IPMI functionality in a stress environment.

- Get-PcsvDevice
- Get-PcsvDeviecLog
- Restart-PcsvDevice
- Set-PcsvDeviceBootConfiguration
- Set-PcsvDeviceNetworkConfiguration
- Set-PcsvDeviceUserPassword
- Start-PcsvDevice
- Stop-PcsvDevice
- Clear-PcsvDeviceLog

System.Server.AzureStack.Security

Security requirements for servers used in a Azure Stack solution

System.Server.AzureStack.Assurance

Hardware Assurance requirements for Servers used in a Azure Stack solution

Applies to	Windows Server 2019 x64

Description

Servers used in Windows Server Software Defined Solutions must meet the requirements of the Hardware Assurance AQ

Feature	Requirement
System.Server.Assurance	System.Server.Assurance.EnhancedPlatformIntegrityProtection

System.Server.AzureStack.SecureBootUEFIOverPXE

PXE boot requirements for deploying Microsoft Azure Stack

Applies to	Windows Server 2019 x64

Description

Servers used in Microsoft Azure Stack solutions should be able to boot successfully over PXE in UEFI mode with SecureBoot enabled.

System.Server.Base

System.Server.Base.DriverReliability

Drivers in a Windows Server system are fully tested

Applies to	Windows Server 2019 x64

Description:

All drivers in a Windows Server system must meet all Requirements and pass all Tests mandated under Device.DevFund.Server.DriverReliability

The Windows Server operating system will include functionality to block the installation or initialization of drivers that were signed using the Attested Driver Signing process. This functionality could be toggled on for those Windows Server end customers concerned with the risks involved in having untested drivers functioning in their systems and environment.

Business Justification

This requirement ensures that Windows Server end customers do not naively or accidentally install drivers that have had no Certification testing on their Windows Server systems. With this new functionality, Windows Server end customers would have to make a conscious and informed decision to allow Attested Drivers to be installed or initialized in their Windows Server systems and environment.

Mandatory: This Requirement becomes effective for Current Branch for Business (CBB) releases of Windows Server 2016. Enforcement of the Requirement for purposes of Windows Server system Certification testing is already enforced by the "Signed Driver Check (CheckLogo)" Test in test kits from version 1607 and later. The Requirement will be enforced at the end customer level by operating system functionality in stages with succeeding CBB releases of Windows Server.

System.Server.SDDC

System.Server.SDDC.Base

Basic requirements that must be supported by any server granted the Software Defined Data Center (SDDC) Additional Qualification (AQ) that is part of a Windows Server Software Defined (WSSD) offering

Applies to	Windows Server 2019 x64

Description
Requirements for a server used in *a Windows Server Software Defined offering* are captured in the following table.

Feature	Requirement
System.Fundamentals.Firmware	System.Fundamentals.Firmware.FirmwareSupportsUSBDevices
	System.Fundamentals.Firmware.UEFIBitLocker
	System.Fundamentals.Firmware.UEFIBootEntries
	System.Fundamentals.Firmware.UEFICompatibility
	System.Fundamentals.Firmware.UEFIDefaultBoot
	System.Fundamentals.Firmware.UEFILegacyFallback
	System.Fundamentals.Firmware.UEFISecureBoot
	System.Fundamentals.Firmware.Update
System.Server.Virtualization	System.Server.Virtualization.ProcessorVirtualizationAssist

System.Server.SDDC.Security

Security requirements for servers used in a Windows Server Software Defined offering

System.Server.SDDC.Assurance

Hardware Assurance requirements for Servers used in a Windows Server Software Defined offering

Applies to	**Windows Server 2019 x64**

Description

Servers used in *a Windows Server Software Defined offering* must meet the requirements of the Hardware Assurance AQ

Feature	Requirement
System.Server.Assurance	System.Server.Assurance.EnhancedPlatformIntegrityProtection

System.Server.SDDC.BMC

System.Server.SDDC.BMC.Base

Baseboard Management Controller requirements for a Windows Server Software Defined offering

Applies to	**Windows Server 2019 x64**

Description

The BMC feature requirement for *a Windows Server Software Defined offering* is captured in the following table.

Feature	Requirement
System.Server.BMC	System.Server.BMC.OutOfBandRemoteManageability
System.Server.Manageability.Redfish	System.Server.Manageability.Redfish.Basic

In addition to the above, the BMC must implement LDAP-based authentication.

System.Server.SDDC.BMC.Reliability

Baseboard Management Controller reliability requirements for a Windows Server Software Defined offering.

Applies to	**Windows Server 2019 x64**

Description

The IPMI functionality below will be tested from a reliability perspective since it is critical for a successful deployment and continued access to *a Windows Server Software Defined offering*. The following powershell cmdlets will be used with the '-ManagementProtocol IPMI' parameter to exercise IPMI functionality in a stress environment.

- Get-PcsvDevice
- Get-PcsvDeviecLog
- Restart-PcsvDevice
- Set-PcsvDeviceBootConfiguration
- Set-PcsvDeviceNetworkConfiguration
- Set-PcsvDeviceUserPassword
- Start-PcsvDevice
- Stop-PcsvDevice
- Clear-PcsvDeviceLog

System.Server.Base

Basic requirements for server systems

System.Server.Base.64Bit

A server system can natively run a 64-bit version of Windows Server.

Applies to	Windows Server 2019 x64

Description

A server system must be able to natively support and run a 64-bit Windows Server operating system.
Devices in a server system must also have 64-bit drivers available for 64-bit operation.

System.Server.Base.BMC

Baseboard management controller solution must meet requirements.

Applies to	Windows Server 2019 x64

Description

Baseboard management controller (BMC) hardware that uses the Microsoft provided IPMI driver and service provider must comply with the Intelligent Platform Management Interface (IPMI) Specification, Version 1.5 Document (Revision 1.1, February 20, 2002, 6/1/04 MARKUP) or later.

The BMC must be connected to the system through a Keyboard Controller Style (KCS) Interface. The BMC and its KCS interface must be discoverable through ACPI, as prescribed in Appendix C3 of the IPMI V1.5 specification.

Support for interrupt is optional for the BMC. If interrupt is supported, the BMC:

- Must not be shared with other hardware devices.
- Must support the Set Global Flags command.

The BMC driver must support PnP and Power Management according to the minimum device fundamental requirements defined in the Windows Logo Program requirements.

The driver must be compliant to the kernel-mode driver framework (KMDF) component of the Windows Driver Framework (WDF) for the Microsoft Windows family of operating systems. A legacy driver, for backward compatibility reasons, must be Windows Driver Model (WDM) compliant.
The driver must provide a WMI interface, including Timeout Configuration through RequestResponseEx() which is defined in the ipmidrv.mof
file of the WMI interface.

The driver must have support for ACPI Control:

- HARDWARE ID - IPI0001
- COMPATIBLE ID - IPI0001 optional
- _SRV - 1.5 or 2.0 IPMI
- _CRS/_PRS - Format of resources: A single 2-byte or two 1-byte each I/O port or memory mapped I/O

The driver must call the Windows ACPI driver to get the above listed ACPI data.

Support for interrupt is optional in the driver, if supported the IPMI driver must:

- Assign only one interrupt
- Not share interrupts
- Handle disabling of non-communication interrupts that the driver does not fully support through the Set Global Flags command.
- Be capable of handling both communication and non-communication interrupts.

Design Notes:
To prevent interrupt storm, the driver enables BMC interrupt when it starts and disables BMC interrupt supports when stops by using the "Set BMC Global Enables" IPMI command. The field needs to set is the bit [0] - Receive Message Queue interrupt. However, this bit is shared for KCS communication interrupt and KCS non-communication, so the driver needs to be able to properly handle both interrupts.
A KCS communication interrupt is defined as an OBF-generated interrupt that occurs during the process of sending a request message to the BMC and receiving the corresponding response. It's also encountered during the course of processing a GET_STATUS/ABORT control code.
A KCS non-communication interrupt is defined as an OBF-generated interrupt that occurs when the BMC is not in the process of transferring message data or getting error status. This will typically be an interrupt that occurs while the interface is in the IDLE_STATE].

System.Server.Base.BMCDiscovery

Baseboard Management Controller is discoverable and enumerable.

Applies to	Windows Server 2019 x64

Description

A system that has a baseboard management controller (BMC) present must expose it for discovery and enumeration by Windows through Plug-and-Play (PnP) methods appropriate for its device interface. If the BMC is connected to the system through a non-PnP legacy link such as the keyboard controller style (KCS) interface, its resources must be exposed through SMBIOS or ACPI for discovery and enumeration by Windows.

System.Server.Base.Compliance

Server system includes components and drivers that comply with Windows Hardware Certification Program.

Applies to	Windows Server 2019 x64

Description

All buses, devices, and other components in a system must meet their respective Windows Hardware Certification Program requirements and use drivers that are either included with the Windows operating system installation media or that Microsoft has digitally signed.

System.Server.Base.DevicePCIExpress

Server system includes storage and network solutions that use PCI Express architecture

Applies to	Windows Server 2019 x64

Description

A server system must use PCI Express connectivity for all the storage and network devices installed in the system. The devices may either be adapters installed in PCI Express slots or chip down directly connected to the system board. This requirement does not apply to integrated devices that are part of the chipset.

System.Server.Base.ECC

System memory uses ECC or other technology to prevent single-bit errors from causing system failure.

Applies to	Windows Server 2019 x64

Description

Server systems must support error correction code, memory mirroring, or another technology that can detect and correct at least a single-bit memory error. The system memory and cache must be protected with ECC) or other memory protection. All ECC or otherwise protected RAM, visible to the operating system must be cacheable. The solution must be able to detect at least a double-bit error in one word and to correct a single-bit error in one word, where "word" indicates the width in bits of the memory subsystem. A detected error that cannot be corrected must result in a system fault.

System.Server.Base.HotPlugECN

Server system that supports native Hot Plug functionality meets requirements defined in Hot-Plug ECN No. 31.

Applies to	Windows Server 2019 x64

Description

A server system must meet requirements defined in the PCI Hot-Plug ECN No. 31 if it supports hot-plug of PCI Express devices or adapters; for example as an inherent behavior of a dynamically hardware partitionable design, or in the form of either Express Module or a comparable hot-plug PCI Express I/O option design.

System.Server.Base.NoPATA

Persistent storage devices on servers classified as Hard Disk Drives must not be PATA.

Applies to	Windows Server 2019 x64

Description

Persistent storage devices classified as Hard Disk Drives, either fixed or removable, must not be controlled by any of the following: Parallel Advanced Technology Attachment (also known as Parallel ATA, PATA, IDE, EIDE, or ATAPI) controllers, to include RAID versions of these devices. PATA controllers of any kind may only be connected to CD, DVD or other storage devices not classified as hard disk drives.

Parallel Advanced Technology Attachment (also known as Parallel ATA, PATA, IDE, EIDE, or ATAPI) controllers, to include RAID versions of these devices, do not support the ability to hot remove a hard disk drive from the system should a hard disk drive fail and need to be replaced. This forces the system to be unavailable for long periods.

Parallel Advanced Technology Attachment (also known as Parallel ATA, PATA, IDE, EIDE, or ATAPI) controllers, to include RAID versions of these devices, do not support the ability to hot remove a hard disk drive from the system should a hard disk drive fail and need to be replaced. This forces the system to be unavailable for long periods.

System.Server.Base.OSInstall

Server system includes a method for installing the operating system for emergency recovery or repair.

Applies to	Windows Server 2019 x64

Description

The server system must provide a method for installing the operating system for emergency repair support. The following are examples of possible solutions:

- PXE support
- Internal or externally attached, bootable, rewriteable DVD.

System.Server.Base.PCIAER

Windows Server systems may implement AER (Advanced Error Reporting) as provided by the platform and specified in PCI Express Base Specification version 2.1 and ACPI Specification 3.0b

Applies to	Windows Server 2019 x64

Description

Server System vendors which elect to set the Advanced Error Reporting (AER) bit (0x3) in the PCI _OSC table in the system BIOS must implement the following:
· The _HID value on the root bus of the system must be PNP0A08, so that the operating system can discover the devices are PCI Express and support AER.
· To use PCI AER with Windows the system must report _OSC control in the device and the _SB/PC10 objects in ACPI. The following bits must be enabled:
· 0x0 - PCI Express Native Hot Plug
· 0x1 - Hot Plug Control
· 0x3 - Advanced Error Reporting (AER)
· 0x4 - PCI Express reliability structure control
· The MCFG ACPI table in PCI Firmware Specification, Revision 3.0b, so that the operating system can access the AER Capability registers in the PCIe extended configuration space.

Design Notes:
This is an If Implemented requirement for Server system vendors. There is no Windows Server 8 requirement to provide AER_OSC to give control to the operating system, and systems may implement a "firmware first" error policy.

System.Server.Base.RemoteManagement

Server system supports remote, headless, out of band management capabilities.

Applies to	Windows Server 2019 x64

Description

Server systems must provide the capability of being managed without the operating system being present, or when the operating system is not fully functional.
The system must provide the following remote, headless, out of band management capabilities:

- Power up the server
- Power off the server
- Reset the server
- Provide access to Windows Server Emergency Management Services on the server
- View system Stop errors on the server

The following are not required if the system is a pedestal/standalone system with 8GB or less max RAM that was logo'd for Windows Server 2003 prior to December 31, 2007:

- Change BIOS settings of the server
- Select which operating system to start on the server

The above capabilities can be provided using any combination of the following methods:

- Serial port console redirection
- Service processor

- BIOS redirection
- Baseboard Management Controller
- Other management device

This requirement addresses the minimum capabilities required for headless server support.
Design Notes:

Console redirection can be forced with a setup command-line switch,

[/emsport:{com1|com2|usebiossettings|off}

/emsbaudrate:*baudrate*]

EMS Setup, SPCR and EFI or BIOS redirection settings can be configured per the information at http://msdn2.microsoft.com/en-us/library/ms791506.aspx.

See the Microsoft Headless Server and Emergency Services Design specifications and the IPMI specification at http://go.microsoft.com/fwlink/?linkid=36699.

See service processor console redirection details at http://go.microsoft.com/fwlink/?LinkId=58372.

System.Server.Base.ResourceRebalance

Server device drivers must support Resource Rebalance requests

Applies to	Windows Server 2019 x64

Description

A system wide resource rebalance can be executed on Windows Server. One case where this occurs is when a device is dynamically added to a server. Device drivers must honor the resource rebalance flow and the plug and play requests that are dispatched as part of the flow. Device Drivers must queue all IO requests during the resource rebalance operation.

System.Server.Base.ServerRequiredComponents

Server system must include necessary devices and functionality.

Applies to	Windows Server 2019 x64

Description

Server systems must include the following devices or functionality.

Device or Functionality	Requirement	Comments
IO Bus and Devices		
	System.Fundamentals.SystemPCIController.PCIRequirements	Various PCI Specification reqts

	System.Server.Base.HotPlugECN	Hot Plug ECN #31
Memory	2008 – 1 TB, 2008 R2- 2TB, 2012 - 4 TB, 2016 - 24TB	Maximum supported memory
	512 MB	Minimum supported memory
	System.Server.Base.ECC	ECC
Processor	System.Server.Virtualization.ProcessorVirtualizationAssist	Hyper-V support
	1.4 GHz 64-bit	Minimum supported processor speed
	2008 – 64, 2008 R2- 256, 2012 - 640, Server Next - 640 Logical Processors (this is subject to revision at RTM)	Maximum supported processor count
Storage		
	System.Server.Base.NoPATA	IDE, EIDE, ATAPI, Parallel ATA not allowed
	System.Fundamentals.Firmware.Boot.SystemWithBootDeviceGreaterThan	No 2.2 TB Boot HD support for BIOS-based systems
Network	Device.Network.LAN.Base	1GigE and minimum off-load requirement

Recovery	System.Server.Base.OSInstall	For example: DVD, PXE
Debug	System.Fundamentals.DebugPort.SystemExposesDebugInterface	For example: COM, USB, 1394
Remote & OOB Mngmt	System.Server.Base.RemoteManagement	For example: BMC, Service Processor adapter
High Precision Timer	System.Fundamentals.HAL.HPETRequired	
SMBIOS	System.Fundamentals.SMBIOS.SMBIOSSpecification	
	System.Server.SMBIOS.SMBIOS	
Video	System.Server.Graphics.WDDM	Use MS-provided driver, or provide either Display only or full WDDM driver
	System.Fundamentals.Graphics.MicrosoftBasicDisplayDriver	Video minimums, 1024 x 768 x 32 bits per pixel, VESA timing and compliance
RemoteFX	System.Fundamentals.Firmware.SystemCanBootWithEitherGraphicsAdapter	BIOS support for multiple adapters
	System.Fundamentals.Graphics.MultipleOperatingMode	Functionality of multiple GPUs requirement
Marker file	System.Fundamentals.MarkerFile.SystemIncludesMarkerFile	Marker file for OCA
Single container	System.Client.PCContainer.PCAppearsAsSingleObject	Computer appears as single object

	in Devices and Printers folder

The following devices or functionality are not required for Server Systems:

- Bus Controllers & Ports:
    - HD Audio
    - Cardbus & PCMCIA
    - IEEE 1394
    - Secure Digital
- Connectivity:
    - Bluetooth
    - Cardbus & PCMCIA
    - ExpressCard
    - IEEE 1394
    - Infrared
    - Parallel [sysfund-0221] & Serial
    - Wireless USB
- Network:
    - ISDN
    - TCP Chimney NIC
- Display:
    - Auxiliary Displays
- Input:
    - Smart Card Reader
- Streaming Media & Broadcast:
    - Broadcast Receiver
    - Decoder

    - Encoder
    - Video Capture
- TPM:
    - TPM. If implemented, must meet requirements.
    - USB write for BitLocker Recovery
- Watchdog Timer (WDT)
- Baseboard Management Controller (BMC)
- Enhanced Power Management Additional Qualification
- Dynamic Partitioning Additional Qualification,
- Fault Tolerance Additional Qualification
- High Availability Additional Qualification
- Power Management concerning S3, S4 and S5 system states support

System.Server.Base.SystemPCIExpress

Server system supports PCI Express natively

Applies to	**Windows Server 2019 x64**

Description

Server systems are required to support a PCI Express root complex as a connection of the I/O system to the CPU and memory must comply with the requirements defined in the PCI Express 1.0a (or 1.1) Base Specification and PCI Local Bus Specification, Revision 2.3, or later. If discrepancies exist, the PCI Express Base Specification takes precedence.

System.Server.DriveIdentification

Platforms must provide identification and location information for all field-replaceable storage devices.

Terms: If-Implemented

Enforcement Date: October 1, 2017

Description

Platforms must provide identification and location information for all field-replaceable storage devices, whereby the administrator can accurately and confidently locate and identify the storage devices.

The following definitions will be used in describing storage device identification requirements:

- Device Location – where the drive is physically located within a system. "Bay 3, Slot 2", "Tray 1, Slot A", or "Motherboard Slot 4" are good examples.
- Device Identification – the physical-location-independent identity of a storage device. A unique serial number is a good example.

System.Server.DriveIdentification.NVMe

Platform requirements

Applies to	Windows Server 2019 x64

Terms: If-Implemented

Enforcement Date: October 1, 2017

Platforms must meet the following requirements:

- The device location must be described as a string, which is provided by _DSM function 7, as described in the PCI Firmware Specification Revision 3.1.
- The device location string must match the text physically printed on the system (e.g. a motherboard silkscreen, an etched drive bay number, or a legend printed on a tray).

System.Server.DynamicPartitioning

This feature defines dynamic partitioning requirements of server systems. This feature is not required of all server systems.

System.Server.DynamicPartitioning.Application

Servers that support hardware partitioning must supply partition management software as a Windows application running on a Windows operating system.

Applies to	Windows Server 2019 x64

Description

Servers that support hardware partitioning must provide partition manager software, which provides the user interface administrators will use to configure hardware partitions. This software must be offered as a Windows application running on a Windows operating system.

System.Server.DynamicPartitioning.ApplicationInterface

Servers that support hardware partitioning must supply partition management software that provides a GUI and a scripting capability for partition management.

Applies to	Windows Server 2019 x64

Description

Servers that support hardware partitioning must supply partition management software that includes support for a graphical user interface for manual partition management and a scripting capability for remote or automated partition management.

System.Server.DynamicPartitioning.ConfigurationPersist

Servers that support hardware partitioning must support persistence of hardware partition configuration information across a reboot and power cycle.

Applies to	Windows Server 2019 x64

Description

The hardware partition configuration on a server that supports hardware partitioning must persist across a reboot, hibernate, resume, and power cycle of the partition or the server. This requirement assumes that no partition change was initiated while the partition was down.

System.Server.DynamicPartitioning.Core

Systems that support Dynamic Hardware Partitioning must meet requirements.

Applies to	Windows Server 2019 x64

Description

Systems must meet the requirements listed below and pass the Dynamic Hardware Partitioning test in the Windows Hardware Lab Kit in order to be listed in the Windows Server Catalog as supporting Dynamic Partitioning:

- System.Server.DynamicPartitioning.Application
- System.Server.DynamicPartitioning.ApplicationInterface
- System.Server.DynamicPartitioning.ConfigurationPersist
- System.Server.DynamicPartitioning.ErrorEffect
- System.Server.DynamicPartitioning.Firmware
- System.Server.DynamicPartitioning.HotAddLocal
- System.Server.DynamicPartitioning.HotAddReplace
- System.Server.DynamicPartitioning.HotAddVisual
- System.Server.DynamicPartitioning.HotReplacePU
- System.Server.DynamicPartitioning.PartialHotAdd
- System.Server.DynamicPartitioning.SoftwareStatus
- System.Server.DynamicPartitioning.Subsystem

System.Server.DynamicPartitioning.ErrorEffect

Errors detected in a hardware partition on servers that support hardware partitioning cause no operating system-detectable effects on other partitions.

Applies to	Windows Server 2019 x64

Description

Hardware (which includes firmware) or software errors that occur within the boundary of a hardware partition on a server that supports hardware partitioning must not affect the operating system environment within other hardware partitions.

System.Server.DynamicPartitioning.Firmware

Servers that support hardware partitioning must provide server description and partitioning flows in firmware that comply with the Dynamic Hardware Partitioning Requirements Specification.

Applies to	Windows Server 2019 x64

Description

System firmware on a server that supports hardware partitioning provides the ACPI server description, handshaking during partitioning events, and initialization of hardware that is to be added to a partition and must be provided in compliance with the Hot Replace Flow and Requirements and the Hot Add Flow and Requirements specifications.

For access to these specifications, send e-mail to DPFB@Microsoft.com.

System.Server.DynamicPartitioning.HotAddLocal

Hardware components on a server that supports hardware partitioning that are within a unit that is hot added to a partition cannot be accessible from other hardware partitions.

Applies to	Windows Server 2019 x64

Description

Processors, memory, and I/O components within any unit that is hot added to an existing hardware partition on a server that supports hardware partitioning must not be directly accessible by software running in any other hardware partition.

System.Server.DynamicPartitioning.HotAddReplace

Servers that support hardware partitioning must support hot addition of processors, memory, and I/O and hot replace of processor and memory subsystems.

Applies to	Windows Server 2019 x64

Description

Servers that support hardware partitioning must support hot addition and hot replacement of all operating system-supported component types. Hot-add PU-supported component types are processors, memory, and I/O. Hot replace-supported component types are processors and memory subsystems.

System.Server.DynamicPartitioning.HotAddVisual

Servers that support hardware partitioning must provide visual user indication of the status of hot-add events if no software-based notification is provided.

Applies to	Windows Server 2019 x64

Description

Servers that support one or more hot-add component features must provide a visual indication of the status of each hot-add event if no partition management software is provided.

System.Server.DynamicPartitioning.HotReplacePU

In servers that support dynamic partitioning, hot replacement PUs must have equal and compatible hardware resources to the PU being replaced.

Applies to	Windows Server 2019 x64

Description

A processor or memory PU used as a replacement on a server that supports dynamic partitioning must have equal and compatible hardware resources to the PU being replaced; that is, the same processor type and stepping and the same memory configuration.

System.Server.DynamicPartitioning.PartialHotAdd

Partial success of a hot-add action on a server that supports dynamic partitioning does not affect the stability of the partition or server.

Applies to	Windows Server 2019 x64

Description

Components associated with a hot-add action on a server that supports dynamic partitioning that fails to start (a parked component) must not have a detrimental effect on other components in the PU, partition, or server.

System.Server.DynamicPartitioning.SoftwareStatus

Servers that support hardware partitioning must supply partition management software that provides the user with status for each hot-add or hot-replace event.

Applies to	Windows Server 2019 x64

Description

Servers that support hardware partitioning must supply partition management software. Status of a hot-add or hot-replace event is made available by the Windows operating system in the affected partition. The PM software must provide visual indication of this status to the PM administrator.

System.Server.DynamicPartitioning.Subsystem

On servers that support dynamic partitioning, I/O subsystems are provided in a different partition unit to processors and memory subsystems.

Applies to	Windows Server 2019 x64

Description

To enable success of the hot replace feature, I/O subsystems must be implemented in a different PU to processors and memory subsystems on servers that support dynamic partitioning.

System.Server.FaultTolerant

This feature defines fault tolerant requirements of server systems.

System.Server.FaultTolerant.Core

Systems supporting Fault Tolerant operations must meet requirements.

Applies to	Windows Server 2019 x64

Description

Systems must meet the requirements listed below and pass the Fault Tolerance test in the Windows Hardware Certification Kit in order to be listed in the Windows Server Catalog as having Fault Tolerance.

A Fault Tolerant set [FT set] of systems is a grouping of systems that provide redundancy for every hardware component in a single system of the FT set and can mask any hardware failure such that network-connected clients are not impacted by the hardware failure, such as by loss of connectivity due to network timeout to the FT set due to the host name, domain name, MAC address or IP address, and the services or applications hosted on the FT set, becoming unavailable to those network connected clients. Additionally, an FT set appears to network-connected clients as one system with a single host name, domain name, MAC address or IP address, and unique instances of services or applications.

An FT set must include system clocks that operate in actual lockstep, i.e., there is only one clock domain for the FT set, or virtual lockstep, i.e., the clocks in the systems that comprise the FT set are synchronized at regular intervals of much less than one second. This allows the FT set to always respond to exactly the same interrupts at exactly the same time, and thus be executing exactly the same instructions and have exactly the same state at all times, thus providing the required redundancy.

An FT set is able to resynchronize, i.e., make identical, operating system images after a hardware failure in one system of the FT set is corrected, such that network-connected clients are not impacted by the resynchronization, such as by loss of connectivity due to network timeout to the FT set due to the host name, domain name, MAC address or IP address, and the services or applications hosted on the FT set, becoming unavailable to those network connected clients. The correction of the problem may be by replacement or repair of the failed hardware component, or if the hardware failure is transient, may be cleared by a system reset that forces the re-initialization of all the devices in the system that is part of the FT set.

FT systems may disable or not include devices which could cause asynchronous interrupts to occur such that one system in the FT redundant set had to respond to an interrupt to which the other system(s) of the FT set did not experience. Examples of such devices would be monitoring devices [thermal, voltage, etc.], or external devices that would allow a user to inadvertently interrupt or access only one system in an FT set, such as a CD/DVD device, keyboard, mouse, etc.

System.Server.Firmware.UEFI.GOP

This section describes requirements for systems implementing UEFI firmware.

System.Server.Firmware.UEFI.GOP.Display

System firmware must support GOP and Windows display requirements.

Applies to	**Windows Server 2019 x64**

Description

If the system firmware supports UEFI, it may choose to additionally support the Graphics Output Protocol (GOP). If the Graphics Output Protocol (GOP) is supported is must be as defined in UEFI 2.3.1.

During this time when the firmware is in control, the following are the requirements:

Topology Selection

- UEFI must reliably detect all the displays that are connected to the POST adapter. The Pre-OS screen can only be displayed on a display connected to the POST adapter.
- In case multiple displays are detected, UEFI must display the Pre-OS screen based on the following logic:
  - System with an Integrated display(Laptop, All In One, Tablet): UEFI must display the Pre-OS screen only on the integrated display
  - System **without** an Integrated display (integrated display is shut or desktop system): UEFI must display the Pre-OS screen on one display. UEFI must select the display by prioritizing the displays based on connector type. The prioritization is as follows: DisplayPort, HDMI, DVI, HD15, Component, S-Video. If there are multiple monitors connected using the same connector type, the firmware can select which one to use.

Mode Selection

- Once UEFI has determined which display to enabled to display the Pre-OS screen, it must select the mode to apply based on the following logic:
  - System with an Integrated display(Laptop, All In One, Tablet): The display must always be set to its native resolution and native timing
  - System **without** an Integrated display (desktop):
    - UEFI must attempt to set the native resolution and timing of the display by obtaining it from the EDID.

        - If that is not supported, UEFI must select an alternate mode that matches the same aspect ratio as the native resolution of the display.
        - At the minimum, UEFI must set a mode of 1024 x 768
        - If the display device does not provide an EDID, UEDI must set a mode of 1024 x 768
    - The firmware must always use a 32 bit linear frame buffer to display the Pre-OS screen
    - PixelsPerScanLine must be equal to the HorizontalResolution.
    - PixelFormat must be PixelBlueGreenRedReserved8BitPerColor. Note that a physical frame buffer is required; PixelBltOnly is not supported.

Mode Pruning

- UEFI must prune the list of available modes in accordance with the requirements called out in EFI_GRAPHICS_OUTPUT_PROTOCOL.QueryMode() (as specified in the UEFI specification version 2.1).

Providing the EDID

- Once the UEFI has set a mode on the appropriate display (based on Topology Selection), UEFI must obtain the EDID of the display and pass it to Windows when Windows uses the EFI_EDID_DISCOVERED_PROTOCOL (as specified in the UEFI specification version 2.1)to query for the EDID.
- It is possible that some integrated panels might not have an EDID in the display panel itself. In this case, UEFI must manufacture the EDID. The EDID must accurately specify the native timing and the physical dimensions of the integrated panel.
- If the display is not integrated and does not have an EDID, then the UEFI does not need to manufacture an EDID.

System.Server.Firmware.VBE

The requirements in this section are enforced on any graphics device with firmware supporting VBE and driver is implementing display portion of the WDDM.

System.Server.Firmware.VBE.Display

System firmware that supports VBE must comply with the Windows Display requirements.

Applies to	Windows Server 2019 x64

Description

If a system firmware supports VBE for display control then it must meet the following requirements:
The display is controlled by the video device firmware before the WDDM graphics driver takes over. During this time when the firmware is in control, the following are the requirements:

Topology Selection

- Video device firmware must reliably detect all the displays that are connected to the POST adapter. The Pre-OS screen can only be displayed on a display connected to the POST adapter.
- In case multiple displays are detected, video device firmware must display the Pre-OS screen based on the following logic:

- System with an integrated display(Laptop, All In One, Tablet/Convertible): Video device firmware must display the Pre-OS screen only on the integrated display
- System **without** an integrated display (integrated display is shut or desktop system): Video device firmware must display the Pre-OS screen on one display. The video device firmware must select the display by prioritizing the displays based on connector type. The prioritization is as follows: DisplayPort, HDMI, DVI, HD15, Component, S-Video. If there are multiple monitors connected using the same connector type, the firmware can select which one to use.

Mode Selection

- Once video device firmware has determined which display to enabled to display the Pre-OS screen, it must select the mode to apply based on the following logic:
  - System with an Integrated display(Laptop, All In One, Tablet/Convertible): The display must always be set to its native resolution and native timing
  - System **without** an Integrated display (desktop):
    - The video device firmware must attempt to set the native resolution and timing of the display by obtaining it from the EDID
    - If that is not supported, the video device firmware must select an alternate mode that matches the same aspect ratio as the native resolution of the display.
    - At the minimum, the video device firmware must set a mode of 1024 x 768
    - If the display device does not provide an EDID, UEDI must set a mode of 1024 x 768
  - The video device firmware must always use a 32 bit linear frame buffer to display the Pre-OS screen
  - PixelsPerScanLine must be equal to the HorizontalResolution.
  - PixelFormat must be PixelBlueGreenRedReserved8BitPerColor. Note that a physical frame buffer is required; PixelBltOnly is not supported.

Mode Pruning

- The video device firmware must provide a list of modes to Windows when Windows uses the Function 01h (Return VBE Mode Information) as specified in the VESA BIOS Extension Core Functions Standard Version 3.0.
- The video device firmware must prune the modes as appropriate. It should only enumerate the modes that are supported in the EDID of the display that is currently active. It is not required to support all the resolutions supported in the EDID.
- The video device firmware must support 800 x 600 and 1024 x 768
- All modes must be progress at 60 Hz.

Providing the EDID

- Once the video device firmware has set a mode on the appropriate display (based on Topology Selection), video device firmware must obtain the EDID of the display and pass it to Windows when Windows uses command 15h (Display Data Channel) as specified in the VESA BIOS Extension Core Functions Standard Version 3.0:
    - It is possible that some integrated panels might not have an EDID in the display panel itself. In this case, video device firmware must manufacture the EDID. The EDID must accurately specify the native timing and the physical dimensions of the integrated panel
    - If the display is not integrated and does not have an EDID, then the video device firmware does not need to manufacture an EDID

System.Server.Graphics

Base for Graphics on Server Systems

System.Server.Graphics.WDDM

All Windows graphics drivers must be WDDM.

Applies to	Windows Server 2019 x64

Description

The WDDM architecture offers functionality to enable features such as desktop composition, enhanced fault Tolerance, video memory manager, scheduler, cross process sharing of D3D surfaces and so on. WDDM was specifically designed for modern graphics devices that are a minimum of Direct3D 10 Feature Level 9_3 with pixel shader 2.0 or better and have all the necessary hardware features to support the WDDM functionality of memory management, scheduling, and fault tolerance.

WDDMv1.3 is required by all systems shipped with Windows 10.

Table below explains the scenario usage for the Graphic driver types.

	Client	Server	Client running in a Virtual Environment	Server Virtual
Full Graphics	Required as post device	Optional	Optional	Optional
Display Only	Not allowed	Optional	Optional	Optional
Render Only	Optional as non primary adapter	Optional	Optional	Optional
Headless	Not allowed	Optional	N/A	N/A

System.Server.Manageability.Redfish

System.Server.Manageability.Redfish.Basic

Server Baseboard Management Controller (BMC) devices can support out-of-band management capabilities based on the DMTF Redfish standard.

Applies to	Windows Server 2019 x64

Description

BMC devices may support server hardware out-of-band management capability using the DMTF Redfish DSP0266 v1.0.1 specification and associated Redfish Schema definitions (DSP8010). If Redfish is implemented, all of the following requirements are mandatory.

It is not necessary that the BMC implements the full Redfish specification, as only a subset of functionality is required for out-of-band management. The BMC must support the following capabilities and Redfish defined schema:

- Security
    - Support session connections using HTTPS (TLS).
    - Support for both LDAP or Radius based authentication.
    - BMC must not have an anonymous user account configured by default. If this account exists, it must be disabled.
    - The BMC allows remote credential management. The BMC must support its Administrator password being changed through the AccountService schema.
- The hardware event logs can be managed through the BMC using the LogService schema.
    - The hardware event log entries can be read.
    - The hardware event log entries can be cleared.
    - The hardware event log time of the server.
    - The hardware event log capacity information.
- The system's power state can be managed through the BMC using the ComputerSystem schema.
    - The BMC must expose the following server system information:
        - Current power state of the server.
    - The BMC must support the following operations being performed on the server system.
        - Power off of the physical server via the BMC,
        - Power on of the physical server via the BMC.
        - Power cycle a physical server via the BMC
- The system's boot source is configurable through the BMC. This functionality is implemented using the ComputerSystem schema.
    - The server can be configured to boot from the PXE server the next time it is reset
    - The server can be configured to boot from the hard-disk the next time it is reset
    - The server can be configured to always boot from the PXE server
    - The server can be configured to always boot from the hard-disk
- The system's BMC firmware and BIOS version information is exposed through Redfish.
    - The BMC must expose the version information for the following components:
        - BIOS/UEFI (ComputerSystem schema).
        - BMC management firmware (Manager schema).
- The OOB management LAN configuration can be updated through the BMC. This requirement is only applicable for systems that expose OOB management LAN configuration through the Redfish interface.
    - The BMC must expose the following information about its BMC LAN configuration: IP Address, subnet mask, default gateway, and an indicator of whether the BMC is configured with a static IP address or if one is assigned by DHCP (BMC's EthernetInterface schema).

- The system’s basic inventory is exposed through the BMC. The BMC must expose the following server system information through the ComputerSystem schema:
    - Manufacturer of the server hardware
    - Model of the server hardware
    - Server SMBIOS GUID
    - Asset Tag of the server
    - Serial Number of the server
- Hardware monitoring of the system must be supported through the Chassis, Thermal, and Power schemas:
    - Retrieval of physical fan health
    - Retrieval of power supply health
    - Retrievel of sensor alerts for the CPU
    - Retrieval of on-board network adapter health alerts, if supported
    - Retrieval of HBA/Controller health alerts, if supported
    - Retrieval of memory health alerts, if supported

Enforcement

This is an “If-Implemented” optional device requirement. This is a prerequisite device requirement for servers claiming to be out-of-band manageable using the DMTF Redfish standard. This requirement becomes in effect at the release of Windows Server vNext.

Business Justification

Server deployments are moving to RESTful management infrastructures that have shown that they are highly scalable. As scalable deployments become more common, moving from an IPMI based out-of-band management interface to a Redfish interface to provide RESTful methods with common OData conventions is critical to support modern data center security and scale requirements.

System.Server.PowerManageable

This feature defines power manageable requirements of server systems.

System.Server.PowerManageable.ACPIPowerInterface

Power manageable servers support the power metering and budgeting ACPI interface.

Applies to	**Windows Server 2019 x64**

Description

Server provides support for reading system level power consumption and reading and writing the system power budget for the server using the 'Power Supply, Metering, and Budgeting Interface' in the ACPI 4.0 specification. The system power budget provides a supported range that the budget can be set to where the minimum budget value is lower than the maximum budget value. The power meter supports a range of averaging intervals such that the minimum averaging interval is one second or lower and the maximum averaging interval is five minutes or higher. To align with the specification, the sampling interval for the power meter must be equal to or less than the minimum averaging interval.

System.Server.PowerManageable.PerformanceStates

If processor(s) in a server system support performance states, the server provides mechanisms to makes these states available to Windows.

Applies to	Windows Server 2019 x64

Description

If the processors on the server support performance states, the server provides firmware mechanisms to pass control of processor performance states to Windows. This mechanism must be enabled by default on the server.

System.Server.PowerManageable.RemotePowerControl

Power manageable server provides a standards based remote out-of-band interface to query and control the power of the system.

Applies to	Windows Server 2019 x64

Description

Power manageable server provides an out of band remote management interface from the server's Baseboard Management Controller (BMC) that is complaint with the IPMI, DCMI, or SMASH (via WS-MAN) 'Power State Management Profile' to query the power state, power on or off (soft off) the server remotely.
This is a requirement for the Power Manageable Additional Qualification for Windows Server.

More detail on the SMASH profile can be found on the Distributed Management task Force web site at - http://www.dmtf.org/standards/published_documents/DSP1027.pdf.

System.Server.RemoteFX

This feature defines RemoteFX requirements of server systems.

System.Server.RemoteFX.RemoteFX

Server systems supporting RemoteFX must meet requirements.

Applies to	Windows Server 2019 x64

Description

Servers must meet the following requirements:

- CPU SLAT- the CPU must support SLAT. This requirement will assist in the performance in the RemoteFX virtualization scenarios.
- GPU requirements - must be WDDM GPUs that support Direct3D11. These requirements apply to only the GPUs intended to support RemoteFX workloads.
- Homogenous GPUs for RemoteFX- workloads - the GPUs that are intended to run RemoteFX workloads must be the same GPU running the same hardware driver.

System.Server.SMBIOS

This feature defines SMBIOS requirements of server systems

System.Server.SMBIOS.SMBIOS

System firmware must fully and accurately implement SMBIOS structures of type 16 and of type 17

Applies to	Windows Server 2019 x64

Description

System firmware must fully and accurately implement SMBIOS structures of type 16 (description of physical memory arrays) and of type 17 (description of memory devices), as permitted by the SMBIOS specification. Implementation of other SMBIOS memory description structures - Types 19, 20 and 37 - are optional.
A JEDEC compliant DRAM DIMM supports Serial Presence Detect (SPD). Through this mechanism and defined standards, the module can be identified in terms of its manufacturer, serial number and other useful information. The JEDEC standards require specific data to reside in the lower 128 bytes of an EEPROM located on the memory module. Programming of this EEPROM is normally done by vendors of DRAM DIMMs at their origin of manufacture, and can optionally be redone afterward to meet their OEMs' specifications or retailers' requirements for branding purposes while going through distribution channels.
The system firmware (BIOS or UEFI) probes and extracts this information from the DIMM via its SMBus interface. The system firmware uses this information to configure the memory controller. System firmware that supports SMBIOS V2.4 or later, conveys the above DIMM specific information to the operating systems and running applications via a series of SMBIOS structures ("tables") for memory descriptions. These SMBIOS structures also describe the system memory topology, geometry and characteristics. Those are briefly described here for reference purposes and can be found in the current SMBIOS V2.5 Specification (September 5, 2006):

- Physical Memory Array (Type 16) containing information on Location, Use and Error Correction Types; pages 51-52.
- Memory Array Mapped Address (Type 19) containing address mapping for a Physical Memory Array (one structure is present for each contiguous address range described); page 56.
- Memory Device (Type 17) containing information on Form Factor, Type and Type Detail; pages 52-54
- Memory Device Mapped Address (Type 20) containing address mapping to a device-level granularity (one structure is present for each contiguous address range described); page 56.
- Memory Channel (Type 37) containing correlation between a Memory Channel and its associated Memory Devices (each device presents one or more loads to the channel); page 68. This support in the system firmware will:
    - Allow the customers to manage their server memory components as deployed IT assets, and to maintain a comprehensive understanding of their investment of these assets in terms of RAS abilities and cost of ownership.
    - Allow server and data center management solutions to exploit this information in their diagnostic tools and methods for better RAS abilities.

- Enable certain classes of ISV products (RAM disk, etc.) to exploit this information for better performance and functionalities on Windows platforms.

System.Server.StorageManageability.Smapi

This feature defines requirements for manageability of server connected storage device. A storage device is considered connected when it operates with a Windows Server system through a fabric interface. This type of storage interface includes FibreChannel, FibreChannel over Ethernet (FCoE), iSCSI, and SMB3.

This manageability of a connected storage device means the user can perform an end-to-end storage workflow using a common user interface such as WMI, PowerShell, or the File and Storage Services in a Server Management tool. This workflow must be achievable even before the operational target Windows Server OS is deployed in the environment. The connected storage device must be manageable from Windows Server, through its Storage Management API (SMAPI). The integration with SMAPI using SNIA Storage Management Interface Specification (SMI-S) or a Storage Management Provider (SMP). Implementing both SMI-S and SMP is not required.

Business Justification

Manageable connected storage devices allow efficient deployment and operation of server systems running Windows Server in a software-defined datacenter and therefore lowering operational costs for the customers where heterogeneous hardware platforms are deployed.

System.Server.StorageManageability.Smapi.BlockStorage

System.Server.StorageManageability.Smapi.BlockStorage.BasicFunction

A connected block storage device must be manageable by Windows through its Storage Management API (SMAPI).

Applies to	Windows Server 2019 x64

Description:

SMAPI supports FC, FcoE, iSCSI, and SAS block storage devices. Connected block storage devices through SMAPI must support the following management operations:

- Discovery of storage pool, storage volumes (aka LUN), storage media, initiator ports, target ports, masking views, consistency, replication groups
- Provisioning of new storage volumes, storage volume deletion, mask/unmask storage volumes,
- Creation and deletion of local storage volume snapshots, clones, or mirrors
- Creation, modification, deletion of consistency groups (aka replication groups)
- Planned/unplanned failover and reverse replication of consistency groups
- Snapshot and clone of consistency groups
- Life cycle indications and alter indications

Enforcement

This is a mandatory device requirement.

System.Server.StorageManageability.Smapi.BlockStorage.RemoteReplication

System.Server.StorageManageability.Smapi.BlockStorage.RemoteReplication.BasicFunction

A connected block storage device remote replication must be manageable by Windows through its Storage Management API (SMAPI).

Applies to	Windows Server 2019 x64

Description:
SMAPI supports FC, FcoE, iSCSI, and SAS block storage devices. Connected block storage devices through SMAPI must support the following management operations:

- Discovery of consistency, replication groups
- Creation and deletion of local or remote storage volume snapshots, clones, or mirrors
- Creation, modification, deletion of consistency groups (aka replication groups)
- Planned/unplanned failover and reverse replication of consistency groups
- Snapshot and clone of consistency groups
- Life cycle indications and alter indications

Enforcement

This is a mandatory device requirement.

System.Server.StorageManageability.Smapi.FileStorage

System.Server.StorageManageability.Smapi.FileStorage.BasicFunction

A connected file storage device must be manageable by Windows through its Storage Management API (SMAPI).

Applies to	Windows Server 2019 x64

Description:
SMAPI supports SMB3 file storage devices. Connected file storage devices through SMAPI must support the following management operations:

- Discovery of filesystem
- Create/delete file system volumes
- Create /delete file share
- Modify permissions of fileshares
- Life cycle indications and alter indications

Enforcement

This is a mandatory device requirement.

System.Server.StorageManageability.Smapi.Smi

System.Server.StorageManageability.Smapi.Smi.Ctp

An industry-standard connected storage device that is manageable through its native SMI-S v1.6.1 Provider interface demonstrates such conformance through a successful CTP test pass..

Applies to	Windows Server 2019 x64

Description:
A connected storage device is considered industry-standard when it supports the Storage Networking Industry Association (SNIA) Storage Management Initiative specification (SMI-S) v1.6.1 for manageability purposes. This SMI-S v1.6.1 Provider interface must be implemented in the connected storage device without the aid of an external companion provider operating in a separate device enclosure. This should demonstrate such conformance through a successful test pass of the SNIA SMI-S Conformance Testing Program (CTP), and the test result must be endorsed by the SNIA SMI Lab Conformance Committee.

Enforcement

This is a mandatory device requirement for a connected storage device claiming to be industry-standard and manageable from a Windows Server system using Smapi via Smi.

However, this and all related sub-requirements are mandatory for a connected storage device claiming to be industry-standard and manageable from a Windows Server system. Connected storage devices that support SMI-S must support the requirements detailed here: https://msdn.microsoft.com/en-us/library/windows/hardware/dn265461(v=vs.85).aspx

System.Server.SVVP

This feature defines requirements for the SVVP program.

System.Server.SVVP.SVVP

Products participating in the Server Virtualization Validation Program must meet requirements.

Applies to	Windows Server 2019 x64

Description

Server platforms participating in the Server Virtualization Validation Program must meet the requirements called out here: http://www.windowsservercatalog.com/svvp.aspx.

System.Server.SystemStress

This feature defines system stress requirements of server systems.

System.Server.SystemStress.ServerStress

Server system must function correctly under stress.

Applies to	Windows Server 2019 x64

Description

Server system must operate correctly under long-haul, non-deterministic, high stress conditions. The hardware and software components of the Server system must not cause data corruption, hangs, leaks, memory resource fragmentation, crashes, or have impacts on other components of the system. Server systems must be able to reliably shutdown and restart while under stress to prevent unnecessary and unplanned downtime.
This will be tested using stress tools that emulate loads which may be placed upon a Windows Server system.

System.Server.Virtualization

This feature defines virtualization requirements of server systems.

System.Server.Virtualization.ProcessorVirtualizationAssist

Processors in the server support virtualization hardware assists.

Applies to	Windows Server 2019 x64

Description

All processors in the server must support one of the following processor virtualization hardware assist technologies:

- Intel VT technology
- AMD-V technology

Details on specific requirements for each of these technologies are available in the Windows Server 2008 Virtualization Requirements document.

For access to the Windows Server 2008 Virtualization Requirements document, send e-mail to lhvrtreq@microsoft.com.

System.Server.WHEA

System.Server.WHEA.Core

Server enables reporting of system hardware errors to the operating system

Applies to	Windows Server 2019 x64

Description
Servers are required to provide mechanisms to enable reporting or communication of corrected and uncorrected system hardware errors that are available on the server to the operating system. The platform may perform thresholding of corrected errors.

The minimal set of error sources are:
* IA64 - Machine Check Exception, Corrected Machine Check, Corrected Platform Error, INIT, PCI Express AER
* X86-64 - Machine Check Exception, Corrected Machine Check, Non Maskable Interrupt, PCI Express AER, BOOT errors.

An interface must be provided on the server to facilitate persistence of error records. The interface must preserve the error records across a server reboot and power cycle. At a minimum, the platform must provide enough storage space for one uncorrectable error record. Options to implement this interface are described in the WHEA Platform Design Guide.

Windows Server provides an OSC mechanism to indicate the presence of WHEA in the OS. The server must honor these mechanisms and enable WHEA flows when the OSC is detected. Optional mechanisms are provided to enable the firmware to process error events from specified error sources before handing control off to WHEA and to communicate this behavior to the OS. This helps avoid conflicts on software handling of hardware error events. These mechanisms are described in the WHEA Platform Design Guide.

Servers must support WHEA-defined interfaces for software insertion of a subset of hardware error conditions into the platform to enable WHEA validation. The injection mechanism must support the injection of one fatal uncorrected and one corrected error; each injectable error is injected using one of the error sources on the platform, and using the signaling mechanism specified for that error source. Options to provide this interface are described in the WHEA Platform Design Guide.

For access to the WHEA Platform Design Guide, send e-mail to WHEAFB@Microsoft.com.

System.Solutions.AzureStack

Microsoft Azure Stack (MAS) is a Microsoft offering that delivers a consistent set of Azure Cloud services on premise. While the exact composition of Microsoft Azure Stack will evolve through its product life cycle, the components that will be required to build a "cloud-inspired infrastructure" solution can be broadly split into the categories below.

Compute	Components in the compute cluster of the Microsoft Azure Stack solution—typically, all parts that go into making an individual server (CPU, memory, a motherboard, a boot disk, a graphics card, a BIOS, and so forth).
Network	Components that provide the networking fabric for the Microsoft Azure Stack solution—NICs (with a varying number of ports and functional levels), switches, hardware- and software-based load balancers, and so forth.
Storage	Components that provide permanent storage media for the Microsoft Azure Stack solution—physical disks (HDDs and SSDs), HBAs and storage enclosures.
Security	TPM-based components needed to guarantee platform security and integrity—typically used by components such as BitLocker, Microsoft Assurance, and shielded VMs.

The goal of this feature is to define product requirements for partners who build private cloud solutions based on the Microsoft Azure Stack reference architecture.

OEMs and Solution Integrators that build Microsoft Azure Stack solutions must incorporate components that have passed the associated Microsoft Azure Stack requirements tests, including the Private Cloud Simulation (PCS) test. The fully assembled solutions must pass the PCS tests in their minimum and maximum scale supported configurations.

System.Solutions.AzureStack.CloudStress

Windows Azure Stack solutions must comply with this specification in their minimum and maximum configurations

Applies to	Windows Server 2019 x64

Description

Private cloud solutions comprise of tightly integrated software and hardware components to deliver resiliency with high performance. Issues in any of the components (software, hardware, drivers, firmware, and so forth) can compromise the solution and undermine any promises made regarding the Service Level Agreement (SLA) for the private cloud.

Many of these issues are surfaced only under a high-stress, private cloud simulation. The Private Cloud Simulator (PCS) enables you to validate your component in a cloud scenario and identify such issues. It simulates a live datacenter/private cloud by creating VM workloads, scheduling administrative operations (load balancing, software/hardware maintenance), and injecting faults (unplanned hardware/software failures) on the private cloud.

To comply with this specification, the solution must pass the PCS test run with the 'Azure Stack - Solutions' profile in its **minimum** and **maximum** configuration. For instance, if a Azure Stack solution ships with a 4-node minimum scale configuration and a 16-node maximum scale configuration, PCS is required on both 4-node and 16-node configurations, but not on any intermediate (aka 8-node or 12-node) configuration.

NOTE: All HLK tests required for Azure Stack that the must be run on Space Direct instance must have ReFS as the filesystem or the results are invalid.

System.Solutions.AzureStack.Network

Core network requirements for Windows Azure Stack

Applies to	Windows Server 2019 x64

Description

Windows Server Software-Defined solutions must use network components that support the following features:

Component	SDDC Feature Support
LAN Card (NIC)	Device.Network.LAN.SDDC
Switch	Device.Network.Switch.SDDC

Third party Hyper-V Switch Extensions

Third party extensible switches for Hyper-V that support capturing, filtering, or forwarding of network traffic are not supported in Microsoft Azure Stack solutions.

System.Solutions.AzureStack.Server

Server system requirements for Windows Azure Stack

Applies to	Windows Server 2019 x64

Description

Azure Stack solutions must use server systems that:

- Are certified for Windows Server 2016
- Support Azure Stack features and thereby meet all the corresponding device requirements for that feature

The feature support table is as below:

Component	SDDC Feature Support
Server	System.Server.AzureStack

System.Solutions.AzureStack.Storage

Core storage requirements for Windows Azure Stack

Applies to	Windows Server 2019 x64

Description

Azure Stack solutions must use storage components that:

- Are certified for Windows Server 2016
- Support Azure Stack features and thereby meet all the corresponding device requirements for that feature

The feature support table is as below:

Component	Azure Stack Feature Support
Controller (HBA)	Device.Storage.Controller.AzureStack
Enclosure	Device.Storage.Enclosure.AzureStack
Drive	Device.Storage.Hd.AzureStack

System.Solutions.SDDC

System.Solutions.SDDC

Microsoft Windows Server Software Defined solutions must comply with this specification

Applies to	Windows Server 2019 x64

Description

Windows Server 2016 introduced 'Storage Spaces Direct', which enables building highly available (HA) storage systems with local storage. This is a significant step forward in Microsoft Windows Server Software-Defined storage (SDS) as it simplifies the deployment and management of SDS systems and also unlocks use of new classes of disk devices, such as SATA and NVMe disk devices, that were previously not possible with clustered Storage Spaces with shared disks.

OEMs and Solution Integrators that build Windows Server Software-Defined solutions must incorporate components that have passed the associated Software-Defined Data Center logo requirement tests, including the Private Cloud Simulation (PCS) test.

The following capabilities are not supported by Windows Server Software-Defined solutions:

1. RAID controllers (RAID or JBOD mode) are not supported
2. FC/iSCSI connected devices are not supported
3. MPIO or physically connecting disk via multiple paths is not supported

System.Solutions.SDDC.BVTandStress

Windows Server Software-Defined solutions must comply with this specification in their minimum and maximum configurations

Applies to	Windows Server 2019 x64

Description

This requirement describes the BVT and stress scenarios that Windows Server Software-Defined solutions have to support in a non-virtualized scenario.

The BVT performs two types of tests: - Moving the Cluster Shared Volume (CSV) on top of Storage Spaces Direct between nodes while performing random write IO, and verifying that IO is uninterrupted and CSV does not fail. - Bringing down a node by stopping cluster service, killing cluster service, evict node, graceful machine restart, and non-graceful machine restart (with each action targeting a random node). Test also performs random write IO targeting the appropriate CSV during node failures and verifies that IO does not fail.

The stress tests cause repeated and random node failures (by stopping or killing cluster service), potentially causing multiple nodes to fail if tolerated by the given configuration. During node failures, the test performs multiple IO streams from multiple nodes targeting the appropriate Cluster Shared Volume (with each stream performing sequential/random read/write with read data verification). The test can run for a user-specified amount of time, up to 24 hours.

To comply with this specification, the solution must pass these tests in its **minimum** configuration, in either a 2-node or 4-node test, depending on the maximum scale being offered. For instance, if a Storage Spaces Direct solution ships with a 2-node minimum scale configuration and a 4-node maximum scale configuration, these tests are required on the 2-node configuration. If, on the other hand, a solution ships with a 2-node minimum scale configuration and a 16-node maximum scale configuration, it must be tested in a 4-node configuration.

System.Solutions.SDDC.CloudStress

Windows Server Software-Defined solutions must comply with this specification in their minimum and maximum configurations

Applies to	**Windows Server 2019 x64**

Description

Private cloud solutions comprise of tightly integrated software and hardware components to deliver resiliency with high performance. Issues in any of the components (software, hardware, drivers, firmware, and so forth) can compromise the solution and undermine any promises made regarding the Service Level Agreement (SLA) for the private cloud.

Many of these issues are surfaced only under a high-stress, private cloud simulation. The Private Cloud Simulator (PCS) enables you to validate your component in a cloud scenario and identify such issues. It simulates a live datacenter/private cloud by creating VM workloads, scheduling administrative operations (load balancing, software/hardware maintenance), and injecting faults (unplanned hardware/software failures) on the private cloud.

To comply with this specification, the solution must pass the PCS test run with the 'Storage Spaces Direct - Solutions' profile in its **minimum** configuration. For instance, if a Storage Spaces Direct solution ships with a 2-node minimum scale configuration and a 4-node maximum scale configuration, these tests are required on the 2-node configuration. If, on the other hand, a solution ships with a 2-node minimum scale configuration and a 16-node maximum scale configuration, it must be tested in a 4-node configuration.

System.Solutions.SDDC.Network

Core network requirements for Windows Server Software-Defined solutions built on 'Storage Spaces Direct'

Applies to	**Windows Server 2019 x64**

Description

Windows Server Software-Defined solutions must use network components that support the following features:

Component	SDDC Feature Support
LAN Card (NIC)	Device.Network.LAN.SDDC
Switch	Device.Network.Switch.SDDC

RDMA capable NICs are recommended for best performance and density. The RDMA protocol used must be one of the following: iWARP or RoCE (either RoCE version 1 or RoCE version 2). When available, routable RDMA protocols are preferred (e.g. iWARP or RoCEv2) for greatest flexibility in support of scalable solutions. If RDMA capable NICs are used, the network switches connected to those NICS must provide the relevant capabilities in support of the RDMA protocol (for example but not limited to switch support of Data Center Bridging protocols in support of RoCE).

System.Solutions.SDDC.Server

Server system requirements for Windows Server Software-Defined solutions

Applies to	**Windows Server 2019 x64**

Description

Windows Server Software-Defined solutions must use server systems that support the following features:

Component	SDDC Feature Support
Server	System.Server.SDDC

Server configuration should be homogenous.

System.Solutions.SDDC.Storage

Core storage requirements for Windows Server Software-Defined solutions built on 'Storage Spaces Direct'

Applies to	**Windows Server 2019 x64**

Description

Windows Server Software-Defined solutions must use storage components that support the following features:

Component	SDDC Feature Support
Controller (HBA)	Device.Storage.Controller.SDDC
Enclosure	Device.Storage.Enclosure.SDDC
Drive	Device.Storage.Hd.SDDC

System.Solutions.WSSD

Windows Server offers a range of competitive and differentiated capabilities to enable lower cost, cloud scale Software-Defined Datacenter (SDDC) scenarios. One key learning in the early days of SDDC, across the broader industry, is the need for prescriptive guidance including certified hardware components and configuration. The goal with Windows Server Software-Defined (**WSSD**) program is to ensure that end customers have a seamless deployment and steady state operational experience on validated hardware.

WSSD provides three offerings:

1. **Hyper-converged Infrastructure (HCI) Standard** - Combines compute and storage in the same cluster of server nodes to provide a highly virtualized solution that's easy to deploy, manage, and scale. This deployment option simplifies IT infrastructure since customers no longer need traditional IT silos of compute, shared storage (SAN/NAS), and networking. It's best suited for small to mid-sized IT environment running virtualized (Hyper-V) workloads.
2. **Converged Software-Defined Storage (SDS)** –Provides a lower cost, enterprise-grade, shared storage alternative to traditional SAN/NAS. Built using a cluster of server nodes, it's easy to deploy, manage, and scale out to build storage capacity as customer's needs grow over time. On one hand, it's simplicity and low cost would appeal to small/mid-sized IT environments, it's scale, flexibility, and cloud-scale traits would

benefit large service providers and enterprise IT. Any workloads that are compatible with SMB storage are a good fit for this offer.

3. **Hyper-converged Infrastructure (HCI) Premium** Provides a comprehensive software-defined "datacenter in a box". Building on the same foundation as HCI-Standard, these offers add Software-Defined Networking (SDN) and Assurance to the stack. These offerings provide the perfect building blocks for customers – typically a large enterprise, service provider or hoster – that want to build on premise SDDC that emulates large public clouds like Azure. While SDN provides the benefit to deploy, provision and manage networking services at scale, Assurance provides essential tenant isolation and services for running a secure on-premises multi-tenant cloud.

		HCI Standard	Converged SDS	HCI Premium
Positioning		Hyper-converged compute and storage for Hyper-V Targeted at Windows Server 2008 or later Hyper-V customers	Scale Out File Server storage for Hyper-V Seamless SAN/NAS replacement with no compute cluster changes Targeted at Windows Server 2012 or later Hyper-V customers	SDDC for new WSSD customers Targeted at new Windows Server 2019 deployments
Compute	Software Defined Compute – Hyper-V	✓		✓
Storage	Software Defined Storage – Storage Spaces Direct	✓	✓	✓
Networking	V-Switch, Switch-Embedded Teaming (SET), and SMB Direct	✓	✓	✓
	Software-Defined Networking (Network Controller, Software Load Balancer, Gateway)			✓
Security	Platform security (UEFI secure boot)	✓	✓	✓
	Assurance (TPM 2.0, Shielded VM's)			✓

Software Defined Data Center (SDDC) Additional Qualifications (AQ's)

Component		Required Features	Software-Defined Data Center (SDDC) Standard AQ	Software-Defined Data Center (SDDC) Premium AQ
NIC	Device.Network.LAN.10GbOrGreater		✓	✓
		Device.Network.LAN.VMQ	✓	✓
		Device.Network.LAN. RSS	✓	✓
		Device.Network.LAN.LargeSendOffload	✓	✓
		Device.Network.LAN.ChecksumOffload	✓	✓
		Device.Network.LAN.Base	✓	✓
		Device.Network.LAN.VXLAN		✓
		Device.Network.LAN.VMMQ		✓
		Device.Network.LAN.MTUSize	Required if using Encap offloads	✓
		Device.Network.LAN.KRDMA		✓
		Device.Network.LAN.GRE		✓
		Device.Network.LAN.DCB	Required if using	✓

			RoCE RDMA	
		Device.Network.LAN.SDDC		✓
SAS HBA		Device.Storage.Controller	✓	✓
		Device.Storage.Controller.Flush	✓	✓
		Device.Storage.Controller.PassThroughSupport	✓	✓
		Device.Storage.Controller.Sas	✓	✓
		Device.Storage.Controller.SDDC	✓	✓
NVMe Storage Devices	Device.Storage.ControllerDrive.NVMe		✓	✓
		Device.Storage.Hd.SDDC	✓	✓
HDD (SAS)	Device.Storage.Hd		✓	✓
		Device.Storage.Hd.DataVerification	✓	✓
		Device.Storage.Hd.Flush	✓	✓
		Device.Storage.Hd.PortAssociation	✓	✓
		Device.Storage.Hd.Sas	✓	✓

		Device.Storage.Hd.Scsi.ReliabilityCounters	✓	✓
		Device.Storage.Hd.SDDC	✓	✓
		Device.Storage.Hd.FirmwareUpgrade		✓
HDD (SATA)	Device.Storage.Hd.Sata		✓	✓
		Device.Storage.Hd	✓	✓
		Device.Storage.Hd.DataVerification	✓	✓
		Device.Storage.Hd.Flush	✓	✓
		Device.Storage.Hd.PortAssociation	✓	✓
		Device.Storage.Hd.SDDC	✓	✓
		Device.Storage.Hd.FirmwareUpgrade		✓
SSD (SAS)		Device.Storage.Hd	✓	✓
		Device.Storage.Hd.DataVerification	✓	✓
		Device.Storage.Hd.PortAssociation	✓	✓
		Device.Storage.Hd.Sas	✓	✓
		Device.Storage.Hd.SDDC	✓	✓

	Device.Storage.Hd.FirmwareUpgrade		✓
Server	System.Fundamentals.Firmware	✓	✓
	System.Server.Virtualization	✓	✓
	System.Server.SDDC.Security	✓	✓
	System.Server.Assurance		✓
	System.Server.SDDC.BMC		✓