



Release 390 Quadro, NVS, Tesla, & Notebook Drivers - Version 392.65

Windows 10

Release Notes

TABLE OF CONTENTS

1	Introduction to Release Notes	1
	Structure of the Document	1
	Changes in this Edition	1
2	Release 390 Driver Changes	2
	Version 392.65 Highlights	3
	Existing Support	3
	What's New in Version 392.65	3
	What's New in Release 390	3
	Limitations Under Windows 10	5
	Discontinued and Unsupported Features	5
	Advanced Instructions for this Release	8
	Turning Off V-Sync to Boost Performance	8
	NVIDIA Application Configuration Engine (ACE)	8
	Using the WDDM Driver Model with Tesla GPU GOMs	9
	SLI Multi-OS - GPU Assignment in System Virtualization	11
	Driver Security	13
	Restricting Access to GPU Performance Counters	13
	Changes in Version 392.00	15
	Fixed Issues in this Release	15
	Changes in Version 391.74	16
	Hardening of Software Security Updates	16
	Changes in Version 391.33	17
	Security Updates in this Release	17
	Changes in Version 391.03	18
	Fixed Issues in this Release	18
	Changes in Version 390.77	19
	Fixed Issues in this Release	19
	Changes in Version 390.65	20
	NVIDIA Software Security Updates	20
	Fixed Issues in this Release	20
	Open Issues in Version 392.65	21
	Windows 10 Issues	21

TABLE OF CONTENTS

Issues Not Caused by NVIDIA Drivers	22
Application Issues	22
Known Product Limitations	23
System Should not Enter Sleep/Hibernate Mode With SDI Capture in Progress	23
Once Installed, the SDI Capture Driver Release Must Always Match the Graphics Driver	24
Some APIs do not Report Total Available Graphics Memory Correctly ..	24
Using HDMI/DisplayPort Audio with Displays that have a High Native Resolution	25
Using HDMI/DisplayPort Audio in Dualview or Clone Mode Configurations	26
GPU Runs at a High Performance Level (full clock speeds) in Multi-display Modes	26
SLI Connector Requirement on NVIDIA Quadro SLI Cards	26
Applying Workstation Application Profiles	27
3 The Release 390 Driver	28
Supported Operating Systems	28
Supported NVIDIA Workstation GPUs	28
NVIDIA Quadro & NVS Product	29
NVIDIA Quadro Sync Products	31
NVIDIA Quadro SDI Products	31
NVIDIA Quadro Blade/Embedded Graphics Board	31
NVIDIA Tesla Products	32
Supported NVIDIA Notebook GPUs	33
Supported Languages	34
Driver Installation	35
Minimum Hard Disk Space	35
Before You Begin	35
Installation Instructions	35
Appendix A: NVIDIA Tesla Compute Cluster Mode	37
About Tesla Compute Cluster Mode	37
TCC Overview	37
Running CUDA Applications	38

Operating on Systems with non-TCC NVIDIA GPUs	39
Setting TCC Mode	39

LIST OF TABLES

Table 1	GOM and Driver Model Compatibility	10
Table 2.1	NVIDIA Software Security Updates	17
Table 3.1	Supported NVIDIA Quadro & NVS Products.....	29
Table 3.2	Supported NVIDIA Quadro Sync II Products	30
Table 3.3	Supported NVIDIA Quadro Sync Products	31
Table 3.4	Supported NVIDIA Quadro SDI Products	31
Table 3.5	Supported NVIDIA Quadro Blade/Embedded Graphics Board Series	31
Table 3.6	Supported NVIDIA Tesla Products.....	32
Table 3.7	NVIDIA NVS Notebook GPU Support	33
Table 3.8	NVIDIA Quadro Notebook GPU Support	33
Table A.1	Default TCC Mode	39

01 INTRODUCTION TO RELEASE NOTES

This edition of *Release Notes* describes the Release 390 family of NVIDIA[®] Quadro[®], NVS[™], Tesla[®], and Quadro Notebook Drivers for Microsoft[®] Windows[®] 10. NVIDIA provides these notes to describe performance improvements and bug fixes in each documented version of the driver.

Structure of the Document

This document is organized in the following sections:

- ▶ [“Release 390 Driver Changes” on page 2](#) gives a summary of changes, and fixed and open issues in this version.
- ▶ [“The Release 390 Driver” on page 28](#) describes the NVIDIA products and languages supported by this driver, the system requirements, and how to install the driver.
- ▶ [“NVIDIA Tesla Compute Cluster Mode” on page 37](#) describes the Tesla Compute Cluster mode.

Changes in this Edition

This edition of the *Release Notes* for Windows 10 includes information about NVIDIA graphics driver version 392.65, and lists changes made to the driver since version 388.16. These changes are discussed beginning with the chapter [“Release 390 Driver Changes” on page 2](#).

02 RELEASE 390 DRIVER CHANGES

This chapter describes open issues for version 392.65, and resolved issues and driver enhancements for versions of the Release 390 driver up to version 392.65. The chapter contains these sections:

- ▶ “Version 392.65 Highlights” on page 3
- ▶ “Advanced Instructions for this Release” on page 8
- ▶ “Driver Security” on page 13
- ▶ “Changes in Version 392.00” on page 15
- ▶ “Changes in Version 391.74” on page 16
- ▶ “Changes in Version 391.33” on page 17
- ▶ “Changes in Version 391.03” on page 18
- ▶ “Changes in Version 390.77” on page 19
- ▶ “Changes in Version 390.65” on page 20
- ▶ “Open Issues in Version 392.65” on page 21
- ▶ “Issues Not Caused by NVIDIA Drivers” on page 22
- ▶ “Known Product Limitations” on page 23

Version 392.65 Highlights

This section provides highlights of version 392.65 of the NVIDIA Release 390 Driver for Windows 10.

- ▶ Existing Support
- ▶ What's New in Version 392.65
- ▶ What's New in Release 390
- ▶ Discontinued and Unsupported Features
- ▶ Limitations in This Release

Existing Support

- ▶ This release supports the following APIs:
 - Open Computing Language (OpenCL™ software) 1.2 for NVIDIA® Kepler™ and later GPUs
 - OpenGL® 4.6
 - Vulkan® 1.0
 - DirectX 11
 - DirectX 12 (Windows 10)
 - NVIDIA® CUDA® 9.1
- ▶ This driver installs **nView Desktop Manager** version 149.34.

What's New in Version 392.65

- ▶ Added security updates for driver components.
See the [NVIDIA Security Bulletin 5172](#) for details.
See also the section “Driver Security” on page 13 for actions to take to mitigate vulnerabilities.
- ▶ See also [What's New in Release 390](#).

What's New in Release 390

Quadro ODE Driver

Release 390 is an 'Optimal Drivers for Enterprise'(ODE) branch release. ODE drivers are designed and tested to provide long-term stability and availability, making these drivers

ideal for enterprise customers and other users who require application and hardware certification from ISVs and OEMs respectively.

New Features

- ▶ Added support for the NVIDIA Quadro GV100 (64-bit Windows OS only).
- ▶ Added support for CUDA 9.1
- ▶ nView desktop management software updated to 149.34.
- ▶ Added support for Windows 10 Fall Creators Update
- ▶ Added security updates.

See also the section “[Driver Security](#)” on [page 13](#) for actions to take to mitigate vulnerabilities.

- ▶ Added security updates for driver components.
 - Version 392.63 added security updates for driver components.
See [NVIDIA Security Bulletin 5142](#) for details.
 - Version 392.62 added security updates for driver components.
See [NVIDIA Security Bulletin 5075](#) for details.
 - Version 392.61 added security updates for driver components.
See [NVIDIA Security Bulletin 5031](#) for details.
 - Version 392.59 added security updates for driver components.
See [NVIDIA Security Bulletin 4996](#) for details.
 - Version 392.58 added security updates for driver components.
See [NVIDIA Security Bulletin 4907](#) for details.
 - Version 392.56 added security updates for driver components.
See [NVIDIA Security Bulletin 4841](#) for details.
 - Version 392.53 added security updates for driver components.
See [NVIDIA Security Bulletin 4797](#) for details.
 - Version 392.37 added security updates for driver components.
See [NVIDIA Security Bulletin 4772](#) for details.
- ▶ NVIDIA Control Panel

Updated to version 8.1.950. Added new *Developer->Manage GPU Performance Counters* controls.
- ▶ Added DP Inband Stereo option to the *NVIDIA Control Panel ->Manage 3D Settings->Stereo-Display Mode* setting.

Limitations Under Windows 10

Cross-adapter Clone Mode

Under Windows 10, clone mode across graphics processors is handled by the Windows OS, and not by the NVIDIA driver. Consequently, there are no controls for cross-adapter clone mode in the NVIDIA Control Panel under Windows 10.

Functionality of some display controls in the NVIDIA Control Panel may be affected if cross-adapter clone mode is enabled through the Windows Control Panel. In this case, use the Windows Control Panel to adjust display settings.

Optimus Systems

Because cross-adapter clone mode is handled by the Windows 10 OS, there are no display controls in the NVIDIA Control Panel if no display is connected to the NVIDIA GPU.

Discontinued and Unsupported Features

Advance Notification of Future Discontinued Support

► 32-bit Operating Systems

After Release 390, NVIDIA will no longer release drivers for 32-bit operating systems for any GPU architecture.

► NVS 310/315

After Release 390, NVIDIA will no longer support the following NVS products:

- NVS 315
- NVS 310

► Quad-Buffered Stereo

After Release 390, the NVIDIA Professional Drivers for Windows will no longer support select quad-buffered stereo features. See the [NVIDIA Knowledge Base Article](#) for details.

Discontinued Support in this Release

► Discontinued Support for Select Quadro Products

Beginning with the Release 378, the NVIDIA professional drivers no longer support the following NVIDIA Quadro products:

Quadro	Quadro Blade/Embedded	Quadro Notebook
Quadro Plex 7000	Quadro 4000M	Quadro 5010M

Quadro	Quadro Blade/Embedded	Quadro Notebook
Quadro 6000	Quadro 3000M	Quadro 5000M
Quadro 5000	Quadro 100M	Quadro 4000M
Quadro 4000	Quadro 500M	Quadro 3000M
Quadro 2000		Quadro 2000M
Quadro 2000 D		Quadro 1000M
Quadro 600		

The NVIDIA support team will continue to address critical driver issues for these products in Release 375 through March 1, 2018. However, future driver enhancements and optimizations in driver releases after Release 375 will not support these products.

Limitations in This Release

The following features are not currently supported or have limited support in this driver release:

External Graphics

► External GPU Surprise Removal

Not all applications have been designed to address surprise removal of the external GPU; disconnection of the external GPU while applications are running is not advised.

► Mixed GeForce/Quadro Products

Mixed GeForce/Quadro products are supported (Geforce GPU + Quadro eGPU, or Quadro GPU + Geforce eGPU), but requires installation of the GeForce driver package. The Quadro package does not install GeForce drivers.

Deep Color (10 bpc) on HDR-Capable Monitors Under Windows 10 RS2 and RS3

Depending on the monitors you have connected, Windows may initially set the color depth to 8-bpc (bits per channel). You can then enable deep color (10bpc) through the NVIDIA Control Panel. If you enable deep color on HDR-capable monitors, the screen may become blank due to the current SDR/HDR (standard dynamic range/high dynamic range) management policies in Windows 10 RS2 and RS3. In this event, the driver will revert back to the 8-bpc color space.

Experimental OpenCL 2.0 Features

Select features in OpenCL 2.0 are available in the driver for evaluation purposes only. The following are the features as well as a description of known issues with these features in the driver:

► Device side enqueue

- The current implementation is limited to 64-bit platforms only.

- OpenCL 2.0 allows kernels to be enqueued with `global_work_size` larger than the compute capability of the NVIDIA GPU. The current implementation supports only combinations of `global_work_size` and `local_work_size` that are within the compute capability of the NVIDIA GPU.

The maximum supported CUDA grid and block size of NVIDIA GPUs is available at <http://docs.nvidia.com/cuda/cuda-c-programming-guide/index.html#compute-capabilities>. For a given grid dimension, the `global_work_size` can be determined by CUDA grid size x CUDA block size.

- For executing kernels (whether from the host or the device), OpenCL 2.0 supports non-uniform ND-ranges where `global_work_size` does not need to be divisible by the `local_work_size`. This capability is not yet supported in the NVIDIA driver, and therefore not supported for device side kernel enqueues.

► **Shared virtual memory**

- The current implementation of shared virtual memory is limited to 64-bit platforms only.

Advanced Instructions for this Release

This section clarifies instructions for successfully accomplishing the following tasks:

- ▶ Turning Off V-Sync to Boost Performance
- ▶ NVIDIA Application Configuration Engine (ACE)
- ▶ Using the WDDM Driver Model with Tesla GPU GOMs
- ▶ SLI Multi-OS – GPU Assignment in System Virtualization

Turning Off V-Sync to Boost Performance

To get the best benchmark and application performance measurements, turn V-Sync off as follows:

- 1 Open the NVIDIA Control Panel and make sure that *Advanced Settings* is selected from the control panel tool bar.
- 2 From the *Select a Task* pane, under 3D Settings, click **Manage 3D Settings**, then click the Global Settings tab.
- 3 From the Global presets pull-down menu, select **Base profile**.
- 4 From the Settings list box, select **Vertical sync** and change its value to **Force off**, then click **Apply**.
- 5 From the Global presets pull-down menu, select **3D App - Default Global Settings** (the driver's default profile) or use the application profile that matches the application you are testing, then click **Apply**.

Be sure to close the NVIDIA Control Panel completely —leaving it open will affect benchmark and application performance.

NVIDIA Application Configuration Engine (ACE)

This driver includes the NVIDIA Application Configuration Engine (ACE), which automatically detects the workstation application and configures the appropriate profile settings in the NVIDIA Control Panel.

See the *NVIDIA Quadro Professional Drivers: NVIDIA Control Panel Quick Start Guide* for more information about this feature.

Using the WDDM Driver Model with Tesla GPU GOMs

Tesla GPU Operation Modes

Tesla K20X and K20 GPU Accelerators offer the ability to specify the GPU operation mode using NV-SMI/NVML. (refer to: <https://developer.nvidia.com/nvidia-management-library-nvml>).

By setting the GPU operation mode, developers can selectively turn off certain features in the GPU to get the best performance per watt for certain workloads.

The following are the supported GOMs:

- ▶ **Compute-Only:** For running compute tasks only.
By default the Tesla K20X and K20 accelerator boards ship in this mode.
- ▶ **Low-Double Precision:** For graphics applications that don't require high bandwidth double precision.
This is recommended for workloads that are not sensitive to double precision but at the same time need graphics capabilities.
- ▶ **All On:** This is recommended only when the workload needs full double precision as well as graphics capabilities.

WDDM and TCC Driver Models

Along with the GPU operation mode, the developer needs to select the compatible driver model for the Tesla K20X and K20.

- ▶ Tesla Compute Cluster (**TCC**): Optimized for running compute workloads.
- ▶ Windows Device Driver Model (**WDDM**): Designed for graphics application and not recommended for compute workloads.

Compatibility Between GOM and Driver Models

Table 1 shows which GPU operation modes are compatible with which driver models.

Table 1 GOM and Driver Model Compatibility

GOM	TCC Driver Model	WDDM Driver Model	Use Case Support
All On	YES	YES	All use cases are supported.
Compute-Only	YES	NO	The following are unsupported : X11 and those that require X11 (GLInterop, OCL conformance and VIPER) 32-bit Windows OS
Low Double Precision	YES	YES	All use cases supported.

The compute-only GOM is supported only on the TCC driver model, while the WDDM driver model supports only GOM modes that enable graphics.

The compute-only GOM and WDDM are incompatible and should not be used simultaneously.

The Tesla K20 Active Accelerators for workstations ship in “compute-only” mode and cannot be modified. Therefore, use only the TCC driver model with these products.

Using the WDDM Driver Model

To use the WDDM driver model with Tesla K20x and K20 GPU Accelerators for servers, first switch the GOM mode from compute-only to All On, then switch from TCC to WDDM.

Do not attempt to specify the driver model by editing the registry. Doing so can result in compute-only GOM and WDDM being configured simultaneously, which might require a clean installation of the driver to fix.

Always use NVIDIA-provided tools to specify a processing mode or to switch between driver models. Such tools include nvidia-smi or the NVIDIA Control Panel->Manage Maximus Settings page. These tools provide warnings in the case of a conflict.

SLI Multi-OS - GPU Assignment in System Virtualization

On systems with two or more graphics cards installed, this driver supports a hypervisor's ability to directly assign GPUs to guest virtual machines (VMs). This direct assignment allows each guest VM to run on their own operating system with their own GPU and driver. The assignment allows full GPU performance and functionality in the guest VM.

Hardware Platform Requirements

To make use of GPU passthrough with virtual machines running Windows and Linux, the hardware platform must support the following features:

- ▶ A CPU with hardware-assisted instruction set virtualization: Intel VT-x or AMD-V.
- ▶ Platform support for I/O DMA remapping.

On Intel platforms the DMA remapper technology is called Intel VT-d.

On AMD platforms it is called AMD IOMMU.

Support for these feature varies by processor family, product, and system, and should be verified at the manufacturer's website.

Supported Hypervisors

The following hypervisors are supported:

Hypervisor	Notes
Citrix XenServer	Version 6.0 and later.
VMware vSphere (ESX / ESXi)	Version 5.1 and later.
Parallels Workstation Extreme	Version 4 and later

Supported Graphics Cards

The following GPUs are supported for device passthrough:

GPU Family	Boards supported
Volta	<u>Quadro</u> : GV100 <u>Tesla</u> : V100
Pascal	<u>Quadro</u> : P2000, P4000, P5000, P6000, GP100 <u>Tesla</u> : P100, P40, P4
Maxwell	<u>Quadro</u> : K2200, M2000, M4000, M5000, M6000, M6000 24GB <u>Tesla</u> : M60, M6

GPU Family	Boards supported
Kepler	<u>Quadro</u> : K2000, K4000, K4200, K5000, K5200, K6000 <u>Tesla</u> : K10, K20, K20x, K20Xm, K20c, K20s, K40m, K40c, K40s, K40st, K40t, K80
Fermi	<u>Tesla</u> : C2050, C2075, M2050, M2070, M2070Q, M2075, M2090

Notes and Known Issues

VMware

- PCI I/O hole may need to be changed for Windows 64-bit VMs.

Windows 64-bit VMs may require that you edit the VM configuration file to configure a larger PCI I/O hole for the GPU.

- Access Control Services is required on some switches.

Starting with ESX 5.0 Update 1, Access Control Services (ACS) is required on any switches in the PCIe hierarchy above a PCIe device that is to be used for passthrough. If ACS is not present, ESX will not allow the device to be assigned directly to a VM.

To allow assignment of devices below switches that do not support ACS, you can disable the ACS check as follows:

```
esxcfg-advcfg -k true disableACSCheck
```

- MSI translation must be disabled for ESXi 5.1 and 5.5.

Blue-screen crashes may occur on VMs with assigned GPUs if MSI is initially enabled for passthrough devices.

To avoid this issue, disable MSI translation by setting `pciPassthru0.msiEnabled = "FALSE"` in the VM's VMX file.

Disabling MSI translation is not needed for ESXi 6.0 and later.

Citrix XenServer

- XenServer 6.1 workaround for 64-bit MMIO failures on PCI passthrough.

Dom0 kernel may relocate GPU BARs to an invalid location immediately beyond the end of physical RAM. There are two workaround options to address this condition:

Workaround option #1: Add 'pci=use_crs' to the kernel parameters by running the following command in Dom0:

```
/opt/xensource/libexec/xen-cmdline --set-dom0 pci=use_crs
```

Workaround option #2: Install the hotfix provided by Citrix at <http://support.citrix.com/article/CTX137645>):

Driver Security

Follow these safe computing practices:

- ▶ Only download or execute content and programs from trusted third parties.
- ▶ Run your system and programs with the least privilege necessary. Users should run without administrator rights whenever possible.
- ▶ When running as administrator, do not elevate UAC privileges for activities or programs that don't need them.

This section describes additional actions to take to mitigate specific known security issues. For guidance regarding driver or software package updates to address security concerns, visit the [NVIDIA Product Security](#) page.

Restricting Access to GPU Performance Counters

The NVIDIA graphics driver contains a vulnerability (CVE-2018-6260) that may allow access to application data processed on the GPU through a side channel exposed by the GPU performance counters. GPU performance counters are needed by developers in order to use NVIDIA developer tools such as CUPTI, Nsight Graphics, and Nsight Compute. In order to address CVE-2018-6260 the driver needs to be updated and additional steps listed below are needed to disable access to non-admin users. For more information about CVE-2018-6260 visit the [NVIDIA Security Bulletin 4772](#).

Access to GPU performance counters should be disabled for non-admin users who do not need to use NVIDIA developer tools.

Restricting Access to GPU Performance Counters Using the NVIDIA Control Panel

Restricting access to GPU performance counters can be accomplished through the NVIDIA Control Panel->*Developer*->*Manage GPU Performance Counters* page (NV Control Panel v8.1.950). Refer to the *Developer*->*Manage GPU Performance Counters* section of the NVIDIA Control Panel Help for instructions.

Restricting Access to GPU Performance Counters Across an Enterprise Using Scripts

Enterprise administrators can use scripts to programmatically apply the settings. The scripts should incorporate the registry key information provided below to automate the deployment.



CAUTION: These instructions should be performed only by enterprise administrators. Changes to the registry must be made with care. System instability can result if performed incorrectly.

```
[HKLM\SYSTEM\CurrentControlSet\Services\nvlddmkm\Global\NVTweak]  
Value: "RmProfilingAdminOnly"  
Type: DWORD  
Data: 00000001
```

The data value 1 restricts access to admin users, whereas data value 0 allows access to all users.

A system reboot is required for the changes to take effect.

Changes in Version 392.00

The following sections list the important changes and the most common issues resolved since driver version 391.85.

Fixed Issues in this Release

- ▶ [Quadro P5000][Windows 10]: 30-bit OpenGL pixel formats are not supported when monitor is in HDR mode.

Changes in Version 391.74

The following sections list the important changes and the most common issues resolved since driver version 391.58.

Hardening of Software Security Updates

This driver version improves [mitigations for Spectre Variant 1](#) on Windows by adding additional speculative execution barriers to mitigate Variant 1.



Note: NVIDIA continues to harden its products against known speculative execution side channel vulnerabilities in modern CPUs.

Changes in Version 391.33

The following sections list the important changes and the most common issues resolved since driver version 391.03.

Security Updates in this Release

For more information about medium to high-severity issues, refer to the [NVIDIA Product Security](#) page.

Table 2.1 NVIDIA Software Security Updates

CVE ID	NVIDIA Issue Number	Description
CVE-2018-6247	2003798	Vulnerability in the kernel mode layer (nvlddmkm.sys) handler for DxgkDdiEscape where a NULL pointer dereference may lead to Denial of Service or Escalation of Privileges.
CVE-2018-6248	1970661 1969787	Vulnerability in the kernel mode layer handler for DxgkDdiEscape where the software uses a sequential operation to read or write a buffer, but it uses an incorrect length value that causes it to access memory that is outside of the bounds of the buffer which may lead to denial of service or possible escalation of privileges.
CVE-2018-6249	1960097 1952160 2050960	Vulnerability in kernel mode layer handler where a NULL pointer dereference may lead to denial of service or potential escalation of privileges.
CVE-2018-6250	200337413	Vulnerability in the kernel mode layer (nvlddmkm.sys) handler for DxgkDdiEscape where a NULL pointer dereference occurs which may lead to denial of service or possible escalation of privileges.
CVE-2018-6251	2050736	Vulnerability in DirectX 10 Usermode driver, where specially crafted pixel shader can cause writing to unallocated memory which may lead to denial of service or potential code execution.
CVE-2018-6252	1893760	Vulnerability in the kernel mode layer handler for DxgkDdiEscape where the software allows an actor access to restricted functionality that is unnecessary to production usage, and which may result in denial of service.
CVE-2018-6253	2060652	Vulnerability in DirectX and OpenGL Usermode drivers where specially crafted pixel shader can cause infinite recursion which may lead to denial of service.

Changes in Version 391.03

The following sections list the important changes and the most common issues resolved since driver version 390.77.

Fixed Issues in this Release

- ▶ [Multi-GPU Mosaic]: Displays go blank upon disabling the Mosaic topology, then the primary GPU is disabled upon restarting the system.

Changes in Version 390.77

The following sections list the important changes and the most common issues resolved since driver version 390.65.

Fixed Issues in this Release

- ▶ [Quadro 4000M][Workstation Stereo]: Black shadows appear around stereo images after exiting and then re-launching the OpenGL application.

Changes in Version 390.65

The following sections list the important changes and the most common issues resolved since driver version 388.16.

NVIDIA Software Security Updates

For more information about NVIDIA's vulnerability management, visit the [NVIDIA Product Security](#) page.

CVE ID	NVIDIA Issue Number	Description
CVE-2017-5753	2034846	Security Bulletin: NVIDIA Driver Security Updates for CPU Speculative Side Channel Vulnerabilities

Fixed Issues in this Release

- [Multi-GPU Mosaic][G-Sync][Quadro GP100+ Nvlink]: Mosaic topologies cannot be set.

Open Issues in Version 392.65

As with every released driver, version 392.65 of the Release 390 driver has open issues and enhancement requests associated with it. This section includes lists of issues that are either not fixed or not implemented in this version. Some problems listed may not have been thoroughly investigated and, in fact, may not be NVIDIA issues. Others may have workaround solutions.

Windows 10 Issues

- ▶ [Assimilate Scratch]: The application may crash due to a kernel exception in the NVIDIA OpenGL driver.

If you encounter this issue, roll back the driver to version 385.90, or disable Deep Color within the application as follows:

*From the startup screen choose **System Settings**.*

- *In the System Settings Dialog, choose the Advanced tab.*
- *From the list (under Graphics) select "OpenGL: Disable 'deep color'"*
- *Click the boolean button to turn the setting on.*

- ▶ [Quadro M6000][Quadro Sync]: Unexpected flashing may appear on the display connected to the second GPU.

Please consult your NVIDIA support team for details on resolving this behavior.

- ▶ [Multi-GPU Mosaic][Quadro Sync]: Application corruption and possible blue-screen crash occurs when enabling WARP while Mosaic and Quadro Sync are enabled.

Issues Not Caused by NVIDIA Drivers

This section lists issues that are not due to the NVIDIA driver as well as features that are not meant to be supported by the NVIDIA driver for Windows 10.

- ▶ [“Application Issues” on page 22](#)

Application Issues

- ▶ [3ds Max 2017]: DirectX 9, Mode Texture of some models disappears after some time if no operation (such as zoom, pan, or rotate) is performed on the model.
- ▶ [Quadro K2200][Bunkspeed Shot 2014]: Render Argument exception occurs in Accurate Mode, and Internal Rendering Error occurs with Fast Mode.

Quadro K2200/K60 are not supported by Bunkspeed software.

- ▶ Quadro 6000: OpenCL/OpenGL interoperability performance suffers with `clEnqueueReleaseGLObjects`.

To avoid this issue, use CUDA.

Known Product Limitations

This section describes problems that will not be fixed. Usually, the source of the problem is beyond the control of NVIDIA. Following is the list of problems and where they are discussed in this document:

- ▶ “System Should not Enter Sleep/Hibernate Mode With SDI Capture in Progress” on page 23
- ▶ “Once Installed, the SDI Capture Driver Release Must Always Match the Graphics Driver” on page 24
- ▶ “Some APIs do not Report Total Available Graphics Memory Correctly” on page 24
- ▶ “Using HDMI/DisplayPort Audio with Displays that have a High Native Resolution” on page 25
- ▶ “Using HDMI/DisplayPort Audio in Dualview or Clone Mode Configurations” on page 26
- ▶ “GPU Runs at a High Performance Level (full clock speeds) in Multi-display Modes” on page 26
- ▶ “SLI Connector Requirement on NVIDIA Quadro SLI Cards” on page 26
- ▶ “Applying Workstation Application Profiles” on page 27

System Should not Enter Sleep/Hibernate Mode With SDI Capture in Progress

SDI capture programs will become non-responsive upon resume from sleep or hibernate modes.

This is not a typical use case, so power management tests should not be performed when testing SDI.

Once Installed, the SDI Capture Driver Release Must Always Match the Graphics Driver

To use the Quadro SDI Capture card, you need to install the NVIDIA WDM driver for the Quadro SDI Capture card after installing the Quadro professional driver. The WDM driver version must be from the same branch as the installed NVIDIA graphics driver.

If at a later time you install a different Quadro professional driver version—for example, when upgrading from a Release 260 driver to a Release 265 driver—you must reinstall the WDM driver from the same driver branch as well—in this example, Release 265.

You must install the updated WDM driver even if you remove the SDI Capture card and uninstall the WDM driver. Portions of the old WDM driver remain on the system, and the resulting mismatch with the updated graphics driver results in a faulty driver installation. Installing a matching WDM driver corrects this issue.

Some APIs do not Report Total Available Graphics Memory Correctly

Background-TAG Memory

In the Windows Display Driver Model (WDDM), Total Available Graphics (TAG) memory is reported as the sum of

- Dedicated Video Memory (video memory dedicated for graphics use)
- Dedicated System Memory (system memory dedicated for graphics use), and
- Shared System Memory (system memory shared between the graphics subsystem and the CPU).

The values for each of these components are computed according to WDDM guidelines when the NVIDIA Display Driver is loaded.

Issue

NVIDIA has found that some TAG-reporting APIs represent video memory using 32-bits instead of 64-bits, and consequently do not properly report available graphics memory when the TAG would otherwise exceed 4 gigabytes (GB). This results in under reporting of available memory and potentially undesirable behavior of applications that rely on these APIs to report available memory.

The reported memory can be severely reduced. For example, 6 GB might be reported as 454 MB, and 8 GB might be reported as 1259 MB.

NVIDIA Action for Some GeForce-based Systems

For GeForce GPUs with 2.75 GB or less of video memory, the NVIDIA display driver constrains TAG memory to just below 4 GB¹. In this scenario, the Shared System Memory component of TAG is limited first, before limiting Dedicated Video Memory.

This is a policy decision within the driver, and results in reliable reporting of sub-4 GB TAG memory.

When TAG Reporting Would Not Be Limited

For GeForce-based GPUs with more than 2.75 GB of video memory, as well as all Quadro and Tesla GPUs, the NVIDIA display driver does not constrain TAG memory reporting.

The disadvantage of constraining TAG on systems with larger amounts of video and system memory is that memory which otherwise would be available for graphics use is no longer available. Since shared system memory is limited first, driver components and algorithms utilizing shared system memory may suffer performance degradation when TAG is constrained.

Since these and similar scenarios are prevalent in many Workstation applications, the NVIDIA driver avoids constraining TAG on all Quadro and Tesla-based systems. Likewise, the driver does not constrain TAG for GeForce-based systems with more than 2.75 GB of video memory.

Using HDMI/DisplayPort Audio with Displays that have a High Native Resolution

To use HDMI/DisplayPort audio with some displays that have a native resolution higher than 1920x1080, you must set the display to a lower HD resolution.

Some HDMI TV's have a native resolution that exceeds the maximum supported HD mode. For example, TVs with a native resolution of 1920x1200 exceed the maximum supported HD mode of 1920x1080.

Applying this native mode results in display overscan which cannot be resized using the NVIDIA Control Panel since the mode is not an HD mode.

To avoid this situation and provide a better user experience, the driver treats certain TVs—such as the Viewsonic VX2835wm and the Westinghouse LVM- 37w3—as a DVI monitor when applying the native mode. Because the driver does not treat the TV as an HDMI in this case, the HDMI audio is not used.

1. The WDDM guidelines dictate minimum and maximum values for the components, but the display driver may further constrain the values that are reported (within the allowed minimum and maximum).

Using HDMI/DisplayPort Audio in Dualview or Clone Mode Configurations

Two Audio-enabled Ports

In a multi-display configuration where both HDMI/DisplayPort audio ports are enabled, only the primary display will provide the audio.

One Audio-enabled Port

In a multi-display configuration where only one audio port is enabled, such as when one display is a DVI display, then the HDMI/DisplayPort display can provide the audio whether is it the primary or secondary display.

GPU Runs at a High Performance Level (full clock speeds) in Multi-display Modes

This is a hardware limitation and not a software bug. Even when no 3D programs are running, the driver will operate the GPU at a high performance level in order to efficiently drive multiple displays. In the case of SLI or multi-GPU PCs, the second GPU will always operate with full clock speeds; again, in order to efficiently drive multiple displays. Today, all hardware from all GPU vendors have this limitation.

SLI Connector Requirement on NVIDIA Quadro SLI Cards

The SLI connector that links two SLI cards is needed for proper SLI operation. However, the connector can be removed if you do not intend to enable SLI mode. If you remove the connector, then you must make sure that SLI mode is disabled from the NVIDIA control panel. Enabling SLI mode without the SLI connector installed will result in video corruption.

Applying Workstation Application Profiles

► **Background**

The workstation application profiles are software settings used by the NVIDIA Display Drivers to provide optimum performance when using a selected application. The profile also works around known application issues and bugs.

If there is an available setting for an application, it should be used, otherwise incorrect behavior or reduced performance is likely to occur.

► **Issues**

Configuration changes require that you restart the application.

Once an application is running, it does not receive notification of configuration changes. Therefore, if you change the configuration while the application is running, you must exit and restart the application for the configuration changes to take effect.

03 THE RELEASE 390 DRIVER

This chapter covers the following main topics:

- ▶ “Supported Operating Systems” on page 28
- ▶ “Supported NVIDIA Workstation GPUs” on page 28
- ▶ “Supported NVIDIA Notebook GPUs” on page 33
- ▶ “Supported Languages” on page 34
- ▶ “Driver Installation” on page 35

Supported Operating Systems

The Release 390 driver, version 392.65, has been tested with

- ▶ Microsoft Windows® 10, 64-bit only.

Supported NVIDIA Workstation GPUs

The following tables list the NVIDIA products supported by the Release 390 driver, version 392.65.

- ▶ Table 3.1, “Supported NVIDIA Quadro & NVS Products” on page 29
- ▶ Table 3.2, “Supported NVIDIA Quadro Sync II Products” on page 30
- ▶ Table 3.3, “Supported NVIDIA Quadro Sync Products” on page 31
- ▶ Table 3.4, “Supported NVIDIA Quadro SDI Products” on page 31
- ▶ Table 3.5, “Supported NVIDIA Quadro Blade/Embedded Graphics Board Series” on page 31
- ▶ Table 3.6, “Supported NVIDIA Tesla Products” on page 32

NVIDIA Quadro & NVS Product

Table 3.1 Supported NVIDIA Quadro & NVS Products

Product	GPU Architecture	Notes
NVIDIA Quadro GV100	Volta	64-bit Windows OS only
NVIDIA Quadro GP100	Pascal	
NVIDIA Quadro P6000	Pascal	
NVIDIA Quadro P5000	Pascal	
NVIDIA Quadro P4000	Pascal	
NVIDIA Quadro P2000	Pascal	
NVIDIA Quadro P1000	Pascal	
NVIDIA Quadro P600	Pascal	
NVIDIA Quadro P400	Pascal	
NVIDIA Quadro M6000 24GB	Maxwell	
NVIDIA Quadro M6000	Maxwell	
NVIDIA Quadro M5000	Maxwell	
NVIDIA Quadro M4000	Maxwell	
NVIDIA Quadro M2000	Maxwell	
NVIDIA Quadro K6000	Kepler	
NVIDIA Quadro K5200	Kepler	
NVIDIA Quadro K5000	Kepler	
NVIDIA Quadro K4200	Kepler	
NVIDIA Quadro K4000	Kepler	
NVIDIA Quadro K2200	Maxwell	
NVIDIA Quadro K2000	Kepler	
NVIDIA Quadro K1200	Maxwell	
NVIDIA Quadro K620	Maxwell	
NVIDIA Quadro K600	Kepler	
NVIDIA Quadro K420	Kepler	
NVIDIA Quadro 410	Kepler	
NVIDIA NVS 810	Maxwell	
NVIDIA NVS 510	Kepler	
NVIDIA NVS 315	Fermi	
NVIDIA NVS 310	Fermi	

Table 3.2 Supported NVIDIA Quadro Sync II Products

Product	GPU Architecture
NVIDIA Quadro GV100	Volta
NVIDIA Quadro GP100	Pascal
NVIDIA Quadro P6000	Pascal
NVIDIA Quadro P5000	Pascal
NVIDIA Quadro P4000	Pascal

NVIDIA Quadro Sync Products

Table 3.3 Supported NVIDIA Quadro Sync Products

Product	GPU Architecture
NVIDIA Quadro M6000 24GB	Maxwell
NVIDIA Quadro M6000	Maxwell
NVIDIA Quadro M5000	Maxwell
NVIDIA Quadro M4000	Maxwell
NVIDIA Quadro K6000	Kepler
NVIDIA Quadro K5200	Kepler
NVIDIA Quadro K5000	Kepler
NVIDIA Quadro K4200	Kepler

NVIDIA Quadro SDI Products

Table 3.4 Supported NVIDIA Quadro SDI Products

Product	GPU Architecture
NVIDIA Quadro K6000	Kepler
NVIDIA Quadro K5200	Kepler
NVIDIA Quadro K5000	Kepler
NVIDIA Quadro K4200	Kepler
NVIDIA Quadro K4000	Kepler



Note: Quadro SDI products are not supported under Windows 8.

NVIDIA Quadro Blade/Embedded Graphics Board

Table 3.5 Supported NVIDIA Quadro Blade/Embedded Graphics Board Series

Product	GPU Architecture
NVIDIA Quadro P5000	Pascal
NVIDIA Quadro P3000	Pascal
NVIDIA Quadro M5000 SE	Maxwell
NVIDIA Quadro M3000 SE	Maxwell
NVIDIA Quadro K3100M	Kepler

NVIDIA Tesla Products

The Tesla driver package is designed for systems that have one or more Tesla products installed.

- ▶ Only one GHIC can be connected to the server in a Tesla system.
- ▶ This release of the Tesla driver supports CUDA C/C++ applications and libraries that rely on the CUDA C Runtime and/or CUDA Driver API.

Table 3.6 Supported NVIDIA Tesla Products

Product	GPU Architecture	Notes
Tesla P-Series Products		
NVIDIA Tesla P100	Pascal	
NVIDIA Tesla P40	Pascal	
NVIDIA Tesla P4	Pascal	
Tesla M-Series Products		
NVIDIA Tesla M60	Maxwell	
NVIDIA Tesla M6	Maxwell	
Tesla K-Series Products		
NVIDIA Tesla K80	Kepler	64-bit OS only
NVIDIA Tesla K40(m/c/s/st/t)	Kepler	64-bit OS only
NVIDIA Tesla K20(x/c/m/Xm/s)	Kepler	64-bit OS only
NVIDIA Tesla K10	Kepler	
Tesla S-Class Products		
NVIDIA Tesla S2050	Fermi	
Tesla M-Class Products		
NVIDIA Tesla M2090	Fermi	
NVIDIA Tesla M2075	Fermi	
NVIDIA Tesla M2070	Fermi	
NVIDIA Tesla M2070Q	Fermi	
NVIDIA Tesla M2050	Fermi	
Tesla C-Class Products		
NVIDIA Tesla C2075	Fermi	
NVIDIA Tesla C2070	Fermi	
NVIDIA Tesla C2050	Fermi	

Supported NVIDIA Notebook GPUs

The notebook driver is part of the NVIDIA Verde Notebook Driver Program, and can be installed on supported NVIDIA notebook GPUs. However, please note that your notebook original equipment manufacturer (OEM) provides certified drivers for your specific notebook on their website. NVIDIA recommends that you check with your notebook OEM about recommended software updates for your notebook. OEMs may not provide technical support for issues that arise from the use of this driver.

The following tables list the NVIDIA notebook products supported by the Release 390 driver, version 392.65:

Table 3.7 NVIDIA NVS Notebook GPU Support

Notebook Products	GPU Architecture
NVS 5400M	Fermi
NVS 5200M	Fermi
NVS 4200M	Fermi

Table 3.8 NVIDIA Quadro Notebook GPU Support

Notebook Products	GPU Architecture
Quadro P5000	Pascal
Quadro P4000	Pascal
Quadro P3000	Pascal
Quadro M5500	Maxwell
Quadro M5000M	Maxwell
Quadro M4000M	Maxwell
Quadro M3000M	Maxwell
Quadro M2000M	Maxwell
Quadro M1000M	Maxwell
Quadro M600M	Maxwell
Quadro M500M	Maxwell

Table 3.8 NVIDIA Quadro Notebook GPU Support (continued)

Notebook Products	GPU Architecture
Quadro K5000M	Kepler
Quadro K5100M	Kepler
Quadro K4000M	Kepler
Quadro K4100M	Kepler
Quadro K3000M	Kepler
Quadro K3100M	Kepler
Quadro K2000M	Kepler
Quadro K2200M	Maxwell
Quadro K2100M	Kepler
Quadro K1000M	Kepler
Quadro K1100M	Kepler
Quadro K620M	Maxwell
Quadro K610M	Kepler
Quadro K510M	Kepler
Quadro K500M	Kepler

Supported Languages

The Release 390 Graphics Drivers supports the following languages in the main driver Control Panel:

English (USA)	German	Portuguese (Euro/ Iberian)
English (UK)	Greek	Russian
Arabic	Hebrew	Slovak
Chinese (Simplified)	Hungarian	Slovenian
Chinese (Traditional)	Italian	Spanish
Czech	Japanese	Spanish (Latin America)
Danish	Korean	Swedish
Dutch	Norwegian	Thai
Finnish	Polish	Turkish
French	Portuguese (Brazil)	

Driver Installation

Minimum Hard Disk Space

The hard disk space requirement for international is minimum 1158 MB.

The hard disk space requirement for English-only is minimum 570 MB.

Before You Begin

nTune

If you have previously installed NVIDIA nTune, NVIDIA recommends that you uninstall nTune before installing this driver. After the driver install is complete, you can reinstall NVIDIA nTune.

Notebooks

- ▶ Check to make sure that your notebook has a supported GPU (see [“Supported NVIDIA Notebook GPUs”](#) on page 33).
- ▶ It is recommended that you back up your current system configuration.
- ▶ If you own a Dell Inspiron 1420, Dell XPS M1330, or Dell XPS M1530, or Dell LatitudeD630 or D630c, it is highly recommended that you first install this [Dell software update](#).

SLI Mosaic Mode

You must make sure SLI Mosaic mode is disabled before installing a new driver over a previously installed driver. If SLI Mosaic mode is active on your displays when you install the new driver, the driver will not install properly.

Installation Instructions

- 1 Follow the instructions on the NVIDIA .com Web site driver download page to locate the appropriate driver to download, based on your hardware and operating system.
- 2 Click the driver download link.
The license agreement dialog box appears.
- 3 Click **Accept** if you accept the terms of the agreement, then either open the file or save the file to your PC and open it later.
- 4 Open the NVIDIA driver installation .EXE file to launch the NVIDIA InstallShield Wizard.

- 5 Follow the instructions in the NVIDIA InstallShield Wizard to complete the installation.



Note: If you are overinstalling the driver (installing over a previous driver without first removing the previous driver), then you must reboot your computer in order to complete the installation.

APPENDIX A NVIDIA TESLA COMPUTE CLUSTER MODE

This chapter describes the Tesla Compute Cluster (TCC) mode.

- ▶ “About Tesla Compute Cluster Mode” on page 37
- ▶ “Operating on Systems with non-TCC NVIDIA GPUs” on page 39
- ▶ “Setting TCC Mode” on page 39

About Tesla Compute Cluster Mode

TCC Overview

Tesla Compute Cluster (TCC) mode is designed for compute cluster nodes that have one or more Tesla or supported Quadro products installed.

Benefits

- ▶ TCC drivers make it possible to use NVIDIA GPUs in nodes with non-NVIDIA integrated graphics.
- ▶ NVIDIA GPUs on systems running the TCC drivers will be available via Remote Desktop, both directly and via cluster management systems that rely on Remote Desktop.
- ▶ NVIDIA GPUs will be available to applications running as a Windows service (i.e. in Session 0) on systems running the Tesla driver in TCC mode.

TCC Does not Support Graphics Acceleration

- ▶ TCC mode does not provide CUDA–DirectX/OpenGL interoperability. It is a “non-display” driver, and NVIDIA GPUs using this driver will not support DirectX or OpenGL hardware acceleration.

Running CUDA Applications

- ▶ This release of the Tesla/Quadro driver supports CUDA C/C++ applications and libraries that rely on the CUDA C Runtime and/or CUDA Driver API.
- ▶ NVIDIA GPUs running the Tesla/Quadro driver in TCC mode will be available for CUDA applications running via services or Remote Desktop.
- ▶ In this release, all GPUs will be in compute exclusive mode. As a result, only one CUDA context may exist on a particular device at a time.
- ▶ SDK applications that use graphics will not run properly under TCC mode. The following are examples of CUDA SDK applications that are not supported:

bicubicTexture	boxFilter	cudaDecodeD3D9	smokeParticles
cudaDecodeGL	fluidsD3D9	fluidsGL	SobelFilter
imageDenoising	Mandelbrot	marchingCubes	volumeRender
nbody	oceanFFT	particles	
postProcessGL	recursiveGaussian	simpleD3D10	
simpleD3D10Texture	simpleD3D11Texture	simpleD3D9	
simpleD3D9Texture	simpleGL	simpleTexture3D	

Operating on Systems with non-TCC NVIDIA GPUs

- ▶ NVIDIA GPUs running under TCC mode may coexist with other display devices.
- ▶ The Tesla/Quadro driver is overinstalled over any NVIDIA display driver in the system—the NVIDIA Tesla driver then becomes the only driver for all NVIDIA GPUs in the system.

If the Tesla/Quadro driver is uninstalled at a later time, the previous driver is not restored.

- ▶ NVIDIA GPUs that do not support TCC mode will appear as “VGA adapters” in the Windows Device Manager and can be used to drive displays.

Non-supported NVIDIA GPUs can still function as CUDA devices, but the GPU’s graphics functionality is not available to applications.

Setting TCC Mode

To change the TCC mode, use the NVIDIA **smi** utility as follows:

```
nvidia-smi -g (GPU ID) -dm (0 for WDDM, 1 for TCC)
```

The following table shows the default TCC/non-TCC mode for supported products.

Table A.1 Default TCC Mode

Product	Default Mode
K20Xm/c	TCC
K20m	TCC Off
C2075	TCC
C2050	TCC Off
C2070	TCC Off
S2050	TCC
M2050	TCC
M2070	TCC
M2075	TCC
M2070-Q	TCC Off
M2090	TCC
Quadro (Kepler/Maxwell)	TCC Off

Notice

ALL NVIDIA DESIGN SPECIFICATIONS, REFERENCE BOARDS, FILES, DRAWINGS, DIAGNOSTICS, LISTS, AND OTHER DOCUMENTS (TOGETHER AND SEPARATELY, "MATERIALS") ARE BEING PROVIDED "AS IS." NVIDIA MAKES NO WARRANTIES, EXPRESSED, IMPLIED, STATUTORY, OR OTHERWISE WITH RESPECT TO THE MATERIALS, AND EXPRESSLY DISCLAIMS ALL IMPLIED WARRANTIES OF NONINFRINGEMENT, MERCHANTABILITY, AND FITNESS FOR A PARTICULAR PURPOSE.

Information furnished is believed to be accurate and reliable. However, NVIDIA Corporation assumes no responsibility for the consequences of use of such information or for any infringement of patents or other rights of third parties that may result from its use. No license is granted by implication of otherwise under any patent rights of NVIDIA Corporation. Specifications mentioned in this publication are subject to change without notice. This publication supersedes and replaces all other information previously supplied. NVIDIA Corporation products are not authorized as critical components in life support devices or systems without express written approval of NVIDIA Corporation.

Macrovision Compliance Statement

NVIDIA Products that are Macrovision enabled can only be sold or distributed to buyers with a valid and existing authorization from Macrovision to purchase and incorporate the device into buyer's products.

Macrovision copy protection technology is protected by U.S. patent numbers 5,583,936; 6,516,132; 6,836,549; and 7,050,698 and other intellectual property rights. The use of Macrovision's copy protection technology in the device must be authorized by Macrovision and is intended for home and other limited pay-per-view uses only, unless otherwise authorized in writing by Macrovision. Reverse engineering or disassembly is prohibited.

Third Party Notice

Portions of the NVIDIA system software contain components licensed from third parties under the following terms:

Clang & LLVM:

Copyright (c) 2003-2015 University of Illinois at Urbana-Champaign.

All rights reserved.

Portions of LLVM's System library:

Copyright (C) 2004 eXtensible Systems, Inc.

Developed by:

LLVM Team

University of Illinois at Urbana-Champaign

<http://llvm.org>

Permission is hereby granted, free of charge, to any person obtaining a copy of this software and associated documentation files (the "Software"), to deal with the Software without restriction, including without limitation the rights to use, copy, modify, merge, publish, distribute, sublicense, and/or sell copies of the Software, and to permit persons to whom the Software is furnished to do so, subject to the following conditions:

* Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimers.

* Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimers in the documentation and/or other materials provided with the distribution.

* Neither the names of the LLVM Team, University of Illinois at Urbana-Champaign, nor the names of its contributors may be used to endorse or promote products derived from this Software without specific prior written permission.

THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE CONTRIBUTORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS WITH THE SOFTWARE.

Vulkan Notice

Copyright (c) 2015-2016 The Khronos Group Inc.

Copyright (c) 2015-2016 LunarG, Inc.

Copyright (c) 2015-2016 Valve Corporation

Permission is hereby granted, free of charge, to any person obtaining a copy of this software and/or associated documentation files (the "Materials"), to deal in the Materials without restriction, including without limitation the rights to use, copy, modify, merge, publish, distribute, sublicense, and/or sell copies of the Materials, and to permit persons to whom the Materials are furnished to do so, subject to the following conditions:

The above copyright notice(s) and this permission notice shall be included in all copies or substantial portions of the Materials.

THE MATERIALS ARE PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT.

IN NO EVENT SHALL THE AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE MATERIALS OR THE USE OR OTHER DEALINGS IN THE MATERIALS.

Unless otherwise noted in the LICENSE.txt file in the install folder, all components of the Vulkan Runtime are licensed under the above license. Licenses for any components not so licensed are listed in the LICENSE.txt file.

Trademarks

NVIDIA, the NVIDIA logo, NVIDIA nForce, GeForce, NVIDIA Quadro, are registered trademarks or trademarks of NVIDIA Corporation in the United States and/or other countries.

HDMI, the HDMI logo, and High-Definition Multimedia Interface are trademarks or registered trademarks of HDMI Licensing LLC.

OpenGL® and the oval logo are trademarks or registered trademarks of Silicon Graphics, Inc. in the United States and/or other countries worldwide. Additional license details are available on the SGI website.

OpenCL and the OpenCL logo are trademarks of Apple Inc. used by permission by Khronos.

Vulkan and the Vulkan logo are trademarks of the Khronos Group Inc.

Other company and product names may be trademarks or registered trademarks of the respective owners with which they are associated.

Copyright

© 2018 - 2021 NVIDIA Corporation. All rights reserved.