Intel® Virtual RAID on CPU (VROC) for Windows

User Guide

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1 Introduction

The Intel® Virtual RAID on CPU (Intel® VROC) family of products provide enterprise RAID solutions for both NVMe SSD and SATA devices for the enterprise servers, workstations, and some high-end desktops.

1. Intel® Virtual RAID on CPU (Intel VROC) provides an enterprise RAID solution on platforms that supports Intel® Volume Management Device (Intel® VMD) on Intel® Xeon® Scalable Processors.
2. Intel® Virtual RAID on CPU (Intel VROC) SATA RAID provides an enterprise RAID solution for SATA devices connected to SATA/sSATA Intel® Platform Control Hub (Intel® PCH) configured for RAID.
3. Intel® Virtual RAID on CPU (Intel VROC (NonVMD NVMe RAID)) provides a RAID solution for some Intel NVMe SSDs attached to PCIe slots managed by the platform Intel Xeon Processor (on supported platforms). Intel VROC (NonVMD NVMe RAID) is not intended for, nor supported on platforms that have Intel VMD capabilities (weather Intel VMD is enabled or disabled).

Intel VROC is a high-level blanket product reference for Intel VROC (VMD NVMe RAID), Intel VROC (SATA RAID) and Intel VROC (NonVMD NVMe RAID).

1.1 Terminology

Table 1: Terminology

Term	Description
API	Application Programming Interface
ASM	Intel® Accelerated Storage Manager (Intel® ASM)
BIOS	Basic Input/Output System
GB	Gigabyte
GUI	Graphical User Interface
HII	Human Interface Infrastructure
Hot-Plug	The unannounced removal and insertion of a drive while the system is powered on.
I/O	Input/Output
Initramfs	Initial Ram File system
KB	Kilobyte
Matrix RAID	Two independent RAID volumes within a single RAID array.
MB	Megabyte
Member Disk	An NVMe drive used within a RAID array.
NVMe	Non-volatile Memory Express
OS	Operating System

Term	Description
POST	Power On Self-Test
Pre-OS	A BIOS option to configure Intel VROC UEFI Drivers for Intel VMD and the platform PCH in RAID mode.
RAID	Redundant Array of Independent Disks: allows data to be distributed across multiple drives to provide data redundancy or to enhance data storage performance.
RAID 0 (striping)	The data in the RAID volume is striped across the array's members. Striping divides data into units and distributes those units across the members without creating data redundancy but improving read/write performance.
RAID 1 (mirroring)	The data in the RAID volume is mirrored across the RAID array's members. Mirroring is the term used to describe the key feature of RAID 1, which writes duplicate data from one drive to another; therefore, creating data redundancy and increasing fault tolerance.
RAID 5 (striping with parity)	The data in the RAID volume and parity are striped across the array's members. Parity information is written with the data in a rotating sequence across the members of the array. This RAID level is a preferred configuration for efficiency, fault-tolerance, and performance.
RAID 10 (striping and mirroring)	The RAID level where information is striped across a two drive arrays for system performance. Each of the drive in the array has a mirror for fault tolerance. RAID 10 provides the performance benefits of RAID 0 and the redundancy of RAID 1. However, it requires four hard drives so it's the least cost effective.
RAID Array	A logical grouping of physical drives.
RAID Volume	A fixed amount of space across a RAID array that appears as a single physical drive to the operating system. Each RAID volume is created with a specific RAID level to provide data redundancy or to enhance data storage performance.
Spare	The drive that is the designated target drive in a RAID Volume recovery. The Spare drive is a global setting (not designated to a specific RAID volume). Spare drives on SATA Controller are not available on the sSATA Controller (and vis versa). Spare drives designated on Intel VROC (VMD NVMe RAID) are exposed and available on all Intel VMD domains.
Strip	Block size that is assigned to evenly distribute portions of the stripe across a designated number of drives within a RAID array.
Stripe	The size of the data block that is to be written in each write cycle across the RAID array.
Intel® RSTe	Intel® Rapid Storage Technology enterprise.
RWH	RAID Write Hole
SSD	Solid State Drive
TB	Terabyte

Term	Description
UEFI Mode	*Unified Extensible Firmware Interface*. Refers to the system setting in the BIOS
Intel® VMD	Intel® Volume Management Device
Intel® VROC	Intel® Virtual RAID on CPU

1.2 Reference Documents

Table 2: Reference Documents

Document	Document # / Location
NVM_Express_1_2_Gold_20141209.pdf	Nvmexpress.org
Intel® VROC Technical Product Specification (TPS)	602756

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2 Intel VROC New Features

2.1 New Features Introduced in the Intel VROC 7.6 Release

Please review the Intel VROC Technical Product Specification (TPS) included in the Intel VROC 7.6 release package for the details on the latest features and updates.

Note: These new features will not be addressed in this version of the User Guide.

2.2 Features Introduced in the Intel VROC 7.5 Release

Please review the Intel VROC Technical Product Specification (TPS) included in the Intel VROC 7.5 release package for the details on the latest features and updates.

Note: These new features will not be addressed in this version of the User Guide.

2.3 Features Introduced in the Intel VROC 7.0 Release

2.3.1 Removal of AHCI mode support

With the release of the Intel VROC 7.0 PV package, the package will no longer include drivers to support the PCH configured for AHCI mode. All support for this configuration will be via the Microsoft inbox AHCI driver. Please contact your Intel FAE if you have any further questions.

- For fresh clean (OS installation) configurations, the Intel VROC 7.0 installer will bypass the PCH if it is in AHCI mode.
- For existing platforms that has Intel VROC AHCI driver installed, running the Intel VROC 7.0 installer will remove/uninstall the Intel VROC AHCI driver so the Microsoft inbox AHCI driver can be used. A message will be displayed to inform the user of the upcoming change.

2.3.2 Removal of Legacy Option ROM Support

With the release of the Intel VROC 7.0 PV package, the package will no longer include the Intel VROC (SATA RAID) Legacy Option ROM PreOS components. All PreOS support for Intel VROC (SATA RAID) will only be through the UEFI environment. If Intel VROC (SATA RAID) support, through the Legacy Option ROM environment, is required please continue to use the Intel VROC 6.3 release package. Please contact your Intel FAE if you have any further questions.

2.3.3 Removal of Windows 7 Support

With the release of the Intel VROC 7.0 PV package, the package will no longer include support for Windows 7. All components and support for Windows 7 (Windows drivers and PreOS components) have been removed. If Windows 7 support is required, please continue to use the Intel VROC 6.3 release package. Please contact your Intel FAE if you have any further questions.

2.4 New to Intel VROC 6.3

Please review the release notes and the Intel VROC Technical Product Specification (TPS) included in the Intel VROC 6.3 release package for all the latest updates.

2.5 New to Intel VROC 6.2

Please review the release notes and the Intel VROC TPS included in the Intel VROC 6.2 release package for all the latest updates.

2.6 New to Intel VROC 6.1

2.6.1 Windows 7-64bit Support

The Intel VROC 6.1 release package includes targeted support for Windows 7-64bit. Within this package, is included Intel RSTe 5.6 specifically for Windows 7-64bit. This was added back into the product packaging to support the older platforms.

On platforms that are installing Windows 7-64bit, the Intel RSTe 5.6 driver from the F6 directory should be used. Once the OS is successfully installed, running the Intel VROC 6.1 installation application will install the Intel RSTe 5.6 GUI and middleware and update/install the driver.

This configuration is the exception to the backwards compatibility of the Intel VROC PreOS. Meaning, that after the platform BIOS has been updated to include the Intel VROC 6.1 PreOS, the Intel RSTe 5.6 package (for Windows 7-64bit) will be supported. Table 3 shows the Intel VROC PreOS versions to Intel RSTe 5.6 OS version support.

Table 3: Intel VROC Compatibility Matrix

Intel RSTe 5.6 Windows 7-64bit Support vs PreOS Versions	
Intel VROC PreOS 5.5	Supported
Intel VROC PreOS 6.0	Not Supported
Intel VROC PreOS 6.1	Supported
Intel VROC PreOS 6.2	Supported but not Validated
Intel VROC PreOS 6.3	Supported but not Validated
Intel VROC PreOS 7.0	Not Supported
Intel VROC PreOS 7.5	Not Supported
Intel VROC PreOS 7.6	Not Supported

2.6.2 Microsoft .NET and Intel® ASM No Longer Included

To address functional and security updates, this version of the Intel® Virtual RAID on CPU (Intel VROC) 6.1 Release Package has removed the Microsoft .NET Framework as well as the Intel Acceleration Storage Manager (ASM). Users should update to the latest version.

For the customer's convenience, the Intel VROC product installation application was designed to automatically install the Microsoft .NET Framework and provide an option to install the Intel Acceleration Storage Manager (ASM).

The .NET Framework was included because the Intel VROC user interface relies on the .NET Framework to operate properly. To ensure that customers are able to get the latest version available, Intel is no longer including .NET Framework in the Intel VROC production package. This is not needed because the supported Windows operating systems already include a version of .NET Framework. If the latest version of the .NET Framework is not installed, it can be obtained/downloaded either via a Web update or offline directly from https://dotnet.microsoft.com/.

In addition to removal of the .NET Framework installation, this release also removes the Intel ASM component. The Intel ASM installer has some dependencies on 3rd party libraries and Intel would like to reduce or eliminate these dependencies. Until this is accomplished, the Intel ASM component is being removed. Please contact your Intel FAE for future release details.

For more information please refer to Technical Advisory Reference Number 610700.

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3 Product Overview

The Intel VROC family of products provide enterprise solutions for both NVMe SSD and SATA devices for enterprise servers and workstations. The product family includes the following three products:

1. Intel VROC (VMD NVMe RAID) – This product provides an enterprise RAID solution on platforms that support the Intel VMD technology.
2. Intel VROC (SATA RAID) – This product provides an enterprise RAID solution for SATA devices connected to SATA/sSATA via the Intel Platform Control Hub (PCH) configured for RAID mode.
3. Intel VROC (NonVMD NVMe RAID) – This product provides an enterprise RAID solution for Intel NVMe SSDs attached to PCIe slots managed by the Platform CPU. Intel VROC (NonVMD NVMe RAID) is not intended for, nor supports:
    a. Non-Intel NVMe SSDs.

Platforms with Intel CPUs that contain Intel VMD technology, whether it is enabled or disabled.

3.1 Intel VROC (VMD NVMe RAID) Configuration Features

The key Intel VROC features are activated based on four different configurations that can be used.

1. The first is Intel VROC Pass-thru (no Intel VROC Upgrade Key installed in the platform).
2. The second is the Standard SKU (which has the Intel VROC Standard Upgrade Key installed in the platform). The Standard Upgrade Key will enable the use of RAID 0, RAID 1 and RAID 10.
3. The third is an Intel Only SSD Upgrade Key that will provide the same features as the Premium Upgrade Key, but only if used with Intel SSDs.
4. The final configuration is the Premium SKU (which has the Intel VROC Premium Upgrade Key installed in the platform). Premium Upgrade Keys will allow for the use of all RAID configurations included with the Standard SKU with the addition of RAID 5 support, and the RAID Write Hole option (which provides additional data failsafe protections).

Standard and Premium Upgrade Keys enable the use of Intel VROC features on Intel and approved 3rd party NVMe drives. Intel VROC Pass-thru is the default state, where no upgrade key has been plugged into the system, and can be upgraded based on the features desired. These features are also restricted to approved operating systems for proper operational functionality.

3.2 Scope and Limitations

This is the Intel VROC product family release package and meets Intel's production quality standards.

Here are some constraints:

1. The Intel VROC GUI requires the presence of the latest version of Microsoft .NET Framework. Please refe3r to the Release Notes, included in this package, for more details.
2. The Intel VROC will only reflect drives that are compatible for the RAID type that has been selected. Incompatible drives will not be within the selection values available. You will not be able to force this in the GUI or in the BIOS.

3.3 Supported Platforms/Chipsets/SKUs/Operating Systems

Please refer to either the Intel VROC TPS or the Release Notes included in this package.

3.4 RAID 0 (Striping)

RAID 0 uses the read/write capabilities of two or more drives working in parallel to maximize the storage performance of a computer system. The following table provides an overview of the advantages, the level of fault-tolerance provided, and the typical usage of RAID 0.

Note: RAID 0 is supported for Intel VROC without an upgrade key installed into the platform.

Table 6: RAID 0 Overview

Drives Supported	2 minimum
Advantage	High transfer rates
Fault-tolerance	None – If one drive fails all data will be lost
Application	Typically used in desktops and workstations for maximum performance for temporary data and high I/O rate. 2-drive RAID 0 available in specific mobile configurations. It also should be noted that although RAID 0 can be scaled to many drives there is a performance sweet spot specific to your implementation.

3.5 RAID 1 (Mirroring)

RAID 1 volumes contain two drives where the data is copied to both of the drives in real time, to provide data reliability, in the case of a single disk failure. When one disk drive fails, all data is immediately available on the other drive without any impact to the integrity of the data. The following table provides an overview of the advantages, the level of fault-tolerance provided, and the typical usage of RAID 1.

Table 7: RAID 1 Overview

Drives Supported	2 maximum
Advantage	Redundancy of data. One drive may fail, but data will continue to be accessible. A rebuild to a new drive is recommended to maintain data redundancy.
Fault-tolerance	Excellent – Drive mirroring means that all data on one drive is duplicated on another drive.
Application	Typically used for smaller systems where capacity of one disk is sufficient and for any application(s) requiring very high availability. Available in specific mobile configurations.

3.6 RAID 5 (Striping with Parity)

RAID 5 volumes contain three (minimum) or more drives where the data and parity are striped across all the drives in the volume. Parity is a mathematical method for recreating data that was lost from a single drive, which increases fault-tolerance. If there are N drives in the RAID 5 volume, the capacity for data would be N - 1 drives. For example, if the RAID 5 volume has 5 drives, the data capacity for this RAID volume consists of 4 drives. The following table provides an overview of the advantages, the level of fault-tolerance provided, and the typical usage of RAID 5.

Table 8: RAID 5 Overview

Drives Supported	3 minimum
Advantage	High percentage of usable capacity and high read performance as well as fault-tolerance.
Fault-tolerance	Excellent - Parity information allows data to be rebuilt after replacing a failed drive with a new drive.
Application	Storage of large amounts of critical data. Generally not available in mobile configurations. As with RAID 0 Striping, although RAID 5 can be scaled to many drives there is a performance sweet spot specific to your implementation.

3.7 RAID 10

A RAID 10 volume uses four drives to create a combination of RAID levels 0 and 1. It is a striped set whose members are each a mirrored set. It provides a great balance between performance and excellent fault tolerance as it allows 2 drives to fail while still maintaining access to data but, has a low cost effectiveness. The following table provides an overview of the advantages, the level of fault-tolerance provided, and the typical usage of RAID 10.

Table 9: RAID 10 Overview

Drives Supported	4
Advantage	Combines the read performance of RAID 0 with the fault-tolerance of RAID 1.
Fault-tolerance	Excellent – Drive mirroring means that all data on one drive is duplicated on another drive.
Application	High-performance applications requiring data protection, such as video editing.

3.8 Intel VROC NVMe Hot Insert

Intel VROC (VMD NVMe RAID) has the following limitation when hot inserting an NVMe drive:

- When hot inserting multiple drives, allow enough wait time between each drive for the platform to process each event.
- When inserting an entire RAID volume, we recommend that the system be shut off, the disks inserted and then the system powered back on. If an attempt is made to hot insert all of the drives of the RAID volume, the RAID volume may enter into a Fail state because of the above-mentioned delay. If the RAID volume remains in a failed state after all of the drives are inserted, you can attempt to recover the RAID volume by using the Intel VROC GUI to reset the volume to normal. This may allow the volume to either continue to operate, or force a volume rebuild. There is a risk that the RAID volume could become inoperable.

3.9 Intel VROC RAID Write Hole Closure

The Intel VROC product family will support the ability to close the RAID Write Hole scenario in RAID 5 configurations. This applies to Intel VROC on Intel Xeon Scalable Platforms.

RAID Write Hole (RWH) is a fault scenario, related to parity-based RAID. It occurs when a power-failure/crash and a drive-failure (e.g., strip write or complete drive crash) occur at the same time or very close to each other. Unfortunately, these system crashes and disk failures are correlated events. This can lead to silent data corruption or irrecoverable data due to lack of atomicity of write operations across member disks in parity based RAID. Due to the lack of atomicity, the parity of an active stripe during a power-fail may be incorrect and inconsistent with the rest of the strip data; data on such inconsistent stripes does not have the desired protection, and worse, can lead to incorrect corrections (silent data errors).

The previous Intel VROC mechanisms implemented to address the RAID Write Hole condition encompassed a combination of Dirty Stripe Journaling and Partial Parity Logging. This implementation only partially closed the RAID Write Hole. With the Intel VROC VC product family, the RWH solution included will completely close this condition (when RWH is enabled). When RWH is disabled, the old implementation (using Dirty Stripe Journaling and Partial Parity Logging) is used.

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4 Functionality

Intel VROC provides RAID management through the BIOS that will allow for creation of RAID volumes using Intel VROC using SATA/sSATA drives as the vendor equipment allows. Configuration for each will be specified more directly within the documentation provided with your system.

The Intel VROC GUI enables the management of RAID Volumes on NVMe SSDs attached to PCI express slots managed by:

- The Intel VMD controller via Intel VROC (VMD NVMe RAID) – Intel VMD supported platforms
- The platform CPU via VROC (NonVMD NVMe RAID) – platform that a not Intel VMD capable

As well as RAID management provided for SATA drives connected to the Intel PCH in RAID mode.

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5 Pre Operating System Introduction

RAID Management through the BIOS Setup environment, included with the Intel VROC PC package, incorporates the functionality of Intel VROC and Intel VROC Pre-Operating System (Pre-OS) management components so that RAID management and control can begin within the BIOS Setup directly.

This enables the creation of RAID Volumes that can be assembled in advance of installation of an Operating System. This guide will also cover the instructions of how to load the specialized F6 Windows drivers within the Operating System during installation to utilize this feature.

Please refer to the documentation provided with your system for the exact configuration details for enabling Intel VMD controller and setting the PCH into RAID mode. There will be a generalized series of instructions provided based on one of the Intel Xeon Scalable Platform Customer Reference Board (CRB) as a primer.

5.1 Navigating the Pre Operating System

The BIOS Setup environment is accessed during a system start or Power on Self-Test (POST). The option to access the Setup Menu does vary depending on manufacturer, the examples in the guide will all be presented with the value as F2.

5.2 Enabling Intel VROC (SATA RAID) for SATA/sSATA

Intel VROC (SATA RAID) allows for the creation of RAID volumes through the UEFI HII interface, which is part of the UEFI driver package, and is included with the platform BIOS. The Intel VROC (SATA RAID) UEFI HII can be accessed via the BIOS Setup environment. To enable the ability to create RAID volumes, the steps below have been created using an Intel Customer Reference Board (CRB). Please refer to the instructions that have been supplied by the user's platform BIOS vendor, as those instructions may differ from the set below.

Step 1: Immediately following the POST, select the option that will allow for the user to access the BIOS setup menu. This example uses <F2>.

Step 2: Using the arrow keys, move the cursor to highlight the menu option **Advanced** and press <Enter>.

Step 3: Within the Advanced menu, use the arrow keys to navigate to the item **Mass Storage Controller Configuration** and press <Enter>.

Step 4: Within Mass Storage Controller Configuration, there are two menu options. The first is the sSATA Controller for Ports 0-5, and the second is the SATA Controller for Ports 0-7. Depending where you have the devices connected, they may show in either menu. It is best to check each independently. To do so, highlight the desired controller and press <Enter>.

Step 5: Once the desired controller(s) have been identified, to enable the controller for RAID mode, the option by default will be lit up and set as AHCI. Press <Enter> to open a selection menu. There will be 3 options. One will disable the controller completely. The second is legacy AHCI mode. The third is RAID mode, which will enable the Intel VROC (SATA RAID) PreOS. Highlight RAID mode, and press <Enter>.

Step 6: There will be a small notification in the bottom right hand corner indicating that the configuration has changed. For these changes to be activated, a **Save Changes and Exit** command will need to be given. Press <F10> to initiate **Save Changes and Exit**.

Step 7: There will be a pop up window asking to confirm "Save configuration changes and exit? Press <Y> to continue in order to confirm and reboot the system.

Step 8: Use <F2> again after POST to enter the BIOS.

Step 9: Navigate to Advanced, and press <Enter>.

Step 10: Navigate to **PCI Configuration** and press <Enter>.

Step 11: Navigate to **UEFI Option ROM Control** and press <Enter>.

Step 12: The UEFI Option ROM Control should now show the newly enabled controller below the header, **Storage Controller.**

5.3 Enabling Intel® VMD

Intel VROC (VMD NVMe RAID) allows for the creation of RAID volumes through the UEFI HII interface, that is part of the UEFI driver package, and is included with the platform BIOS. The Intel VROC (VMD NVMe RAID) UEFI HII can be accessed via the BIOS Setup environment. With Intel VROC (VMD NVMe RAID), Intel VMD will also need to be enabled on your new platform. This series of steps are provided based on an Intel Customer Reference Board (CCB). Please refer to the instructions that have been supplied by the user's platform BIOS vendor as those instructions may differ from the set below.

Step 1: Immediately following POST, select the option that will allow the user to access the BIOS setup menu. This example uses <F2>.

Step 2: For the Intel CRB reference BIOS, the user will want to use the arrow keys to move the cursor to Advanced (it will become highlighted) and press <Enter>.

Step 3: Using the arrow keys, move the cursor to PCI Configuration and press <Enter>.

Step 4: Using the arrow keys, move the cursor to Volume Management Device and press <Enter>.

Step 5: This step varies depending on physical configuration of the system. The reference system has 4 direct connections from the backplane to the motherboard using Oculink cables for NVMe devices. Using the arrow keys, move the cursor to CPU1 Oculink Volume Management and press <Enter>. Toggle the selection from Disabled to Enable, and press <Enter> to select.

Step 6: VMD Port 3C (PCIe SSD0) and VMD Port 3D (PCIe SSD1) by default will also be Disabled. Navigate to each in turn. Press <Enter>, and toggle the Disabled setting to Enabled and press <Enter> to set selection.

Step 7: Repeat steps 5 and 6 on CPU2 Oculink Volume Management.

Step 8: Save settings by pressing <F10> to Save Changes and Exit.

Note: Please consult the user's Platform BIOS manufacturer documentation for a complete list of options that can be configured.

Note: There are some additional VMD considerations that must be taken for installations of Windows 10 RS5 and Windows Server 2019. Please refer to the Release Notes that have accompanied the package for the additional steps required for successful installation requirements

5.4 Creating a RAID Volume for a Boot Disk Using Intel® VROC HII

The following instructions are for creating a bootable RAID volume using the Intel VROC UEFI HII. This procedure should only be used for a newly built system or for reinstallation of the operating system. It is advised to use the Intel VROC GUI within the Windows operating system for the creation of RAID volumes after the operating system is installed.

Note: Please consult the user's platform documentation for instructions on how to enter into the Intel VROC HII interface.

The following assumptions have been made:

1. It is known how to enter into the appropriate platform BIOS setup menus.
2. The Intel VMD functionality has been enabled.
3. The appropriate Intel VROC RAID Upgrade Key has been installed.
4. The appropriate number of matching NVMe SSDs have been plugged into the enabled Intel VMD controller.

Step 1: Enter into the BIOS configuration setup menu to access the Intel VROC UEFI HII interface.

Step 2: Navigate to and select **Intel® Virtual RAID on CPU**

Step 3: Navigate to and select **Create RAID Volume**

Step 4: Type in a volume name and press the <Enter> key, or press the <Enter> key to accept the default name.

Step 5: Select the RAID level by pressing the <Enter> key, and using the arrow keys to scroll through the available values. Highlight the desired RAID type and press <Enter> to set the RAID type.

Step 6: **Only data volumes are supported in this configuration, boot volumes that are spanned are not supported.**

To enable spanned volumes, use the arrow key to highlight the < > bracket and press <Enter>. This will open a small selection menu. Navigate the cursor to the X and press the <Enter> to enable volume spanning. To disable, you would set the value back to blank and press <Enter> to save the value.

Step 7: Using the arrow keys, select the drives one by one by highlighting the < > bracket on the line next to that drive's port number. Press <Enter> to open the selection menu, which will be set to blank or off status. Navigate to highlight the X and press <Enter> to include that drive within the array.

Step 8: Repeat step 7 for each drive required within this array.

Step 9: Unless the user has selected a RAID 1, select the strip size by using the arrow keys and pressing <Enter> to open the options menu. Utilize the arrow keys to select the desired strip size and press <Enter> to save the value.

Note: RAID 1 is set at default strip size value of 128k and cannot to be modified.

Step 10: Select the volume capacity and press the <Enter> key. The default value will be displayed as the maximum capacity available with the drives selected. The value is calculated in bytes. A 700GB drive would use the following math: (700 * 1024 = 716000).

Note: Unless specifically selected, the default volume capacity will be 95% of the available space. This is to support disk coercion.

Step 11: Navigate to **Create Volume** and press <Enter>

Step 12: The user will then be returned to the **Intel® Virtual RAID on CPU** screen and the newly created RAID volume will be listed just below the text **Intel VROC Managed Volumes**:.

Other drives or unused portions of drives will be listed under Non-RAID Physical Disks. These may be used to create additional RAID volumes.

Step 13: To exit the user interface, press <Esc>. Press <Esc> again, the user will be presented with the following message: "Changes have not saved. Save changes and exit? Press 'Y' to save and exit, 'N' to discard and exit, 'ESC' to cancel". Press <Y> to save and exit.

Note: Not saving at this time will discard the changes made, including all changes and configuration settings for the RAID array.

Step 14: To save and reboot, in order to begin operating system installation, press <Esc> to return to the Main Menu. Navigate to select Reset and press <Enter> to reboot the system back to the boot menu.

Note: For RAIDs 1, 5 and 10 the system will not automatically initialize these volumes via the UEFI. This will need to be accomplished once the Operating System has been installed.

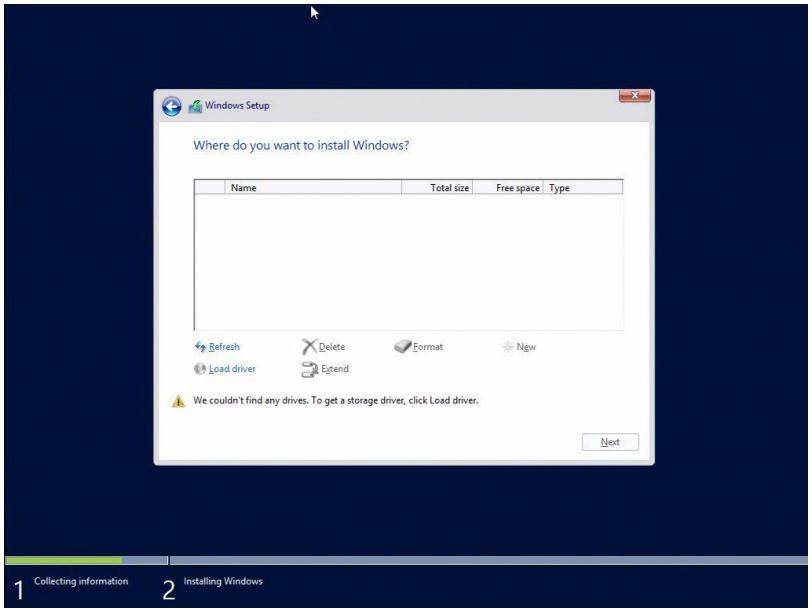
5.5 Installing Windows Server 2019 on a RAID Volume

With RAID boot volumes through Intel VROC available, additional drivers are required in order to properly install a Windows operating system. This is a brief guide to show you the slight difference in order to introduce the F6 Drivers appropriate to utilize your BIOS created RAID volume as a system disk.

The following assumptions have been made:

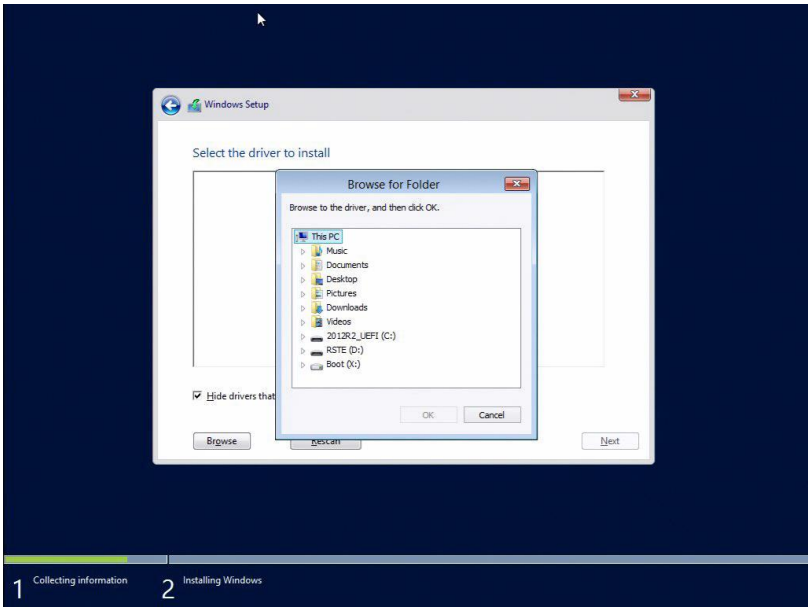
- Intel VMD has been configured and enabled.
- Intel VROC has been utilized and the RAID volume has been created

Image 1: Installation Destination Selection



1. Click ***Load driver***.
2. Click ***Browse***.

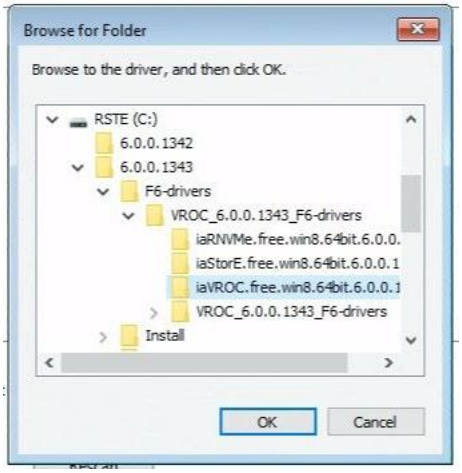
Image 2: Browse Options View



3. Navigate to where you have the correct F6 driver stored. iaStorE drivers are for SATA and sSATA drives, iaVROC will be for NVMe drives (when attached to the Intel VMD controller).

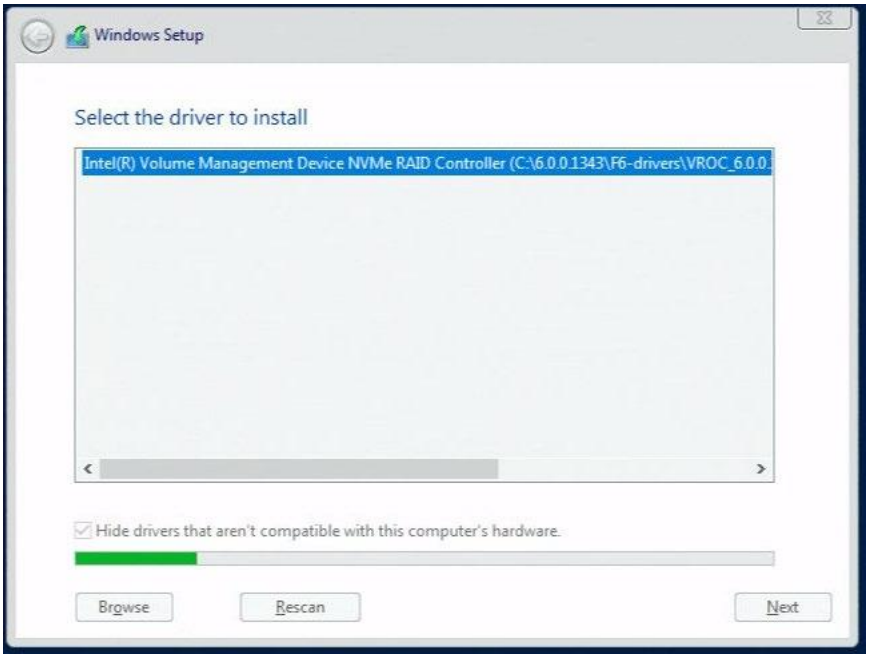
   Note: iaRNVMe is the driver designated for Intel platforms that do not support VMD technology.

Image 3: Drivers Selection



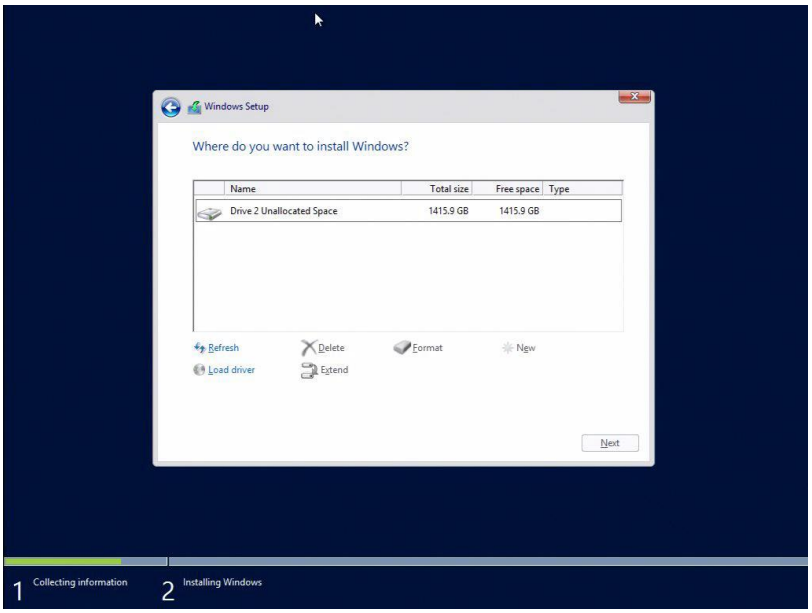
4. Highlight the selected driver and click ***OK*** to install. It requires several minutes to complete installation of the selected driver. Please reference the guidance on VMD enabling for installation of Windows 10 RS5 and Windows Server 2019 provided in the release notes to prevent this step from timing out.

Image 4: Select Driver to Install



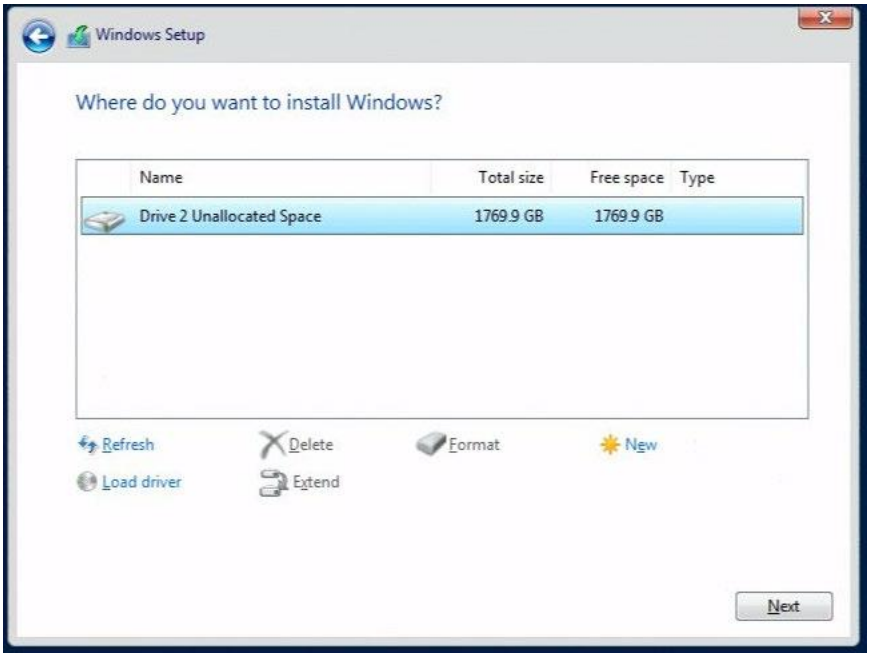
5. The RAID Volume should now appear once the driver has installed. Select the volume and proceed with your operating system installation for Windows as normal. If the drive does not immediately appear, use the Refresh tool to rescan the system for the RAID volume and proceed.

Image 5: Destination Selection Window Refreshed With Drivers Installed



6. After installing the driver, the selection screen may be blank. Click ***Refresh*** to have the system rescan and show your RAID volume.
7. Select the desired volume and click ***Next*** to proceed with the installation of your Windows operating system.

Image 6: Drive Selection



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6 Installing Intel® VROC GUI

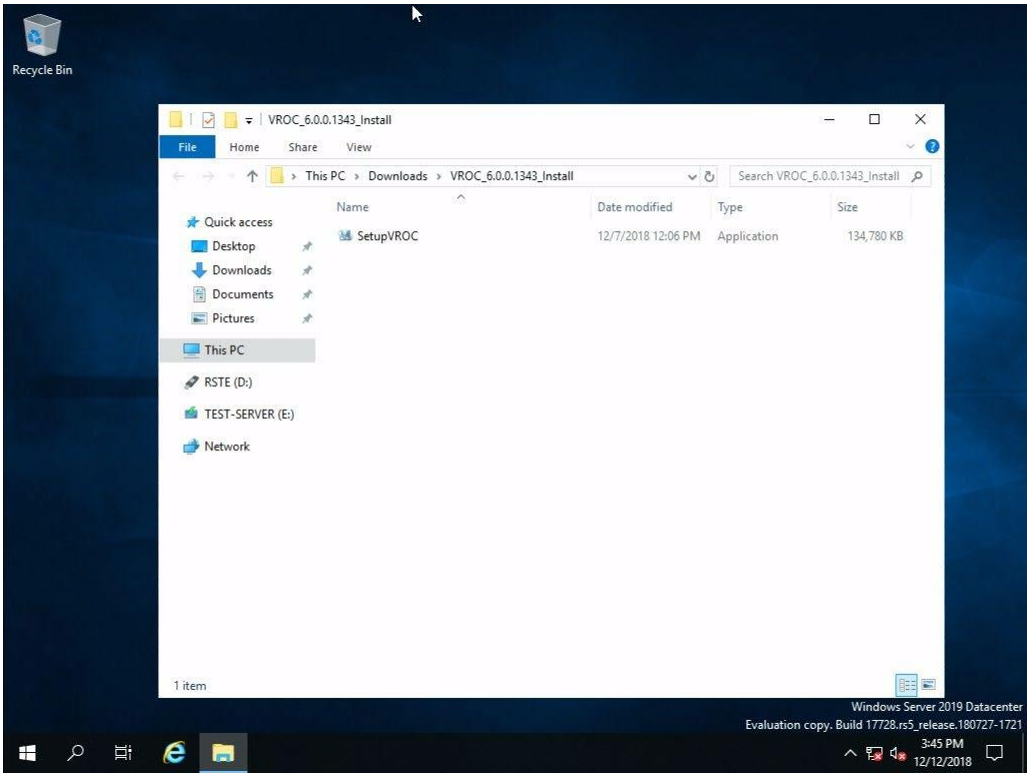
This section discusses the process of installation of the Intel VROC product family that will allow for fully integrated management of the disks installed on your Windows system. This portion of the demonstration has been performed using Windows Server 2016 as the operating system. The GUI interface will appear the same in all Windows operating systems.

6.1 Installing Intel VROC Release Package

This installation example assumes you are installing Intel VROC for the first time. Installing Intel VROC can be accomplished by executing the installation executable.

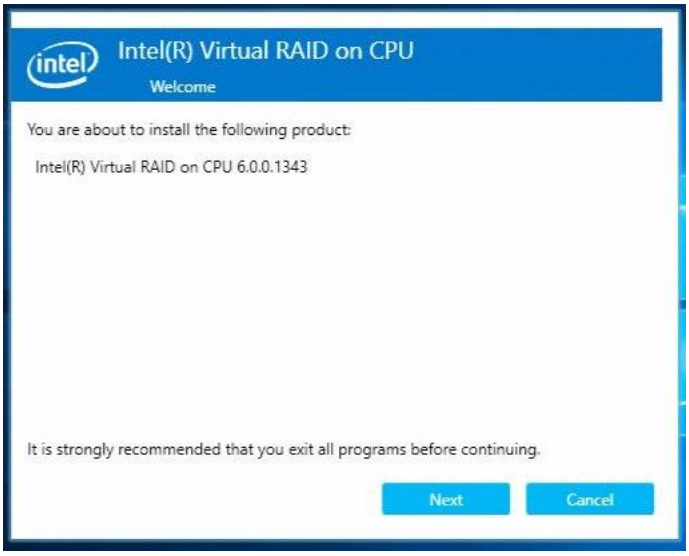
1. In this example you right mouse click ***SetupVROC.exe*** and run as administrator to launch the installer.

Image 7: SetupVROC.exe



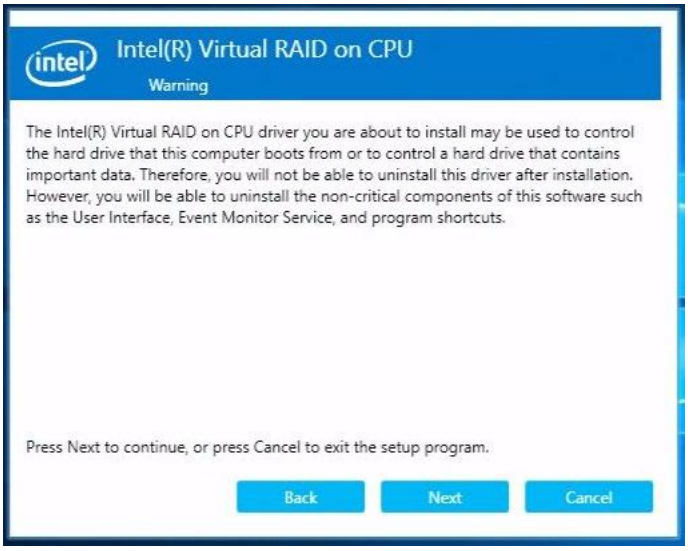
2. The first window that will appear is the Intel® Rapid Storage Technology enterprise “Welcome” window. Select the “Next” button to continue.

Image 8: Installer Wizard Welcome



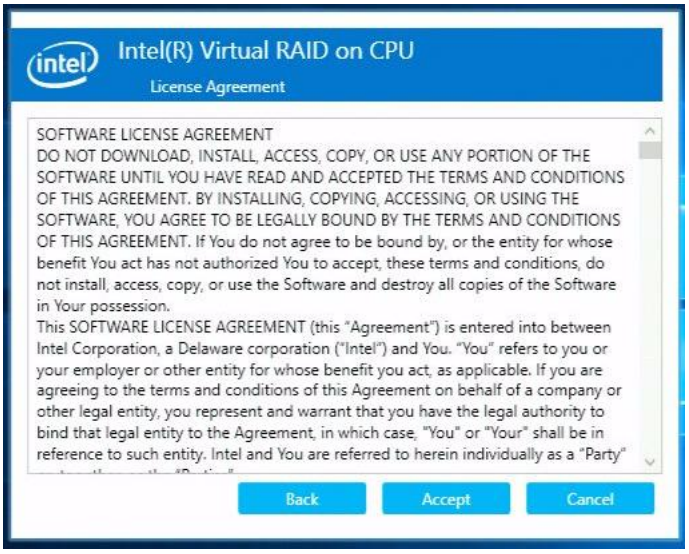
3. The second window is the “Warning” window. Select the “Next” button to continue.

Image 9: Warning



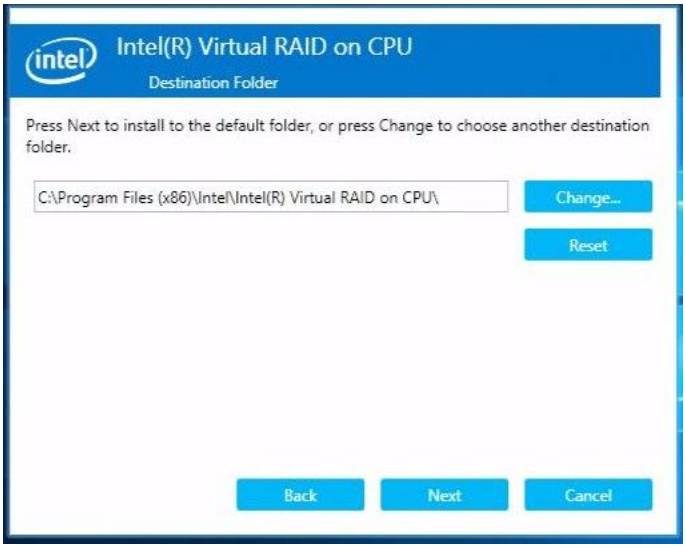
4. Next is the End User License Agreement. Select “Accept” to accept and continue. The full text of this agreement is included in the Appendix.

Image 10: End User License Agreement



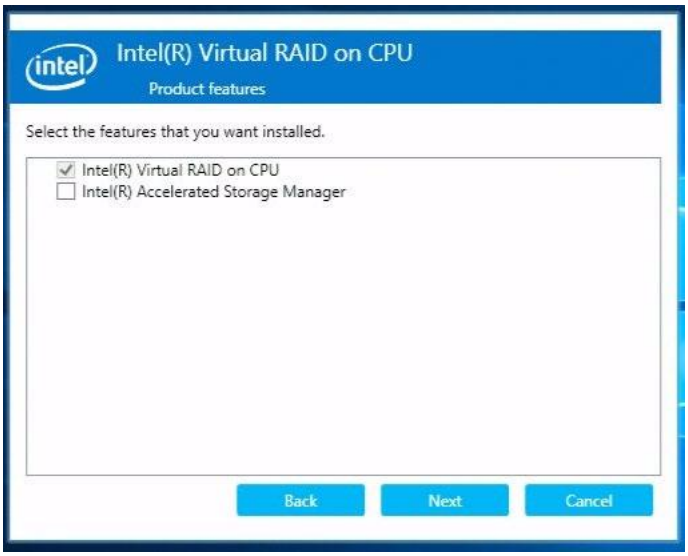
5. The next window is the “Destination Folder”. Select “Next” to install to the default folder, or press “Change” to choose another destination folder.

Image 11: Destination Folder for Installation



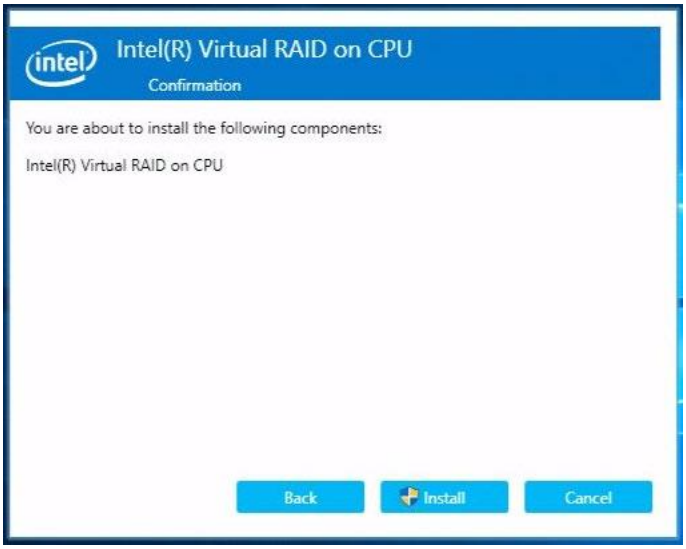
6. The next window is “Product Features”. Select the products desired, then press “Next” to continue. Intel® Accelerated Storage Manager can be installed at the same time as Intel® VROC.
   Note: ASM installation and configuration is covered within the Intel Accelerated Storage Manager Windows Administration Guide.

Image 12: Product Feature Selection



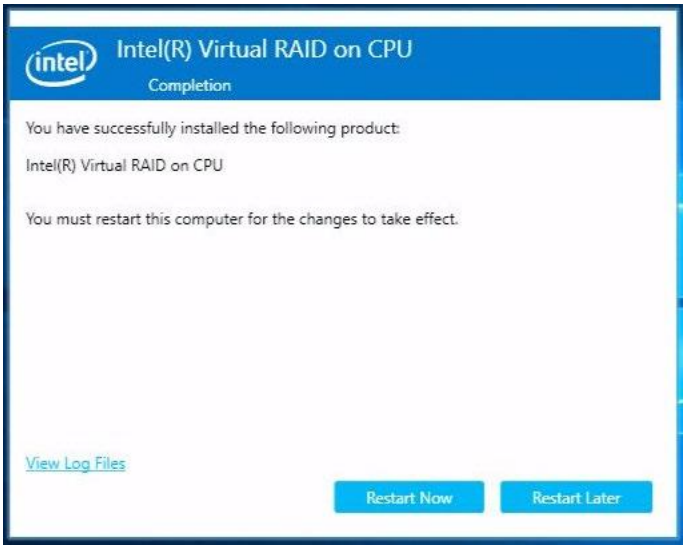
7. This is the “Confirmation” window. Press “Install” to install the selected components.

Image 13: Confirmation



8. The final window is “Completion”. It is important at this point to restart the system to complete the installation process. Select “Restart Now” to complete the installation process and reboot the system.

Image 14: Completion



6.1.1 Windows Server 2012 R2 Updates

With the release of Intel VROC 6.0 and subsequent maintenance updates of VROC, additional updates must be performed upon systems running Windows Server 2012 R2. These KB articles provide the correct updates in the **required order** to enable installation of the VROC user interface.

Note: Newer versions of KB articles may be available after publishing the User Guide, please use the most recent updates.

1. KB4054566
2. KB2999226
3. KB2919355
4. KB3172729

6.1.2 Microsoft .NET Framework 4.7.2

Operating systems that do not already have the .NET Framework updated such as Windows 10 RS5 and Windows Server 2019 will require manual update to Microsoft .NET Framework 4.7.1 or later. The following links will provide access to Microsoft .NET Framework 4.7.2. You may use the online or offline installer as appropriate to your system.

Offline Installer
Web Installer

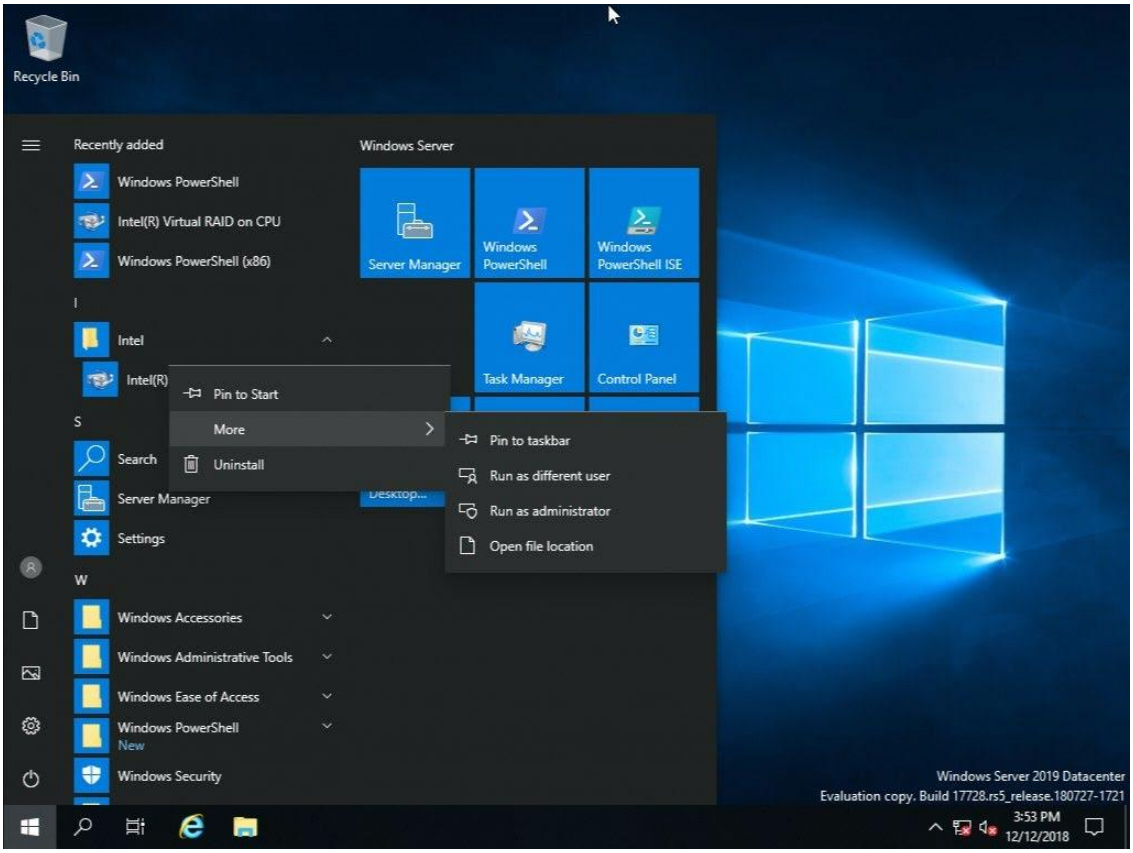
6.1.2.1 Offline Installation Instructions for Microsoft .NET Framework 4.7.2

1. Download zip file from Offline Installer
2. Copy zip file to USB
3. Copy zip file to Downloads folder on target system.
4. Unzip Installer
5. Run .exe as Administrator.

6.2 Opening the Intel VROC GUI

Launch the Intel VROC GUI as shown in the example below, by opening the Windows start menu and locating the application. Then click ***Intel® Rapid Storage Technology enterprise***. You will need to select ***Run as Administrator*** to access the application and utilize the features. This includes use on the account Administrator.

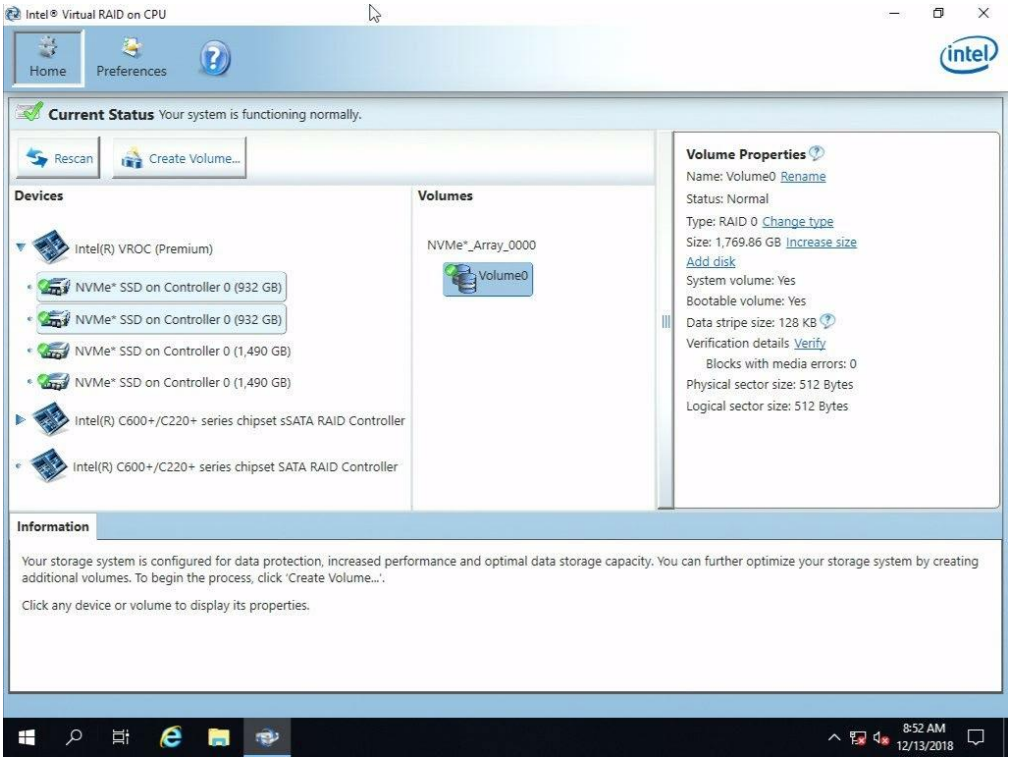
Image 15: Start Menu Location of Intel VROC



The GUI will open to the “Home” page.

Note: The Intel VROC Upgraded Key installed on this system is the Premium Upgrade Key. This will enable all possible RAID functions and variants. You can see the status (Premium) listed next to the Intel VROC controller. For lists of what features are available with other keys and devices, please refer to the documentation provided with your system, and the Intel® VROC and Intel® VROC for Windows TPS.

Image 16: GUI Home



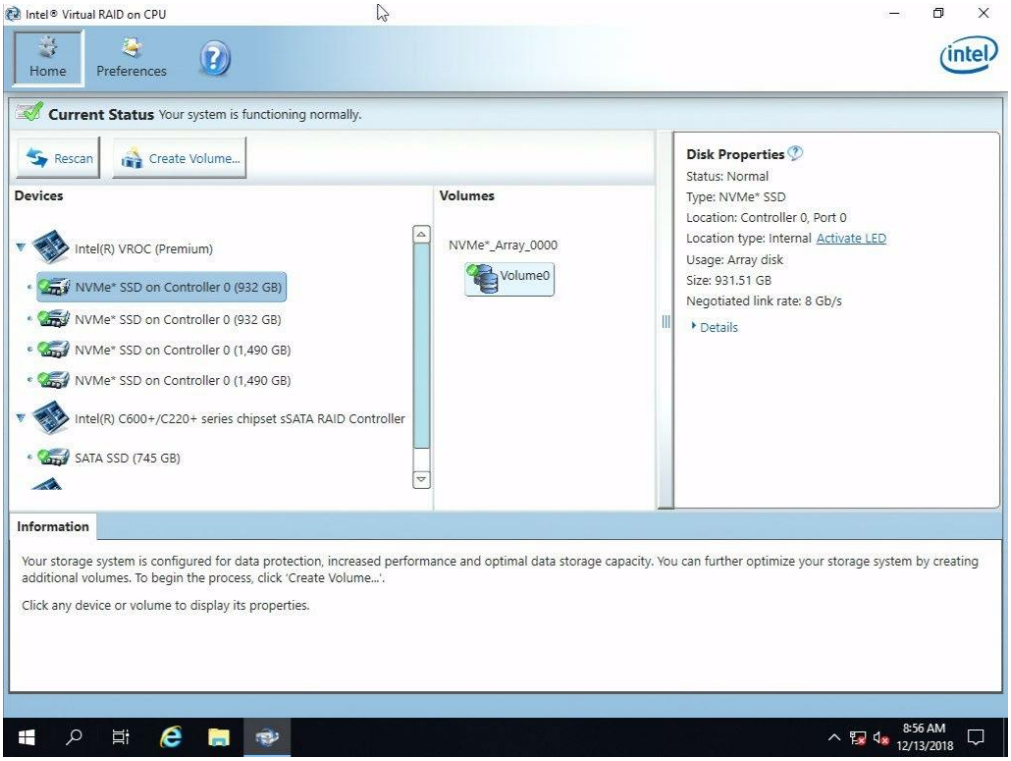
6.3 The Intel VROC GUI Components

The home page is divided into several window panes; each used to convey information to the user depending in the selection made.

1. The “Devices” pane (to the left) will show the devices that are connected to the controller. This will be further broken down into sections based on Intel VROC (SATA RAID) Controller, Intel VROC Controller, or Intel virtual RAID controller (for Intel VROC (NonVMD RAID)) should drives be attached within those categories. If the controller is enabled, but there are no associated drives, that controller has a dot rather than an arrow next to it. (The SATA controller has no devices in the image below.) Order of precedence will be granted to SATA controllers with devices attached.
2. The “Volumes” pane (in the middle) shows the RAID Arrays and RAID Volumes being managed by Intel VROC family of products.
3. The “Properties” pane (to the right) will show the Properties of the component that is high-lighted in either the “Devices” pane or the “Volumes” pane.
4. The “Information” pane (at the bottom) will show information relative to the current status of the host controller, the devices attached to it or the Array and Volume.

Note: The arrow is pointing to a help menu option that will explain, in depth, additional information regarding the disk properties listed and what each item listed, within the Disk Properties pane, represents.

Image 17: Devices Pane

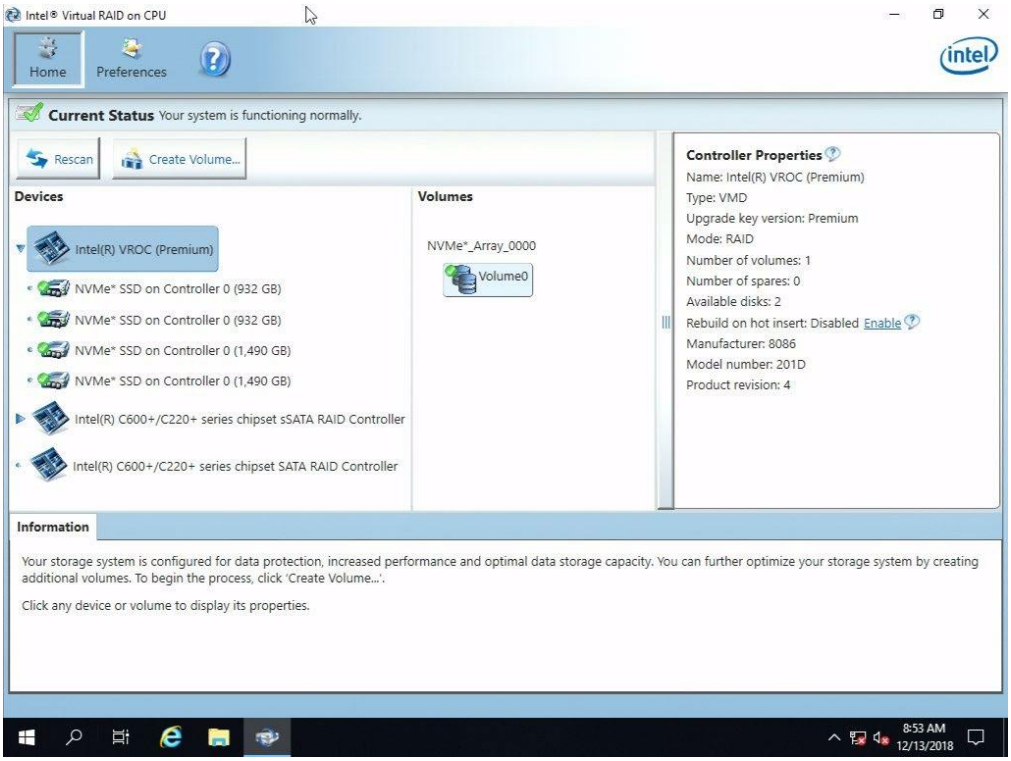


6.4 Devices

The following screenshots show the different information presented in the “Properties” window pane.

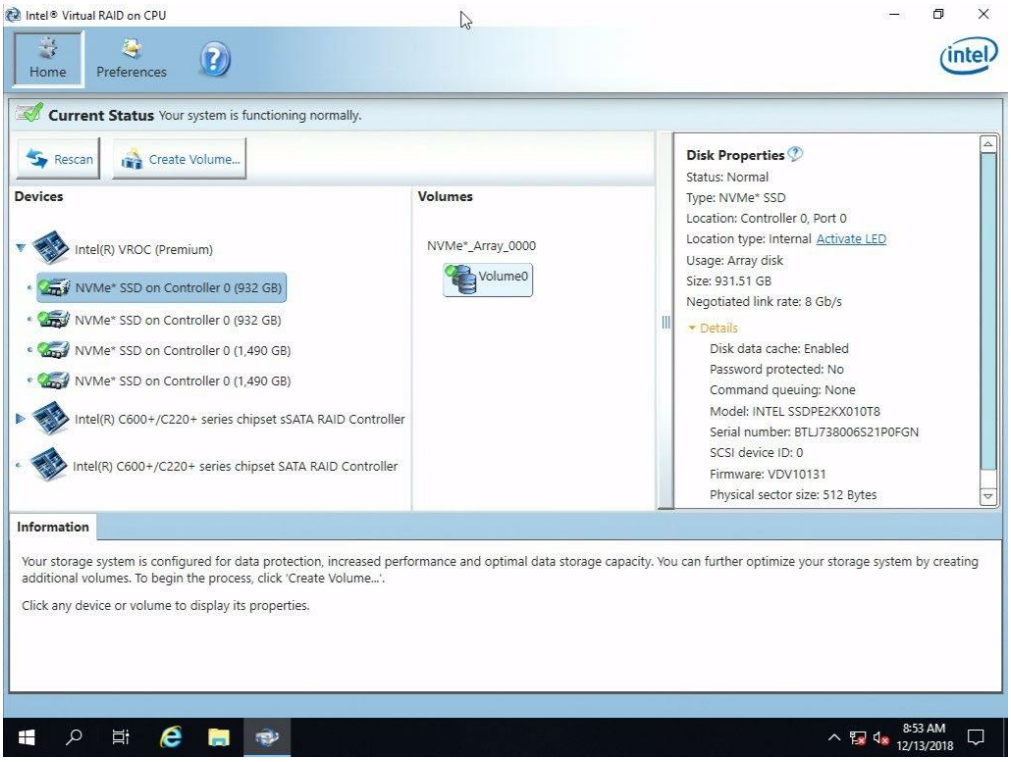
1. Under **Devices** in the home page of the GUI (to the left), selecting the NVMe controller will display the **Controller Properties** in the properties window pane to the right.

Image 18: Controller Properties



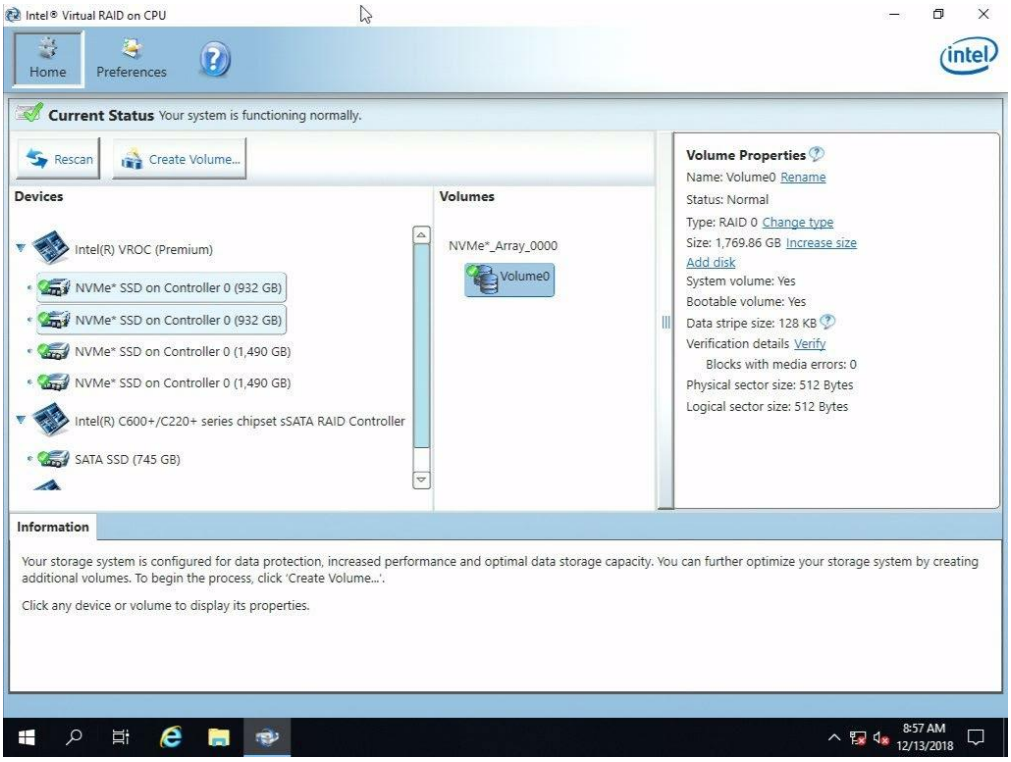
2. By selecting a specific drive, the **Disk Properties** will appear to the right in the properties window pane.

Image 19: Disk Properties



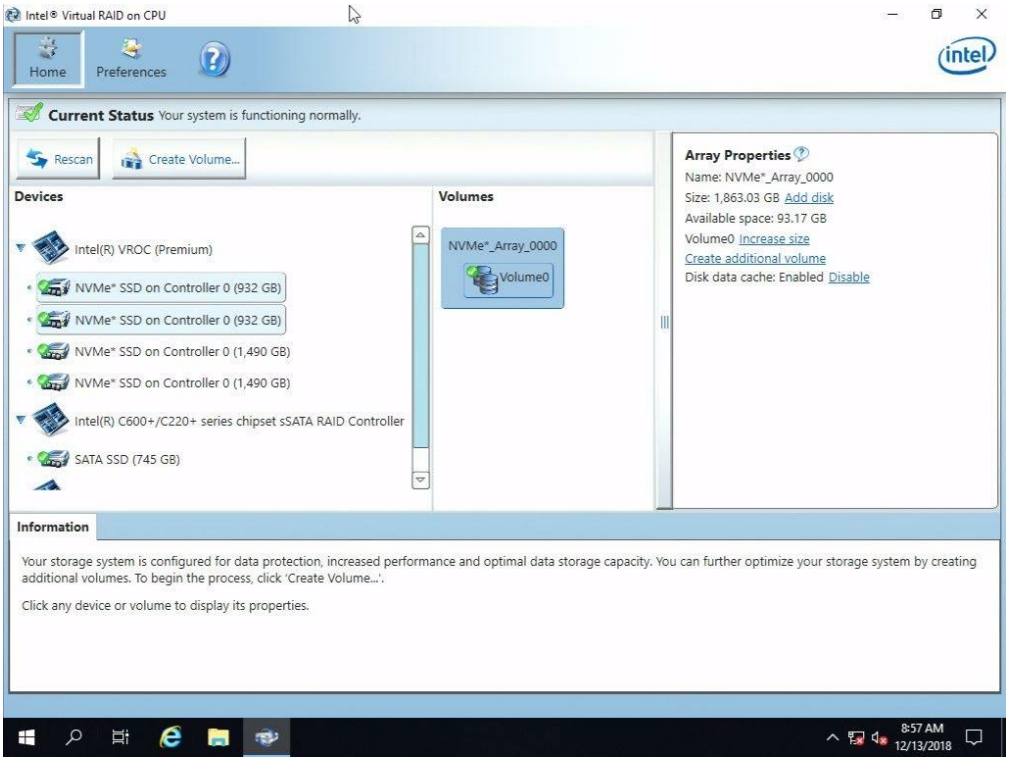
3. By selecting a RAID Volume, the **Volume Properties** will appear to the right in the properties window pane.

Image 20: Volume Properties



4. By selecting the Array, the **Array Properties** will appear to the right in the properties window pane.

Image 21: Array Properties



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7 Volume Creation

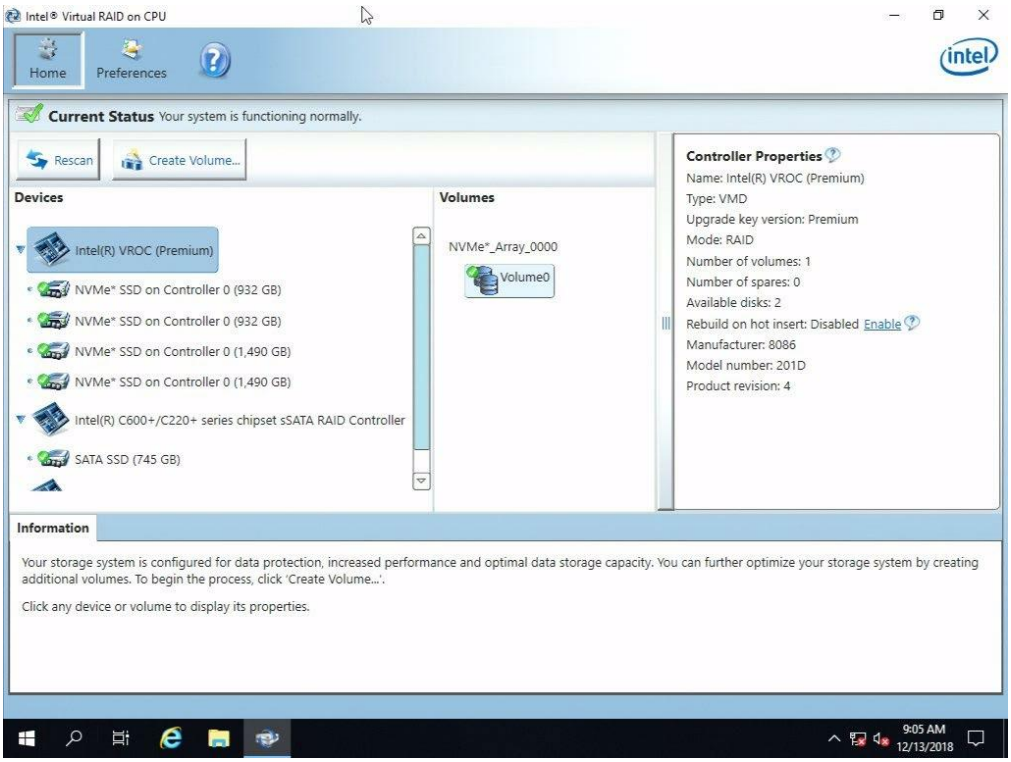
The following will provide guidance on utilizing the Intel VROC GUI in the creation of a RAID volume. It will have the full set of drivers installed so that it will reflect the nature of the System drive on SATA in addition to the NVMe disks that will be employed as a data volume for the example. Only one example will be given as the process is extremely similar in each RAID type, it only varies mildly based on number of disks to be employed.

7.1 Create a 2 Drive RAID 0 Data Volume

The following example will step through the process of creating a 2 drive RAID 0 data volume.

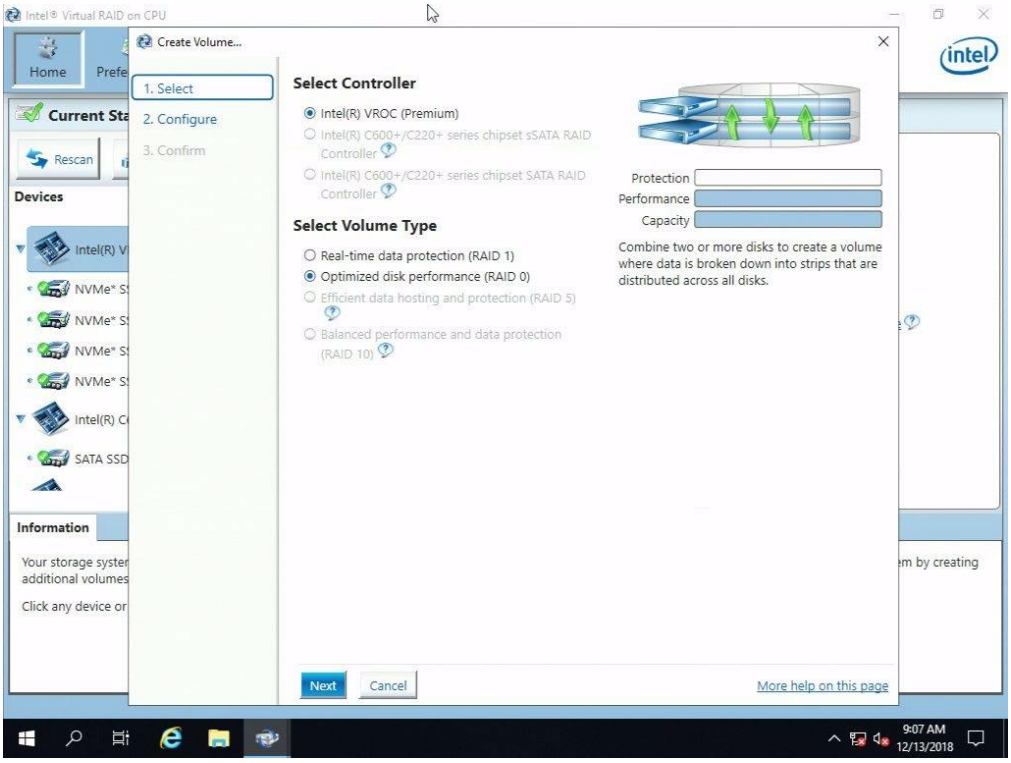
1. Within the Home page select **Create Volume** to begin the process. The arrow below is pointing to the Create Volume button.

Image 22: Create Volume



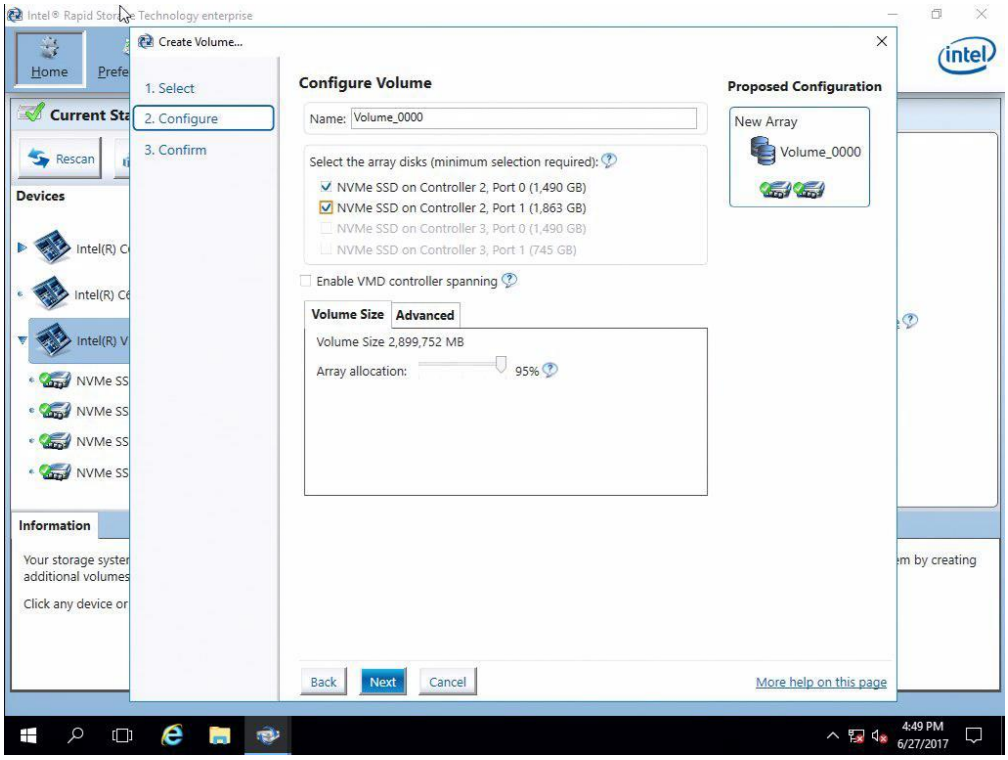
2. Select the **NVMe Devices** controller if not already selected. Next select **Optimized Disk Performance (RAID 0)**. Then, select **Next** to continue.

Image 23: Select Controller



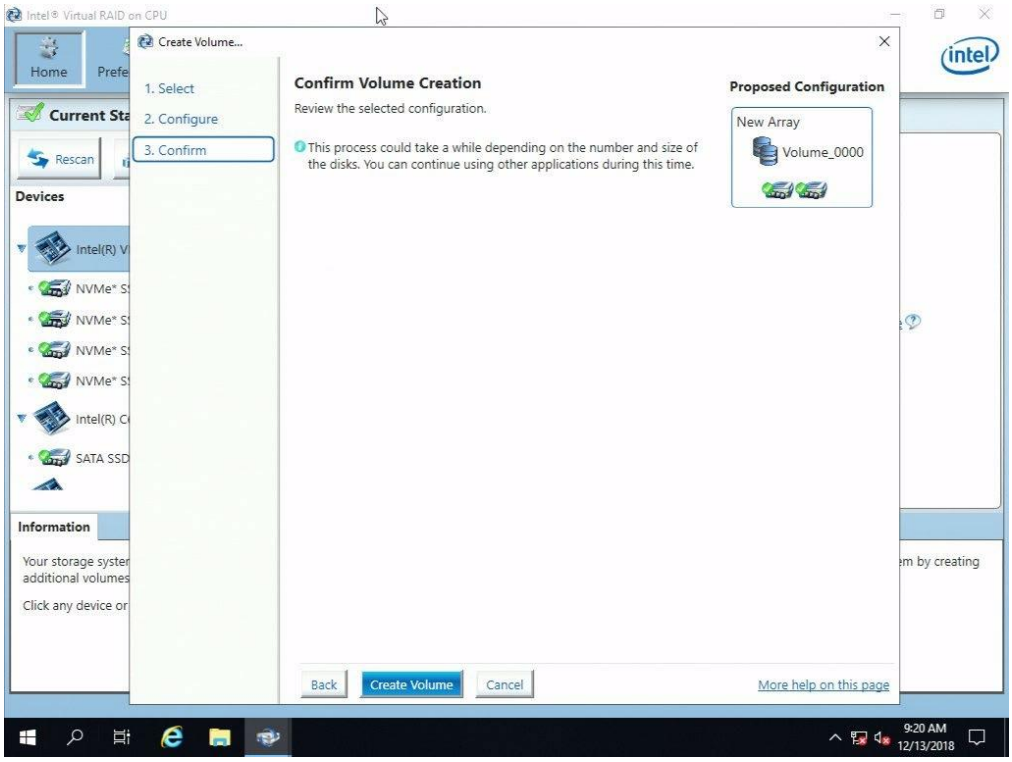
3. To configure the volume, you can first specify the **Name** of the volume. In this example it has been left as default (**Volume_0000).** Next select two drives available to be included in the volume. Then click ***Next.***
   a. For this segment, we are creating a new volume, select No in response to the statement regarding adding this volume to an existing array.
   b. Select the two remaining available disks for the new data volume.
   c. If the selected drives are on different Volume Management Domains or CPUs, check the box that reads Enable VMD controller spanning. This feature can only be used with data volumes. This will enable selection of additional drives if they are engaged on the system.

Image 24: Configure Volume



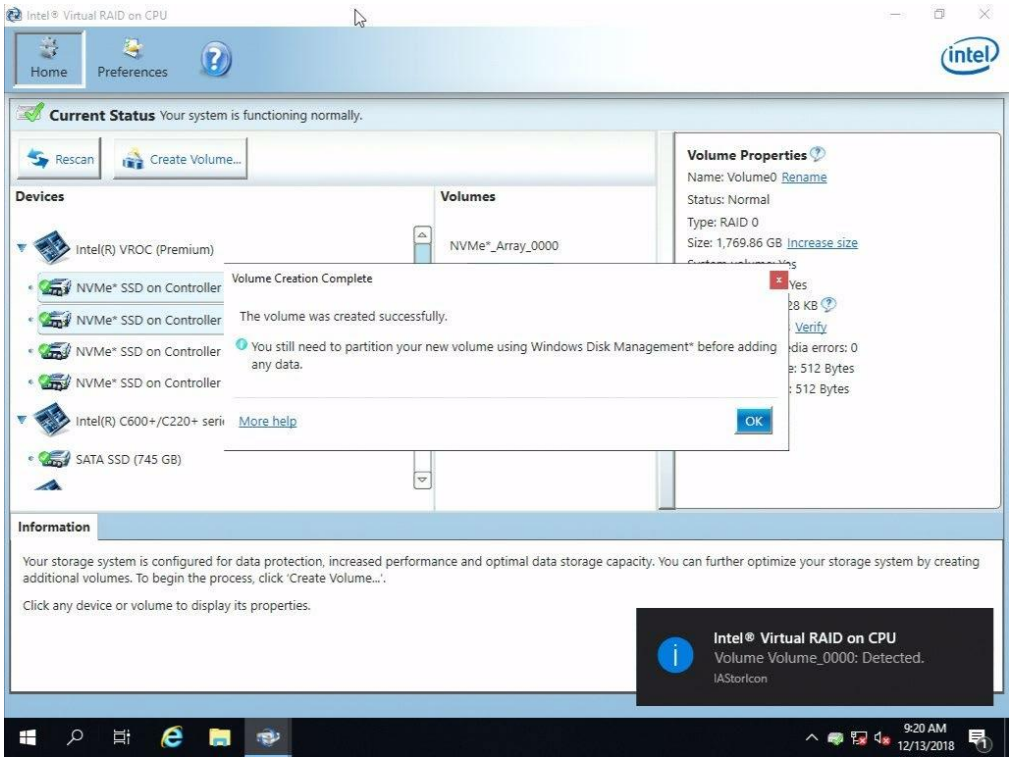
4. Click ***Create Volume***.

Image 25: Confirm Volume Creation



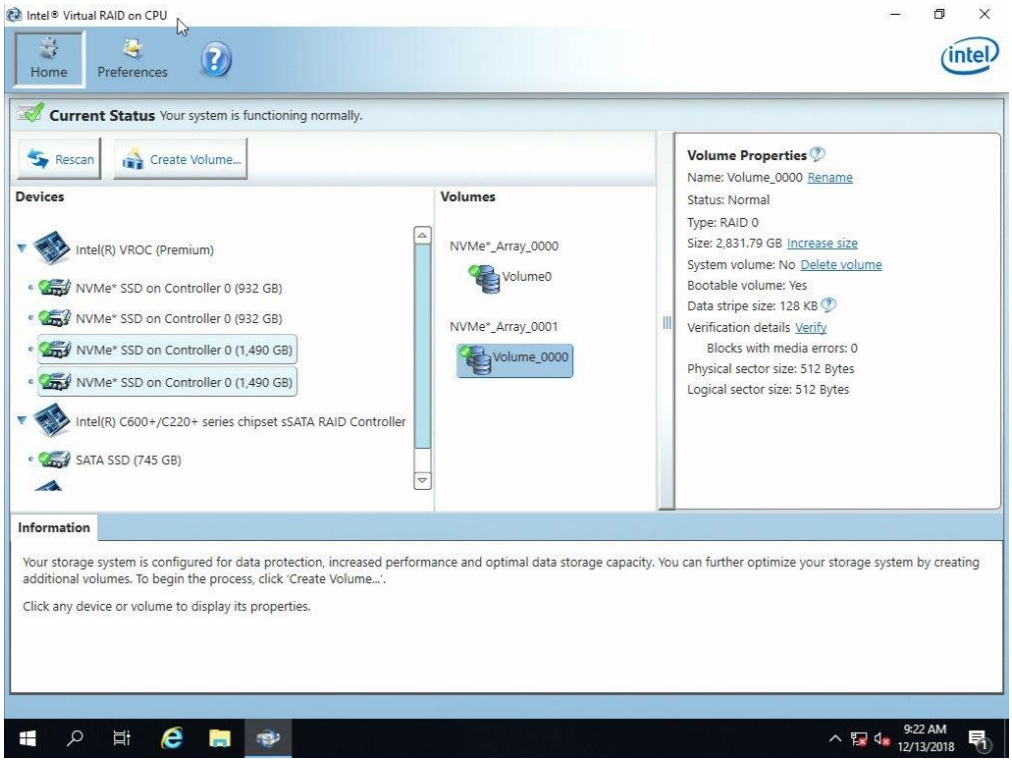
5. Click ***OK*** to continue. This will complete the volume creation process.

Image 26: Volume Creation Complete



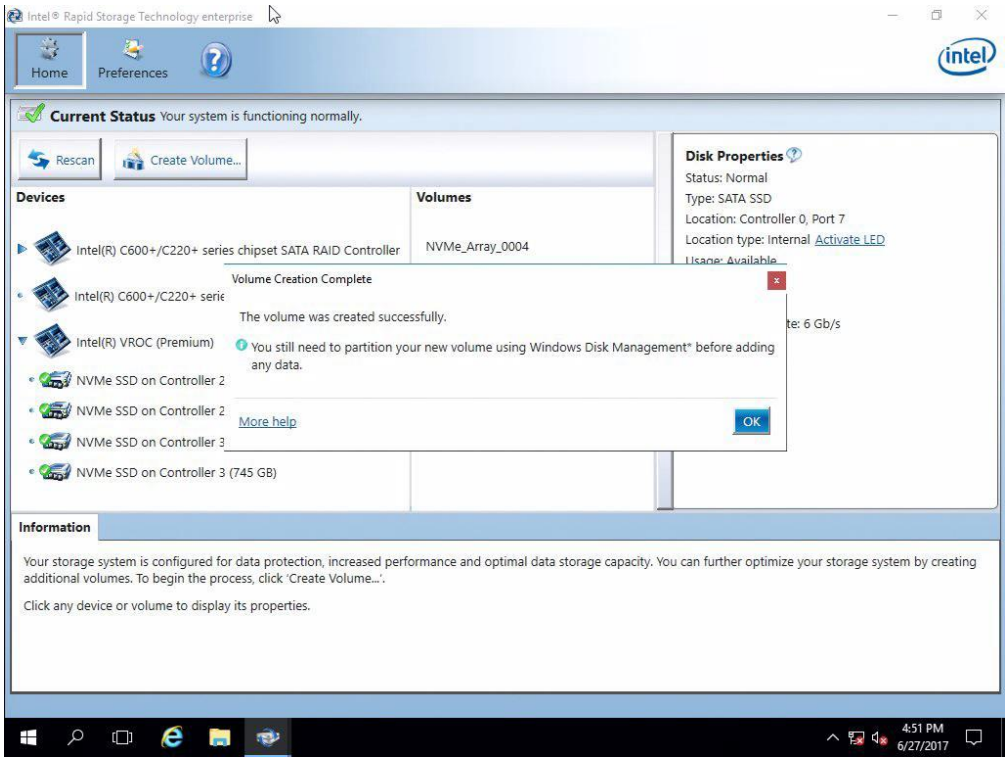
6. RAID volume (**Volume_0000**), the “Properties” pane (right) will refresh to show the current status, properties and available options of the newly created RAID volume.

Image 27: Volume Properties



7. Formatting and mounting of the volume will still be required within Disk Management just as with any new drive added within a Windows environment.

Image 28: Volume Creation Complete

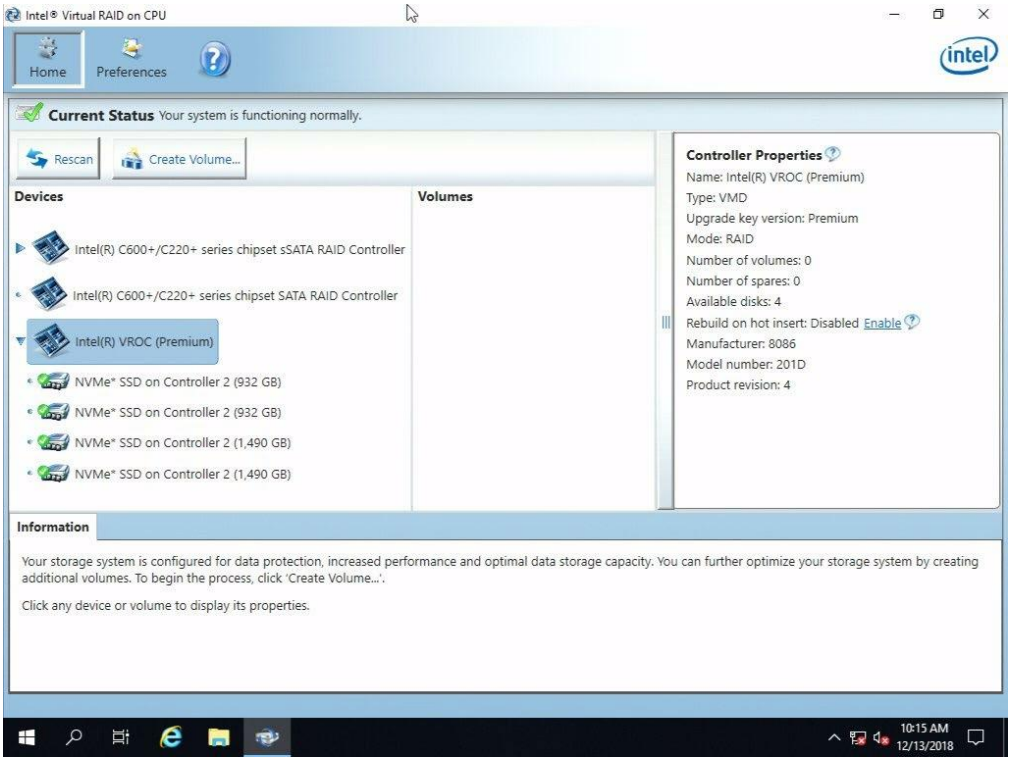


7.2 Create a 3 Drive RAID 5 Data Volume

The following example will step through the process of creating a 3 drive RAID 5 data volume.

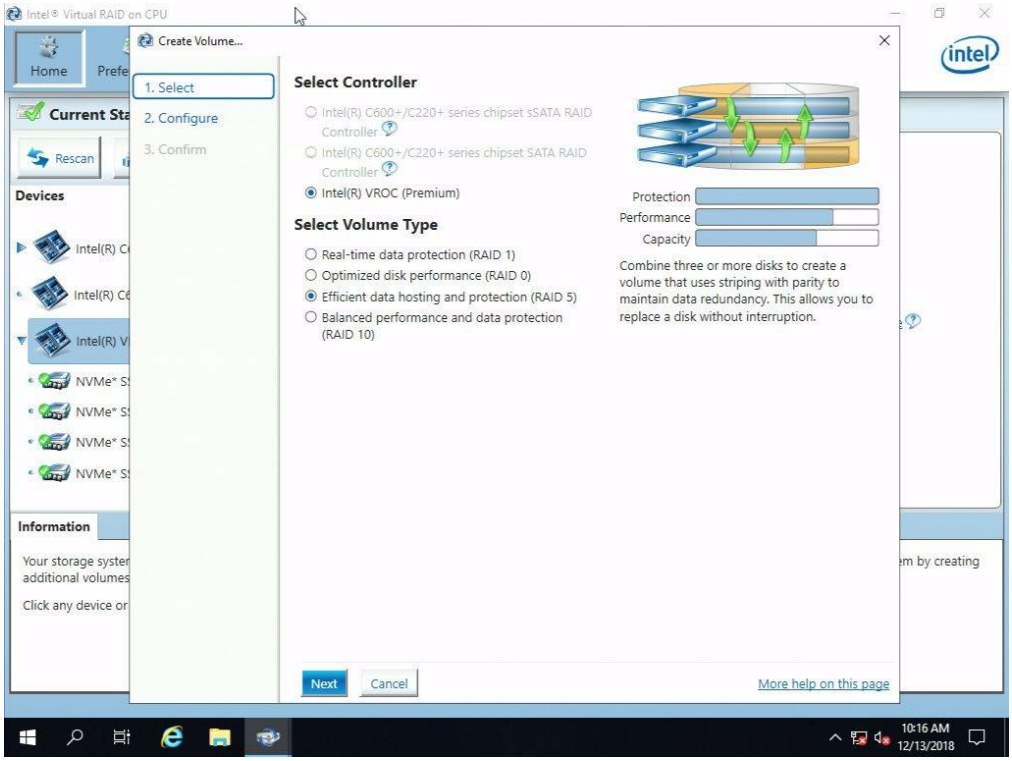
1. Click ***Create Volume...*** to begin.

Image 29: Create Volume



2. Select the **NVMe Devices** controller if not already selected. Next select **Efficient data hosting and protection (RAID 5)**. Then, select **Next** to continue.

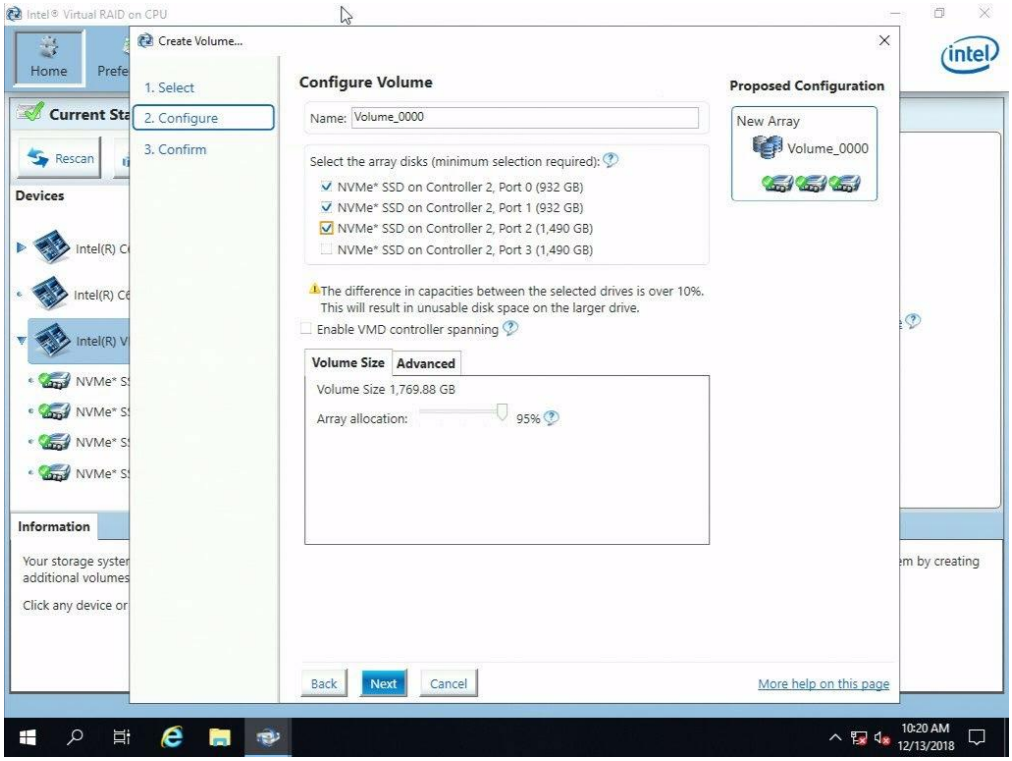
Image 30: Select Controller



3. To configure the volume, you can first specify the Name of the volume. In this example it has been left as default (Volume_0000). Next select three available drives to be included in the volume. As this system has direct connections for the NVMe drives to the board, there are 2 drives per Intel VMD controller. The volume must be spanned across them. This will light up the WARNING: RAID volume spanned across Intel VMD controllers cannot be used as bootable volume. The check in the box to enable Intel VMD controller spanning must be selected before you will be allowed to select drives from additional controllers. Then click Next.

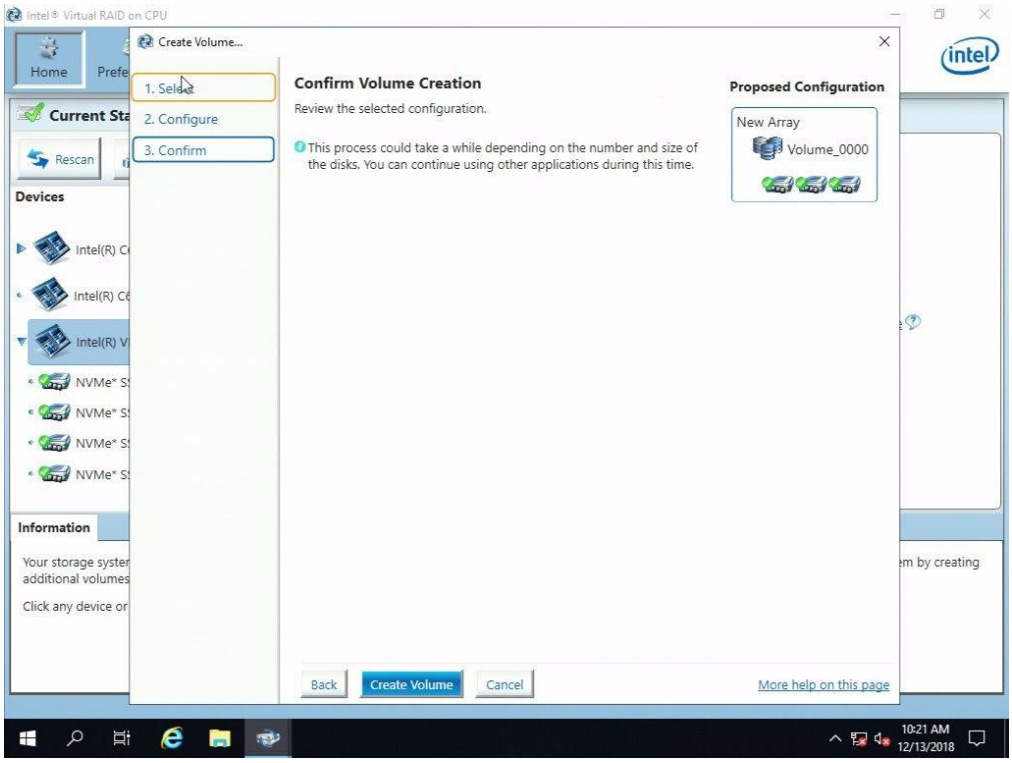
Note: With this scenario, a warning has appeared indicating that there is a difference in the size of the drives that is greater than 10%. This indicates that there will be unused space on the larger drive. To avoid this, use drives of the same size if possible for the new array.

Image 31: Configure Volume



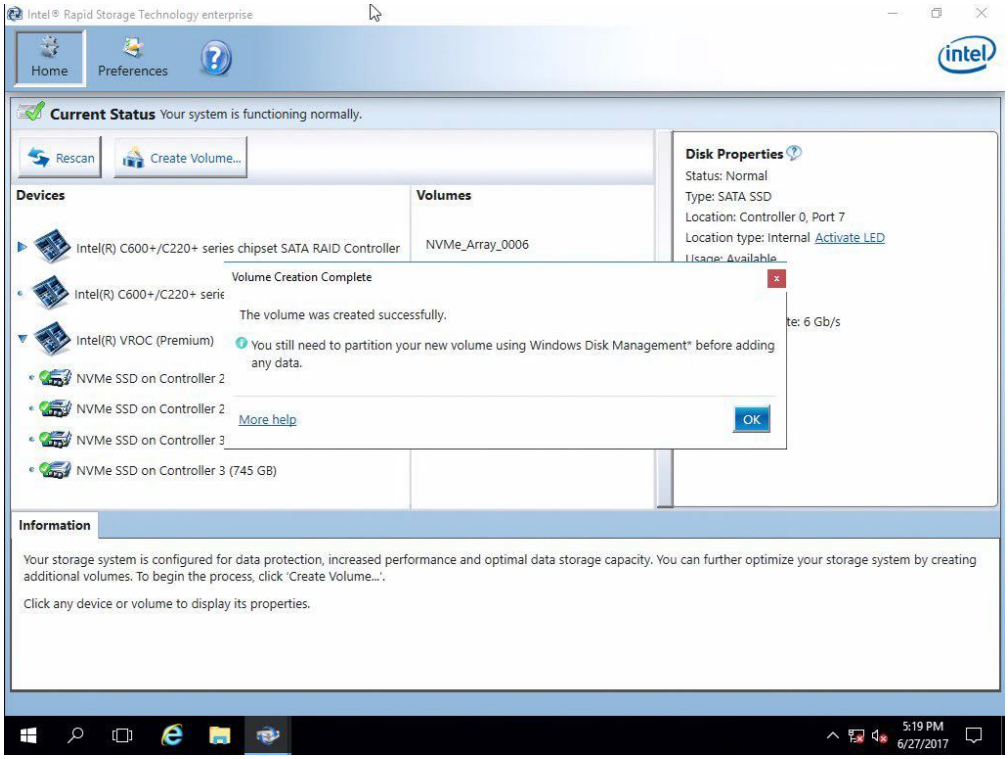
4. Click ***Create Volume***.

Image 32: Confirm Volume Creation



5. Click ***OK*** to finish.

Image 33: Volume Creation Complete

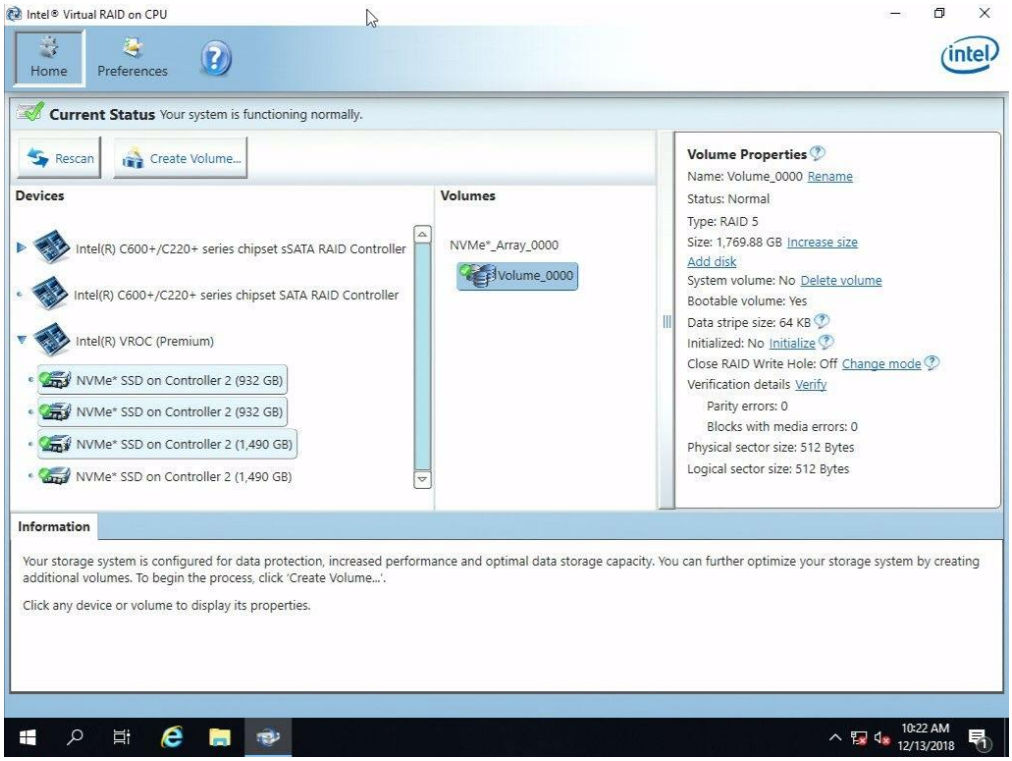


6. Under the Volumes section the new Array and RAID Volume are displayed. By selecting the RAID volume (**Volume_0000**), the "Properties" pane (to the right) will refresh to show the current status, properties and available options of the newly created RAID volume.

7. For RAID 5 volumes, the option to enable RAID Write Hole closure is available. This is a means of allowing for data integrity to be maintained even if a power loss is experienced. It is best selected at the onset of creation of the volume, before data is transferred to it. Changing the mode with data existing can put that data at risk. It will allow you to select a drive that has not already been associated to the array as the additional disk member and allow you to select the mode of distributed or journaling within the advanced pane during creation of the RAID or at time of addition. It is recommended that if this feature is to be used, it be enabled during the volume creation to prevent risk of data loss.

Note: The arrow is pointing to the help icon that will provide additional information for RAID Write Hole.

Image 34: RAID 5 Volume Properties



7.3 Create a Matrix RAID Configuration

The following example will step through the process of creating 2 RAID volumes (RAID 1 and 0) on a single array.

1. Follow the steps in section 7.1 to create a 2 drive RAID 0 volume. It is advised not to use the entire disk space for the first volume in order to have room for the second volume on the array. When completed, the Intel VROC GUI should show as follows. Next, click ***Create Volume...***

Image 35: Existing RAID 0

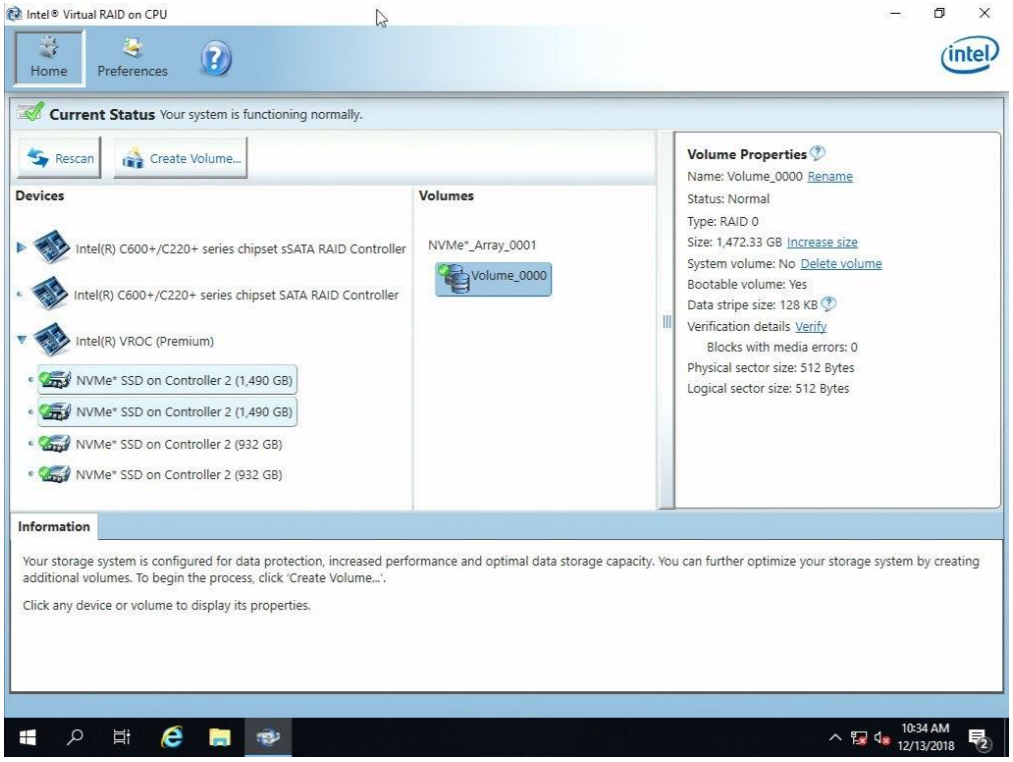
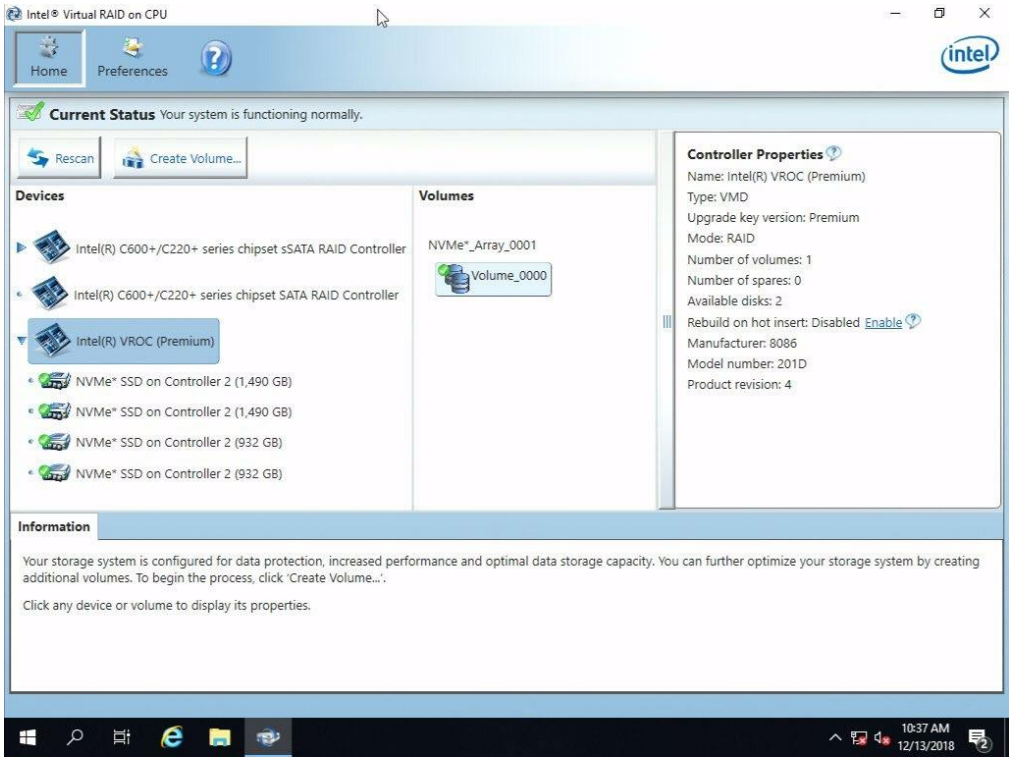
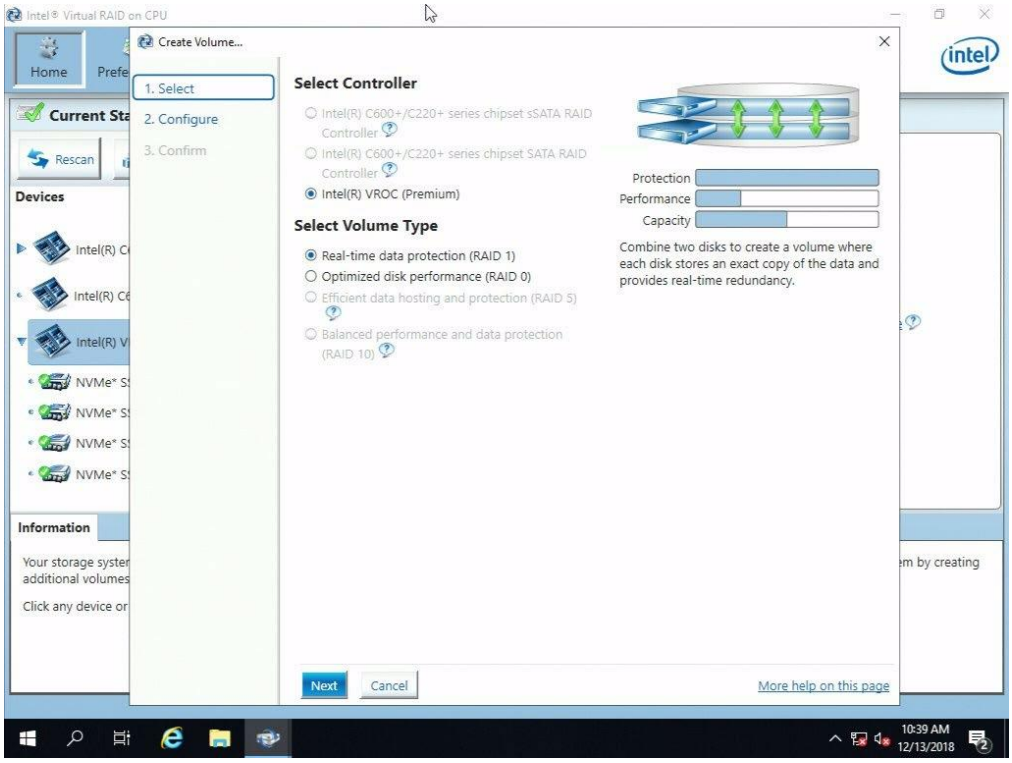


Image 36: Create Volume



2. Select the **NVMe Devices** controller if not already selected. Then select **Optimized Disk Performance (RAID 1)**. Finally, select ***Next*** to continue.

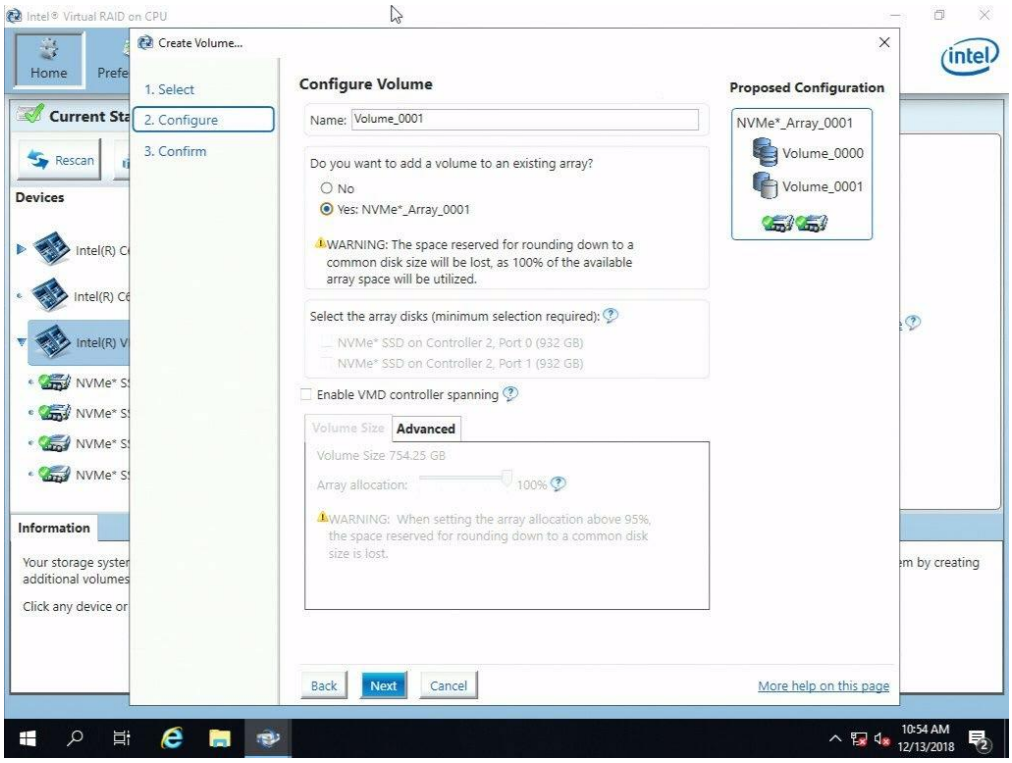
Image 37: Controller Selection



3. Specify the **Name** of the volume or simply leave as default value. In this example it has been left as default **(Volume_0000).** Next, under the section "Do you want to add a volume to an existing array?" select **Yes: NVMe_Array_<arrayNumber>.** Then click ***Next***.

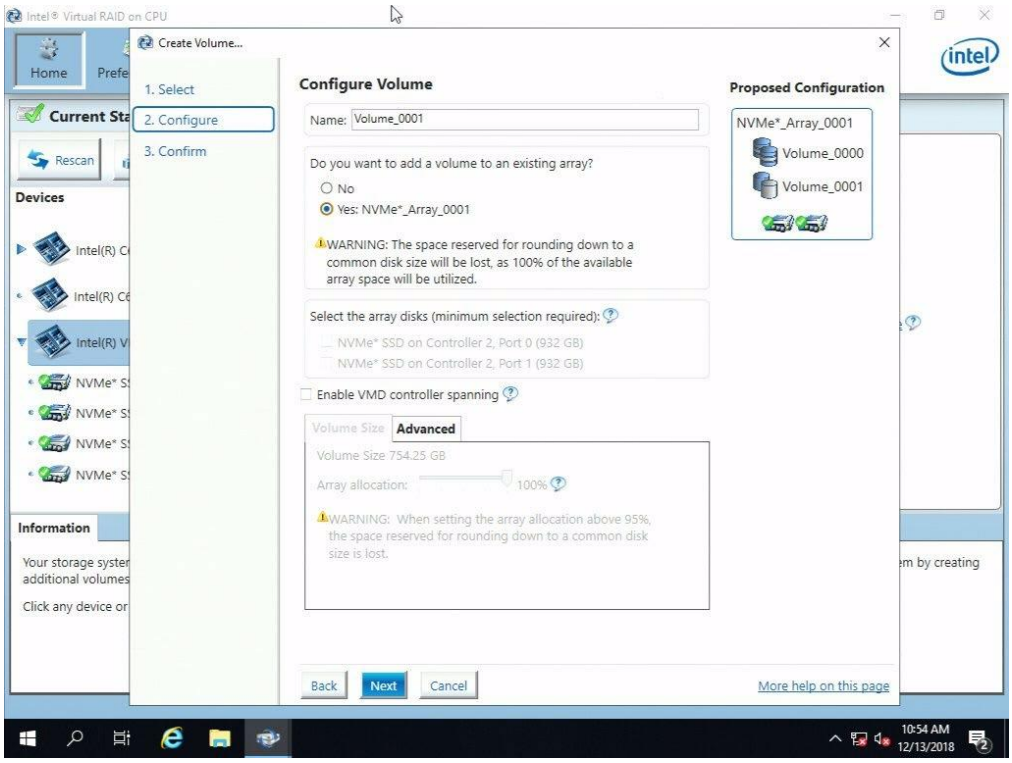
Note: The second array will consume the remaining space on the array that is available.

Image 38: Configure Volume



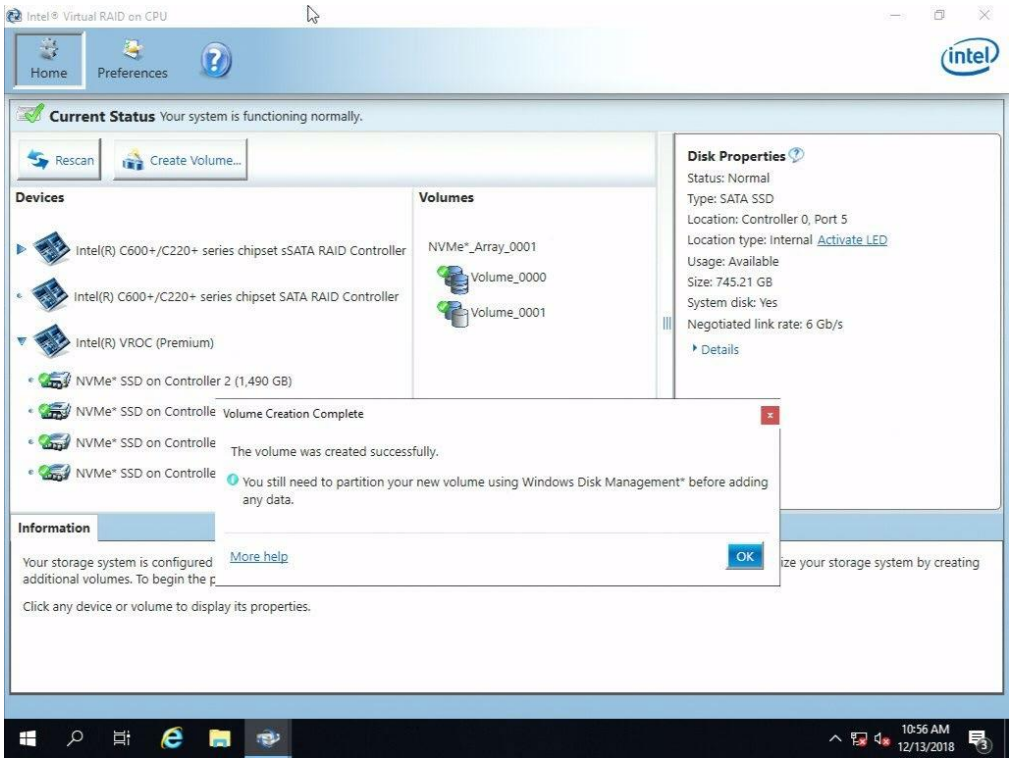
4. Click ***Create Volume***.

Image 39: Confirm Volume Creation



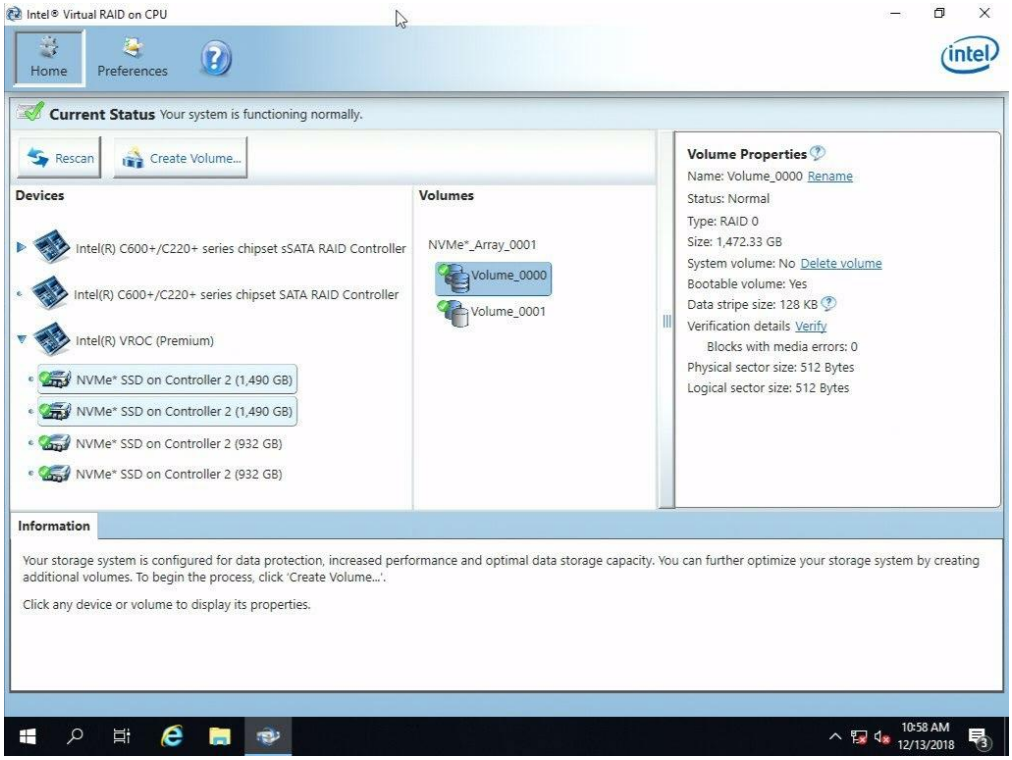
5. Click ***OK*** to finish.

Image 40: Volume Creation Complete



6. Under the Volumes section, both new Arrays and RAID Volumes (Volume_0000 and Volume_0001) will appear. By selecting either RAID Volumes, the “Properties” pane (right) will refresh to show all properties and available options of the selected volume.

Image 41: Volumes Selection

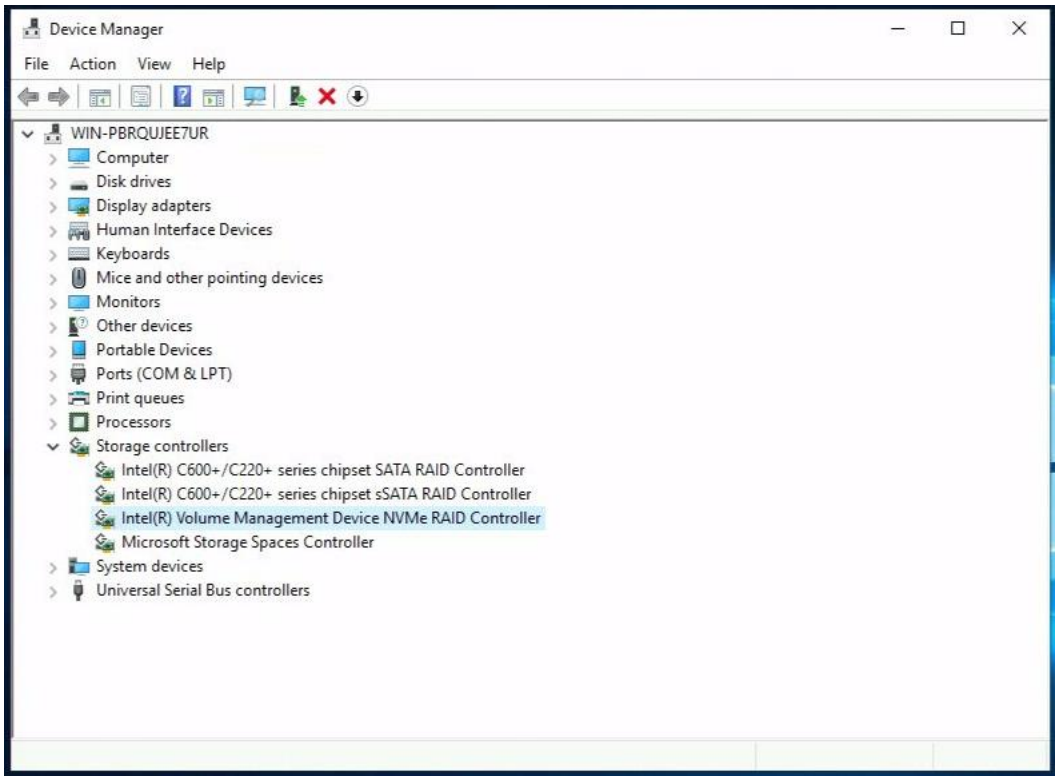


7.4 Viewing RAID Volumes in Windows Control Panel Applets

Attached are some screen captures that show what Window* **Device Manager** and **Disk Management** control panel applet may display after the RAID volume has been created.

1. Bring up **Computer Management** and select Windows **Device Manager**. The newly created RAID volume should be shown under **Disk drives**

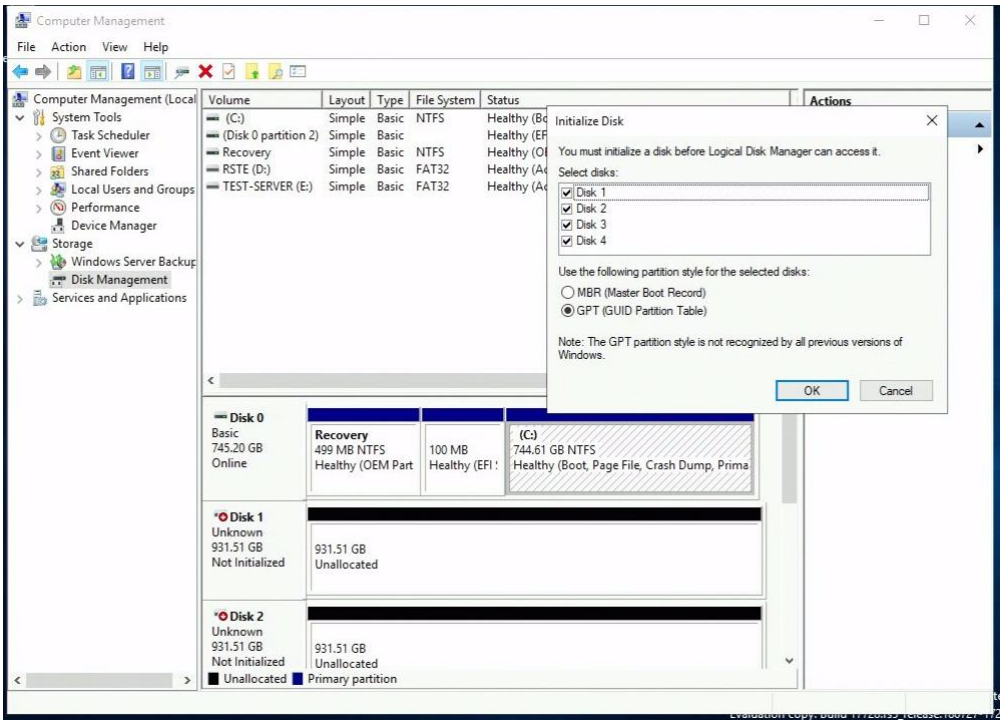
Image 42: Computer Management



2. Under **Storage** -> **Disk Management**, the newly created RAID volume is now available to format. This will include attached disks that have not been added to RAIDs.

Note: Thumb drives that were used as installation media will be assigned letter drive values as seen here.

Image 43: Disk Management



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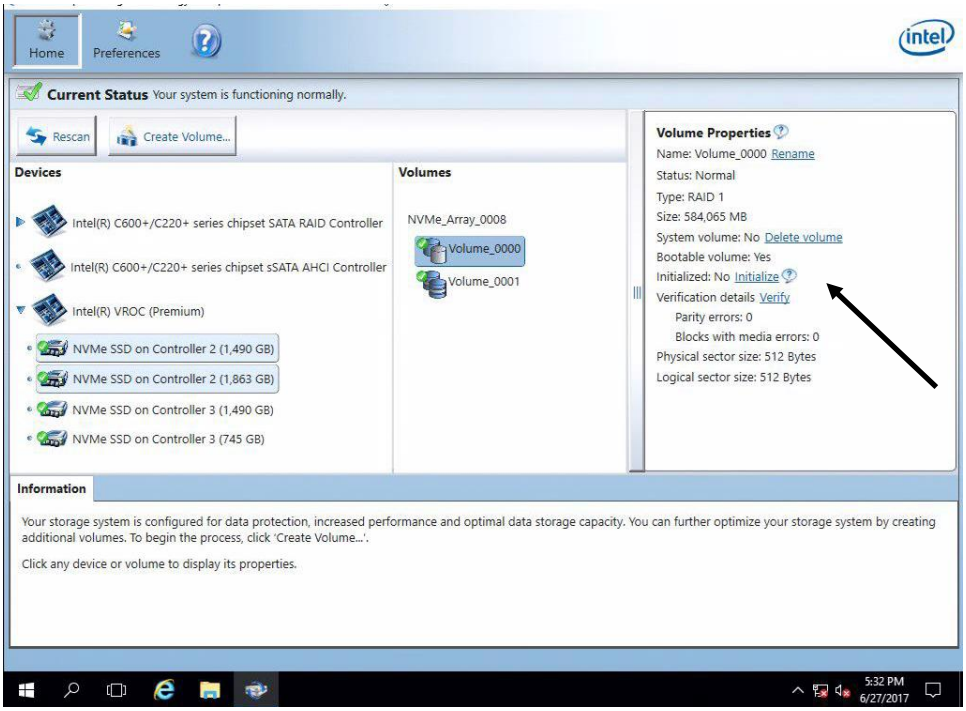
8 Deleting a Volume

The following steps through the RAID Volume deletion process.

1. Select (left mouse click) the RAID Volume to be deleted in the middle under **Volumes**. Then on the right side in the **Volume Properties** window pane select ***Delete Volume***.

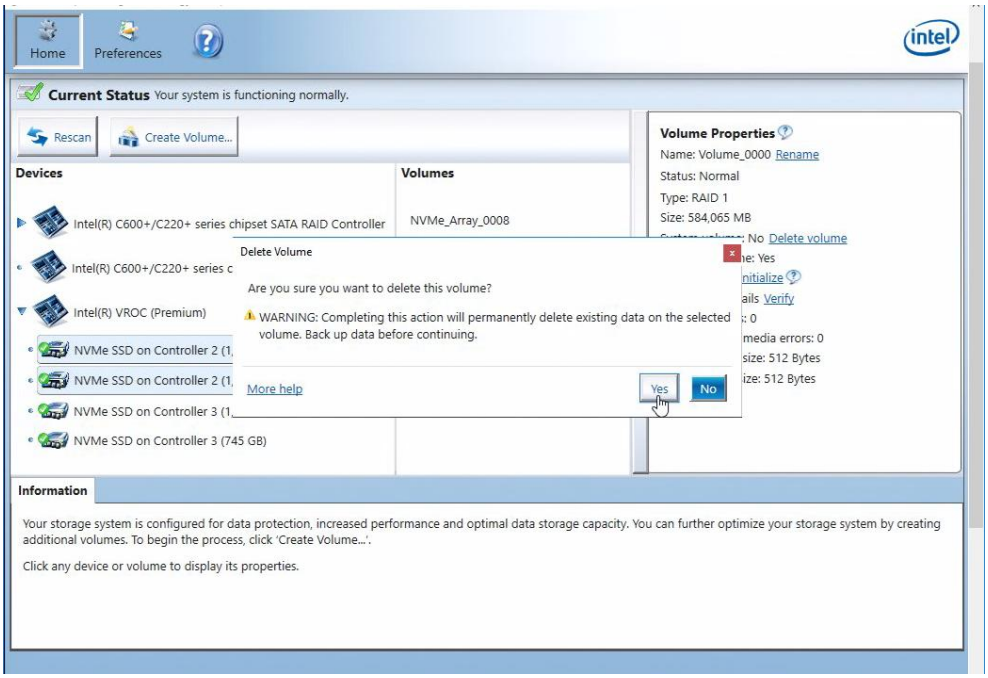
Note: The arrow below is pointing to the option that is Delete volume. It is only available if you have a volume selected. Please take care in selection for deletion of volumes, as the data cannot be recovered.

Image 44: Delete Volume



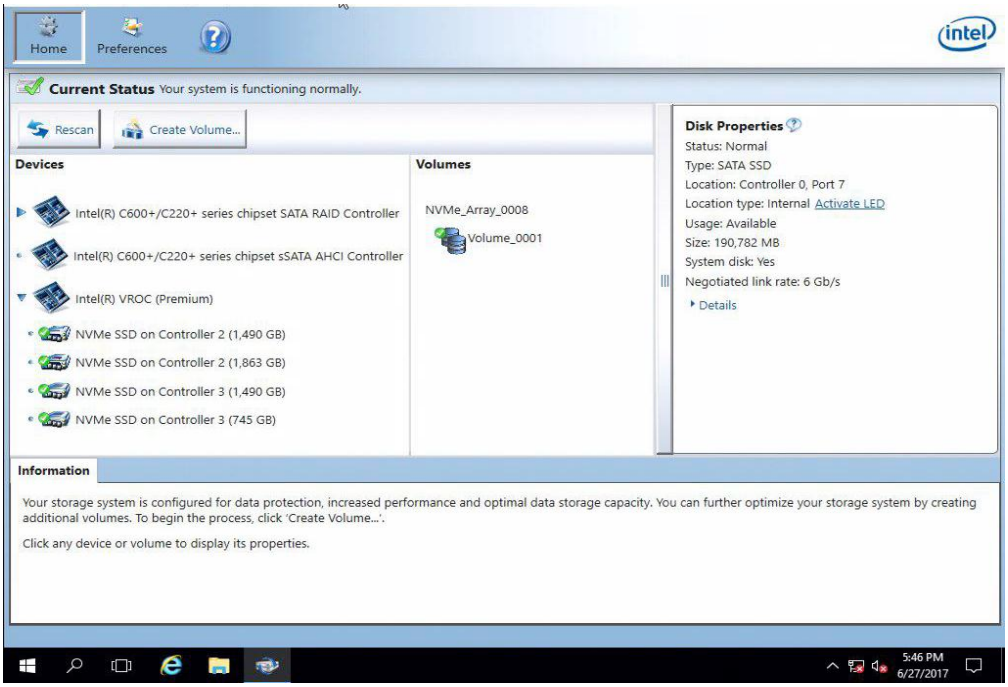
2. Select Yes at the warning to complete the process.

Image 45: Confirm Deletion



3. When the process has completed, the volume will no longer show in the GUI as shown below.

Image 46: Volume Removed



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9 Intel VROC Trial Period

The Intel VROC package comes with a 90 day trial period that will enable Intel VROC Premium mode (in Windows only) for data volumes without requiring an Intel VROC Upgrade Key. This allows the user to test and experience Intel Premium mode for 90 days. The trial period will begin at the time that the first Intel VROC RAID volume is created.

9.1 Intel VROC Trial Period Recommendations and Limitations

The following are key limitations with the Intel VROC Trial Period feature

- The Intel VROC Trial Period does not extend to the Intel VROC UEFI HII environment. As a result, RAID volumes generated in the Intel VROC GUI during this trial period will not be seen in the Intel VROC UEFI HII user interface.
- Intel recommends **not** attempting to migrate a system drive into a RAID volume. This is to prevent the system from becoming unbootable because the trial period does not extend to the Intel VROC UEFI HII environment.
- Intel recommends **not** using Intel VROC Trial Period RAID volume for any mission critical data. It is only intended for evaluation purposes and the data cannot be guaranteed (either in the Intel VROC UEFI HII environment or after the period expires).

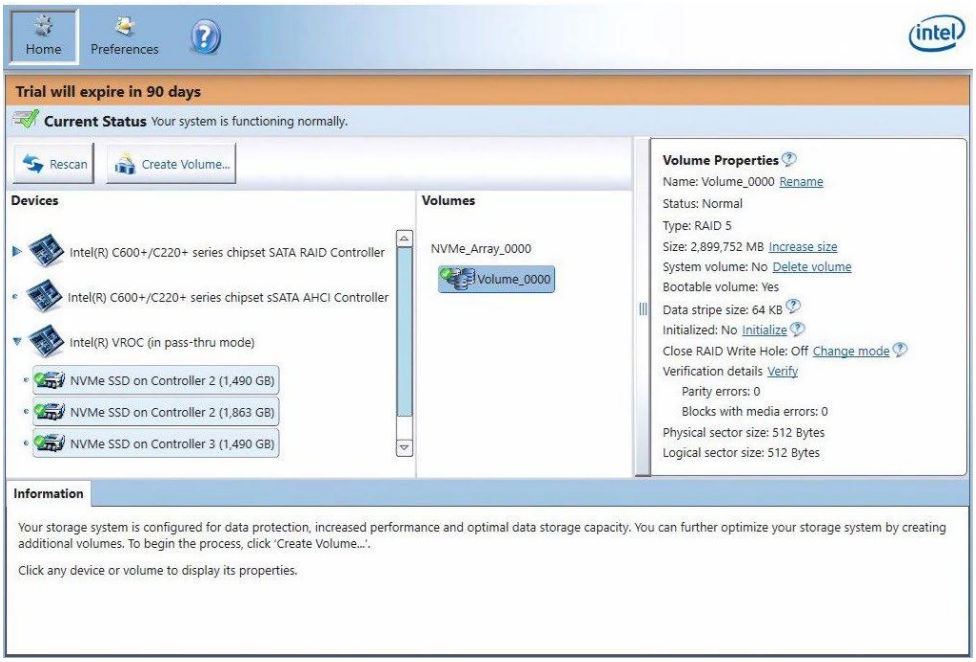
9.2 Intel VROC Trial Period Usage

Since this Intel VROC Trial Period mode only applies to platforms that do not have Intel VROC Upgrade Keys installed, the System Report will report that Intel VROC is in Pass-thru mode.

Prior to initiating the trial period (by creating a RAID volume) the Intel VROC GUI will show no indication of a trial period being activated. After Intel VROC GUI has been installed, the trial period will begin once the first trial RAID volume is created.

The status of the trial is displayed in the Intel VROC GUI as:

Image 47: Trial Status



Note: During the trial period, the Intel VROC UEFI HII will not display that RAID volume, and will show the attached drives as non-RAID disks:

Image 48: VMD during Trial Status

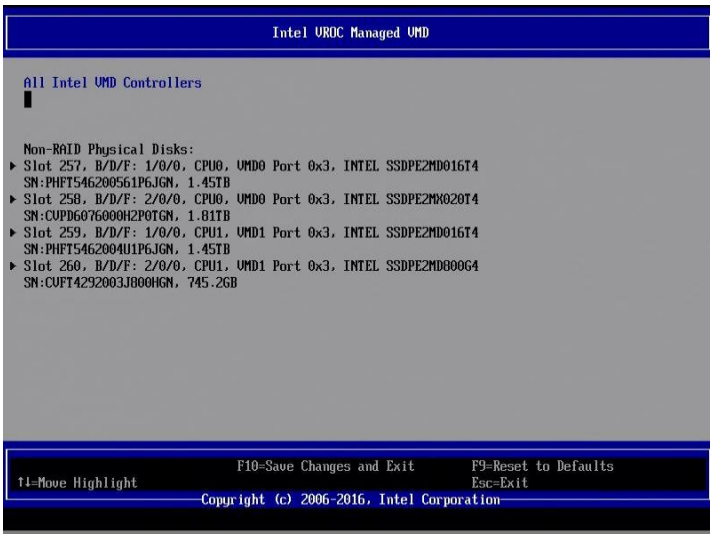
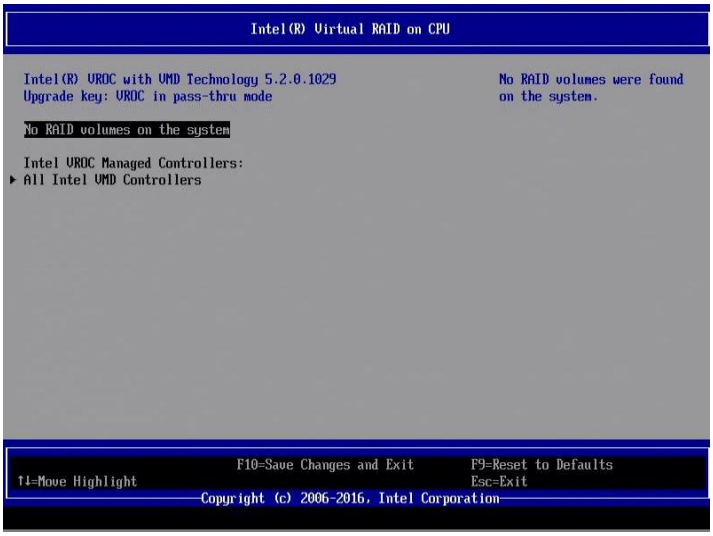
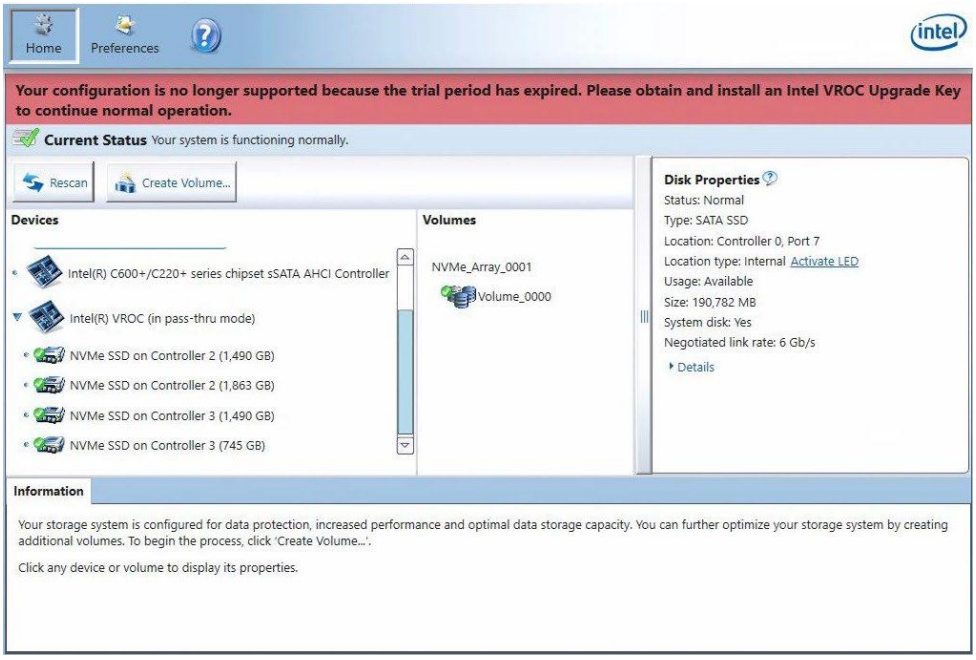


Image 49: VROC During Trial



After 90 days, the trial period will expire and be displayed in the GUI as:

Image 50: Trial Period Expired



Note: At the end of the trial period, any RAID volume generated will be displayed in the Intel VROC GUI, but they will not be accessible.

Once the Intel VROC Upgrade Key is installed in the platform (either during the trial period or after the trial period expires) the environment will become operational and all RAID volumes will be accessible as normal.

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10 Troubleshooting

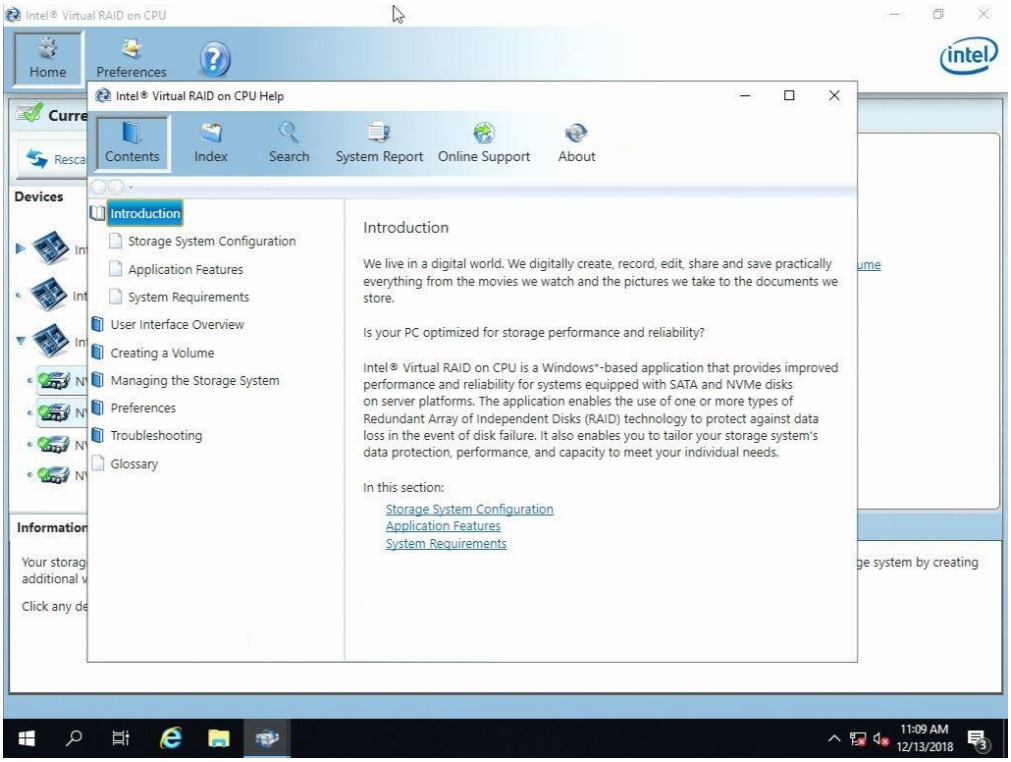
This section will address some of the basic troubleshooting tips that can be used to diagnose and possibly self-treat a handful of issues.

10.1 System Reports

Troubleshooting issues on a Server, Workstation or High-end desktop may be required. One of the tools that is helpful in doing so is called a system report. This tool is embedded within the Help section within the Intel VROC GUI.

1. First, click the ***Help*** icon on the top row**.** It is the button that has the white "?" on the blue shield.

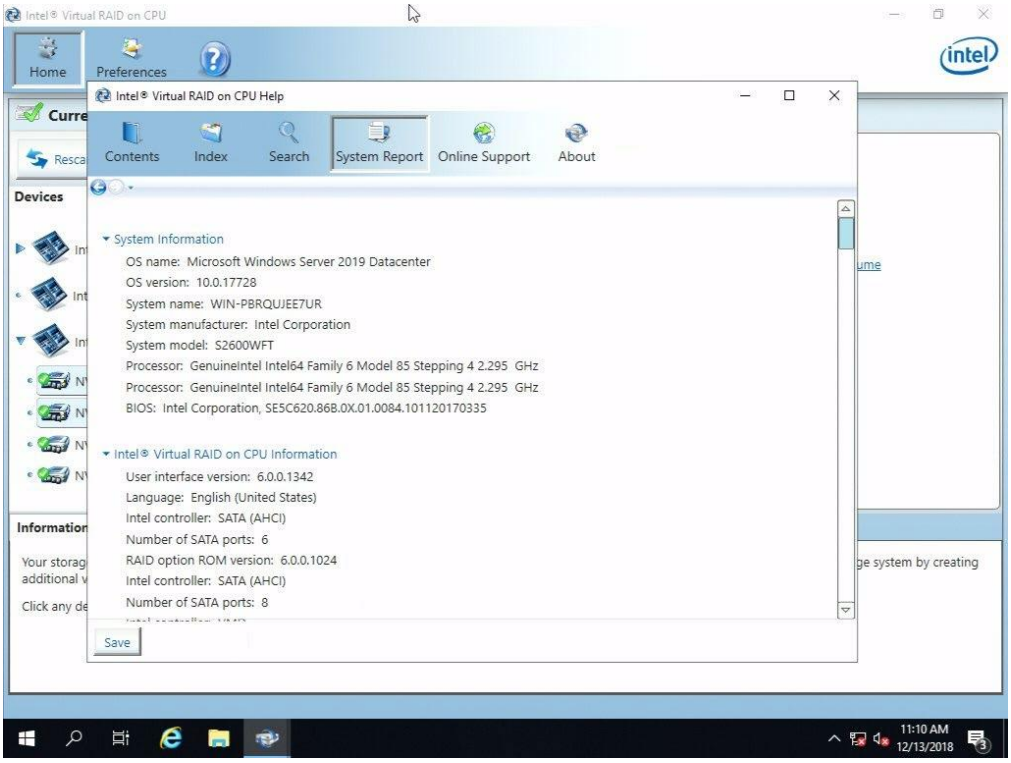
Image 51: Help



This brings a new window to the forefront of the screen.

2. Click on ***System Report***.

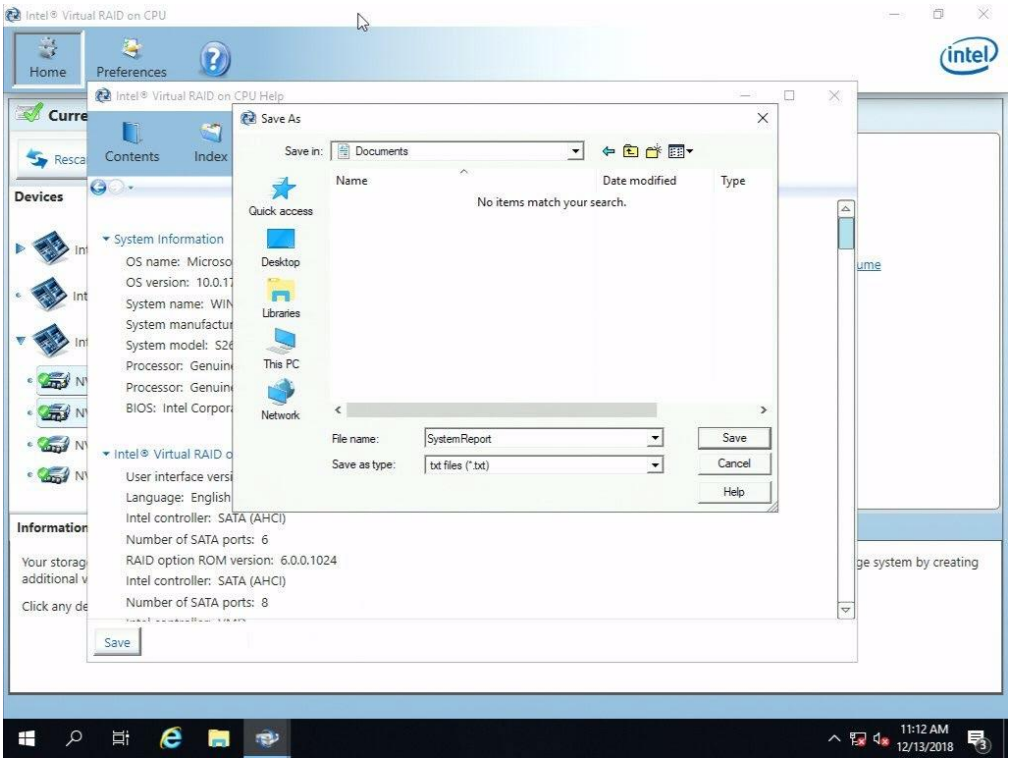
Image 52: System Report



This is the data regarding all items active on this system. This states the status and activity for all functions as it relates to the Intel VROC 6.0 product family.

3. Next, click ***Save*** at the bottom left corner of the **System Report**.

Image 53: Save



Windows will allow the user to select where to save the file, the default is to save in that user's documents folder. This may be altered at the discretion of the user. Once the location and name have been set, click ***Save*** to save the file.

This file is now ready for the support representative to review the data. Please follow their instructions regarding to how to transmit or forward this file to this individual.

10.2 Drive States and Recovery

This section explains how to resolve the most common problems that may occur while using the application. If the user has any questions regarding installing, using or maintaining this product, the user can also visit Intel's online support site which provides the user with self-help resources and electronic problem submission.

10.2.1 Failed Volumes

This section explains how to resolve the most common problems that may occur while using the application. If the user has any questions regarding installing, using or maintaining this product, the user can also visit Intel's online support site which provides the user with self-help resources and electronic problem submission.

Table 10: Failed Volumes

RAID 0

A RAID 0 volume is reported as failed when one of its members is disconnected or has failed. In both cases, the volume and its data are no longer accessible.

Cause	Solution
Missing array disk	Follow this procedure to recover data: 1. Power off the user's computer and reconnect the missing disk. 2. Turn on the user's computer. During the system startup, the volume status will display as 'Normal' in the Intel Rapid Storage Technology enterprise option ROM user interface. 3. Once the operating system is running, open Intel Rapid Storage Technology enterprise from the Start menu or click the ***Intel Rapid Storage Technology enterprise*** notification area icon. 4. Under 'Status', verify that the volume and disks status display as 'Normal'. The user can also review this information under 'Manage'.
Failed array disk	In most cases, the volume cannot be recovered and any data on the volume is lost. However, before deleting the volume, the user can try resetting the disks to normal, and then attempt a data recovery. If the read/write data access consistently fails, the disk will likely return to a failed state immediately. Refer to Troubleshooting Disk Events for instructions on resetting a disk to normal. This procedure deletes the failed volume: 1. Power off the user's computer and replace the failed NVMe or SATA disk with a new one that is of equal or greater capacity. 2. Turn on the user's computer. During the system startup, the volume status will display as 'Failed' in the Intel Rapid Storage Technology enterprise option ROM user interface. 3. Press Ctrl-I to access the main menu of the option ROM user interface. 4. Select Delete RAID Volume from the main menu. 5. From the Delete Volume menu, select the failed RAID volume, using the up and down arrow keys. 6. Press the 'Delete' key to delete the volume, then 'Y' to confirm. 7. Create a new RAID 0 volume using the new disk. If the failed disk was part of the system volume, the user will also need to reinstall the operating system.

RAID 5

A RAID 5 volume is reported as failed when two or more of its members have failed.

Cause	Solution
Two or more array disks failed	In most cases, the volume cannot be recovered and any data on the volume is lost. However, before deleting the volume, the user can try resetting the disks to normal, and then attempt a data recovery. If the read/write data access consistently fails, the disk will likely return to a failed state immediately. Refer to Troubleshooting Disk Events for instructions on resetting a disk to normal. This procedure deletes the failed volume: 1. Power off the user's computer and replace the failed NVMe or SATA disks with new ones that are of equal or greater capacity. 2. Turn on the user's computer. During the system startup, the volume status will display as 'Failed' in the Intel Rapid Storage Technology enterprise UEFI HII. 3. Go into the BIOS setup and go to the Intel VROC UEFI HII. 4. Select Delete RAID Volume from the main menu. 5. From the Delete Volume menu, select the failed RAID volume, using the up and down arrow keys. 6. Press the 'Delete' key to delete the volume, then 'Y' to confirm. 7. Create a new RAID 5 volume using the new disks. If the failed disk was part of the system volume, the user will also need to reinstall the operating system.

RAID 10

A RAID 10 volume is reported as failed when two adjacent members are disconnected or have failed, or when three or four of its members are disconnected or have failed.

Cause	Solution
Two adjacent array disks missing (visual inspection)	1. Power off the user's computer and reconnect the missing disks. 2. The rebuild operation will start automatically. The user can follow the progress by hovering over the notification area icon or by reviewing the volume status under 'Status' or 'Manage'.
Three or four array disks missing	In most cases, the volume cannot be recovered and any data on the volume is lost. This procedure deletes the failed volume: 1. Power off the user's computer and reconnect the missing disks. 2. Turn on the user's computer. During the system startup, the volume status will display as 'Failed' in the Intel Rapid Storage Technology enterprise UEFI HII. 3. Go into the BIOS setup and go to the Intel VROC UEFI HII. 4. Select Delete RAID Volume from the main menu. 5. From the Delete Volume menu, select the failed RAID volume, using the up and down arrow keys. 6. Press the 'Delete' key to delete the volume, then 'Y' to confirm. 7. Create a new RAID 10 volume using the new disks. 8. The user will then need to reinstall the operating system on the new volume.
Two or more array disks failed	In most cases, the volume cannot be recovered and any data on the volume is lost. However, before deleting the volume, the user can try resetting the disks to normal, and then attempt a data recovery. If the read/write data access consistently fails, the disk will likely return to a failed state immediately. Refer to Troubleshooting Disk Events for instructions on resetting a disk to normal. This procedure deletes the failed volume: 1. Power off the user's computer and replace the failed NVMe or SATA disks with new ones that are of equal or greater capacity. 2. Turn on the user's computer. During the system startup, the volume status will display as 'Failed' in the Intel Rapid Storage Technology enterprise UEFI HII. 3. Go into the BIOS setup and go to the Intel VROC UEFI HII. 4. Select Delete RAID Volume from the main menu. 5. From the Delete Volume menu, select the failed RAID volume, using the up and down arrow keys. 6. Press the 'Delete' key to delete the volume, then 'Y' to confirm. 7. Create a new RAID 10 volume using the new disks. 8. The user will then need to reinstall the operating system on the new volume.

10.2.2 Degraded Volumes

Table 11: Degraded Volumes

RAID 1 A RAID 1 volume is reported as degraded when one of its members is disconnected or has failed. Data mirroring and redundancy are lost because the system can only use the functional member.	
RAID 5 A RAID 5 volume is reported as degraded when one of its members is disconnected or has failed. When two or more array disks are disconnected or have failed, the volume is reported as failed.	
RAID 10 A RAID 10 volume is reported as degraded when one of its members is disconnected or has failed, or when two non-adjacent members are disconnected or have failed. When two or more array disks are disconnected or have failed, the volume is reported as failed.	
Cause	**Solution**
Missing array disk	If the user can reconnect the missing disk, follow this procedure to rebuild the volume: 1. Power off the user's computer and reconnect the missing disk. 2. Turn on the user's computer and the rebuild operation will start automatically. If the user cannot reconnect the missing disk and a NVMe or SATA disk is available and normal, follow this procedure to rebuild the volume: 1. If a NVMe or SATA disk is compatible, available and normal, follow this procedure to rebuild the volume: 2. Select the disk the user wants to use to rebuild the volume, and then click ***Rebuild***. 3. The rebuild operation starts immediately. The user can follow the progress by hovering over the notification area icon or by reviewing the volume status under 'Status' or 'Manage'. 4. Once the operation has successfully completed, the array disk and volume status will display as 'Normal'. **Note:** If there is no available disk present, the user will need to power off the user's computer and connect a new NVMe or SATA disk that is at an equal or greater capacity than the failed disk. Once the user's computer is back up and running the user can follow the rebuild procedure described above.
Failed array disk	We recommend that the user rebuild the degraded volume to a new disk to return the volume and overall storage system status to normal. However, the user can try resetting the disk to normal, which will prompt the volume to start rebuilding automatically. But if the read/write data access consistently fails, the disk will likely return to a failed state immediately and the user will need to rebuild the volume to another disk. If a NVMe or SATA disk is compatible, available and normal, follow this procedure to rebuild the volume: 1. Under 'Status', click ***Rebuild to another disk***. 2. Select the disk the user wants to use to rebuild the volume, and then click ***Rebuild***. 3. The rebuild operation starts immediately. The user can follow the progress by hovering over the notification area icon or by reviewing the volume status under 'Status' or 'Manage'. 4. Once the operation successfully completed, the array disk and volume status will display as 'Normal'. **Note:** If there is no available disk present, the user will need to power off the user's computer and connect a new NVMe or SATA disk that is at an equal or greater capacity than the failed disk. Once the user's computer is back up and running the user can follow the rebuild procedure described above.

10.2.3 Other Volume States

Table 12: Other Volume States

Incompatible	
Cause	**Solution**
1) Indicates that the volume was moved to another system that does not support the volume type and configuration.	In this situation, volume data is accessible to the operating system and can be backed up, but the volume cannot operate because the user's system does not support its RAID configuration. Here are the user's options: • Reconnect the volume to the computer where the volume was originally created, and continue using it. • Delete the volume, and then create a new volume with a RAID configuration that is supported by the current system. Follow the procedure described above to delete the volume. **WARNING:** When a volume is deleted, all existing data on the member disks of the selected volume is permanently erased. It's recommended that the user backup all valuable data prior to beginning this action.
2) Indicates that the Intel VROC Upgrade Key is incorrect or missing.	In this situation, volume data may not be accessible to the operating system. Here are the user's options: • Install the proper Intel VROC Upgrade Key
Unknown	
Cause	**Solution**
The volume is in an unexpected state due to a configuration error.	The application is unable to detect the exact nature of the problem. Try restarting the user's computer. If the error persists, back up all valuable data and delete the volume using the option ROM user interface. Refer to the user's manual accessible from the Online Support area for details on using the option ROM.
Missing volume	
Cause	**Solution**
A driver upgrade or downgrade was performed while a data migration was in progress.	The driver cannot recognize the volume or read its data if a driver upgrade or downgrade was performed during a volume migration. Volume migrations occur after one of the following operations was initiated: 1. Creation of a system volume or data volume while preserving data. 2. Volume type change combined with disk addition to the new RAID configuration. 3. Volume size increase. 4. Disk addition to an existing array. **Troubleshooting a data volume** 1. If the data migration involved a data volume, the user will need to reverse the driver upgrade or downgrade operation and return to the original driver version. This will restore driver and volume compatibility. 2. Once the operation has completed, restart the user's computer. 3. Open the application and make sure that the volume displays again in the storage system view. Data migration operation should resume immediately. **Troubleshooting a system disk** If the data migration involved a system disk or volume, it is highly likely that the user will not be able to start the user's system because the driver cannot read the system files. The following options may allow the user to load the operating system again: 1. Restore to the last known good configuration. 2. Boot from a flash drive that supports NTFS partitioning and includes the storage driver files.

	3. Bring the corrupt disk to another system, and then replace the storage driver files from a compatible driver version. Return the disk to the original system and try booting. **Troubleshooting a system volume** If the data migration involved a system disk or volume, it is highly likely that the user will not be able to start the user's system because the driver cannot read the system files. The following options may allow the user to load the operating system again: 1. Restore the last known good configuration. 2. Bring all corrupted volume disks to another system, and then replace the storage driver files from a compatible driver version. Return the corrupted volume disks to the original system and try booting.

10.2.4 Disk Events

Table 13: Disk Events

State	Cause	Solution
At risk	An impending error condition was detected on an internal or external disk and is now at risk of failure.	The application is detecting early warning signs of failure with an NVMe or SATA disk that result from a slow degradation over time. When a disk is reported at risk, the user can reset that disk to normal, but we recommend that the user contacts the manufacturer for more information to prevent potential data loss. Follow this procedure to reset the disk to normal: 1. Under 'Status', in the Manage subsection, locate the disk reported as at risk. The user can also perform this action from Manage Disk, which is accessible by clicking on the disk in the storage system view. 2. Click ***Reset disk to normal***. The page refreshes instantly, returning to a normal state. **Note:** Completing this action clears the event on the disk and does not delete existing data. However, ignoring early warning signs of disk failure may result in data loss. If the disk reported at risk is included in a RAID volume and a compatible spare disk is available, the rebuild process will start automatically. Once complete, the disk reported at risk becomes available and the user can reset it to normal to return to a healthy state.
	An unexpected error was detected on a disk that has RAID configuration data (metadata) on it.	In this state, it is likely that some or all of the disk data is inaccessible. After backing up any accessible data, the user will need to clear the metadata and reset the disk to return to a normal state. **WARNING**: Completing this action will permanently delete existing metadata. Back up any accessible data before continuing. 1. Under 'Status', in the Manage subsection, locate the disk reported as at risk. The user can also perform this action from Manage Disk, which is accessible by clicking the disk in the storage system view. 2. Click ***Clear and reset disk***, and then click ***Yes*** to confirm. 3. Once complete, the page refreshes with the disk returns to a normal state.
Missing	An array disk is not present or physically connected to the computer.	Ensure that the disk is securely connected to the NVMe or SATA port and that the data cable is functioning properly. If the disk is lost or cannot be reconnected, the user will need to connect a new NVMe or SATA disk, and then rebuild the volume to that new disk. Refer to Degraded or Failed Volumes in this section for instructions on how to rebuild a volume.

Failed	An internal or external disk has failed to properly complete read and write operations in a timely manner, and it has exceeded its recoverable error threshold.	Back up the user's data and we recommend that the user replace the disk as soon as possible. If the failed disk is an array disk, the volume will be reported as degraded or failed depending on its configuration. Refer to Degraded or Failed Volumes in this section for instructions on resolving the problem. In a failed state, disk data may be lost, but the user can try resetting the disk to normal, and then attempt a data recovery. Follow this procedure to reset the failed disk to normal: 1. Under 'Status', in the Manage subsection, locate the disk reported as failed. The user can also perform this action from Manage Disk, which is accessible by clicking the disk in the storage system view. 2. Click ***Reset disk to normal***. The page refreshes instantly, returning to a normal state. **Note:** If the failed array disk is part of a redundant volume, the volume will start rebuilding automatically as soon as the disk is reset to normal.

10.2.5 Software Errors

Table 14: Software Errors

Message	Cause	Solution
An unknown error occurred while running this application. If the problem persists, please restart the user's computer or try reinstalling the application.	This error may be related to: 1. Missing components 2. Corrupted application 3. Application unable to connect to the service 4. Application fails to start.	Restart the user's computer or try reinstalling the application.
Intel® Rapid Storage Technology enterprise is trying to connect to the service.	The application is launched and is attempting to connect to the service in order to run.	If the connection succeeds, the application opens and is fully functional; if the connection fails, the error message described above is displayed. Try starting the service manually using Microsoft Windows Services, or follow the recommended solution listed above to resolve the problem.
The Intel® Rapid Storage Technology enterprise service cannot be started in safe mode.	The user's computer was started in safe mode and the operating system is running with a limited set of files and drivers. Intel Rapid Storage Technology enterprise cannot start or run in safe mode.	Once the user is done troubleshooting application or driver problems in safe mode, the user will need to exit safe mode, restart the user's computer, and then let the operating system start normally. The Intel Rapid Storage Technology enterprise service can now be started and open the application.
Multiple users cannot run the application at the same time.	One or more users are attempting to open the application while an instance of the application is already running.	Make sure only one instance of the application is running at a time.

Message	Cause	Solution
An error occurred due to insufficient resources, and the operation could not be completed. Please try again later.	The Intel® Rapid Storage Technology enterprise driver does not have sufficient resources to execute the request. Another operation may be in progress and needs to complete before being able to handle a new request.	Wait a few moments, then try performing the action again.
An unknown error occurred during the volume creation process. Please try recreating the volume.	An unexpected error occurred during the operation, and the application cannot identify its origin. The volume could not be created.	Verify that the user's hardware is properly connected and try recreating the volume.
An error occurred while an operation was in progress. The operation could not be completed.	An unexpected error occurred during an operation, such as a data migration or a rebuild, and the application cannot identify its origin	Restart the operation. If the error persists, try restarting the user's computer and then the operation.

10.3 Troubleshooting Using the UEFI Shell

This portion will discuss troubleshooting with two tools that are available within the Pre-OS kit. These two tools are within the efi_standalone_VROC_rs folder. The first is HWKeyCheckVROCRS.efi and the second will be RCmpVROC.efi. Copy these tools to a USB drive and are executed from a UEFI Shell. All media will be attached to a mapped thumb drive. The examples show that the media was mapped as **FS0:**. To change from the starting location to the thumb drive FS0, type FS0:\ and press Enter. The command will list all files within the directory tree. The command map –r will allow you to return back to all mapped drives and try a different thumb drive if more than one is mapped.

10.3.1 HWKeyCheckVROCRS.efi

This command is used to determine if your system is able to detect a hardware upgrade key's presence plugged into the motherboard.

If there is no key installed, the output will read as follows:

If there is a hardware key installed, the message will be altered as follows:

10.3.2 RCmpVROC.efi

This command will be used to send system information to a text file from within the UEFI shell to your thumb drive. If you need this file to be saved elsewhere, you will have to direct the output to that location. For simplicity, this guide is having the file saved to the same media as what is holding the UEFI shell commands.

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