Intel® Virtual RAID on CPU (Intel® VROC) for Windows*

User Guide for Intel® VROC 9.1

Revision 021

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Contents

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Revision History

Version	Description	Date
001	Initial release	June 2017
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003	Updated for 5.3 release	October 2017
004	Updated for Intel® Xeon® Processor D-2100 Product Family	February 2017
005	Updated for 5.4 release	March 2018
006	Updated for 5.5 release	August 2018
007	Update for name change to Intel® VROC 6.1	May 2019
008	Updated for Intel® VROC 6.2 release	October 2019
009	Updated for Intel® VROC 6.3 release	February 2020
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014	Revision update only. No content changes.	November 2022
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017	Updated for Intel® VROC 8.2 release	August 2023
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020	Updated for Intel® VROC 9.0 release	June 2024
021	Updated for Intel® VROC 9.1 release	January 2025

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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 all SATA controllers on the Intel® Platform Control Hub (Intel® PCH) configured for RAID.

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

Note: Platforms no longer have a PCH, enabling SATA RAID will now require the addition of a Montage IOH Card. Please contact your Intel FAE for further information if needed.

1.1 Terminology

Table 1-1: 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

Term	Description
Member Disk	An NVMe drive used within a RAID array.
NVMe	Non-volatile Memory Express
OS	Operating System
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.

Term	Description
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
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 OEM Platform Documentation

Refer to your OEM for a full list of available feature sets. If any of the information in this document conflicts with the support information provided by the platform OEM, the platform documentation and configurations take precedence.

Customers should always contact the place of purchase or system/software manufacturer with support questions about their specific hardware or software configuration.

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2 Intel® VROC New Features

2.1 New Features Introduced with Intel® VROC 9.1 Release

Review the Intel® Virtual RAID on CPU (Intel® VROC) Technical Product Specification for Windows* for the details on the latest features and updates.

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

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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 two 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 all SATA controllers via the Intel® Platform Control Hub (PCH) configured for RAID mode.

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. Refer to the Intel® Virtual RAID on CPU (Intel® VROC) Release Notes for Windows* for more details.

2. 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

Refer to the OEM platform documentation.

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.

Table 3-1: 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. 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 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 3-2: 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 3-3: 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 3-4: 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 Hot Plug Limitation in Windows*

If multiple NVMe SSDs in a system need to be replaced via the Hot Plug process, the user must give enough time between each process activity. Release one drive at a time. There also must be 45 – 90 seconds (or until the device re-appears / disappears in device manager) between each hot plug events. One Hot Plug event would be the hot removal of the drive. The next Hot Plug event would be the hot insertion of the new drive. Simultaneous Hot Plug events of multiple NVMe drives are not supported.

Surprise Hot Plug Limitations - Due to Microsoft* Windows* time restrictions for resuming from S3 and S4, and Intel® VMD device identification requirements, Hot Plug (insertion and/or removal) of Intel® (VMD NVMe RAID) managed drive, during an S3/S4 low power event, is not supported.

Note: If user does not follow the recommendation, the system could result in BSOD or other abnormal symptoms.

3.10 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 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) on Intel® VMD supported platforms.

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 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 during the Operating System installation process to utilize this feature.

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 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). 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 on 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 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). 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. 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: Consult the user's Platform BIOS manufacturer documentation for a complete list of options that can be configured.

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

5.4 Creating 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: Consult the user's platform documentation for instructions on how to enter the Intel® VROC HII interface.

The following assumptions have been made:

1. It is known how to enter 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 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.

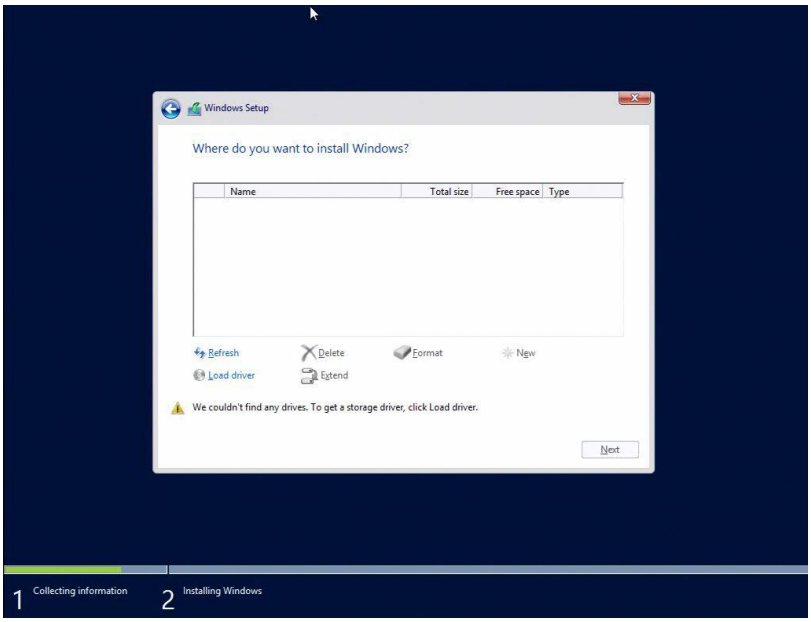
5.5 Installing Windows* Server 2019 on a RAID Volume

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:

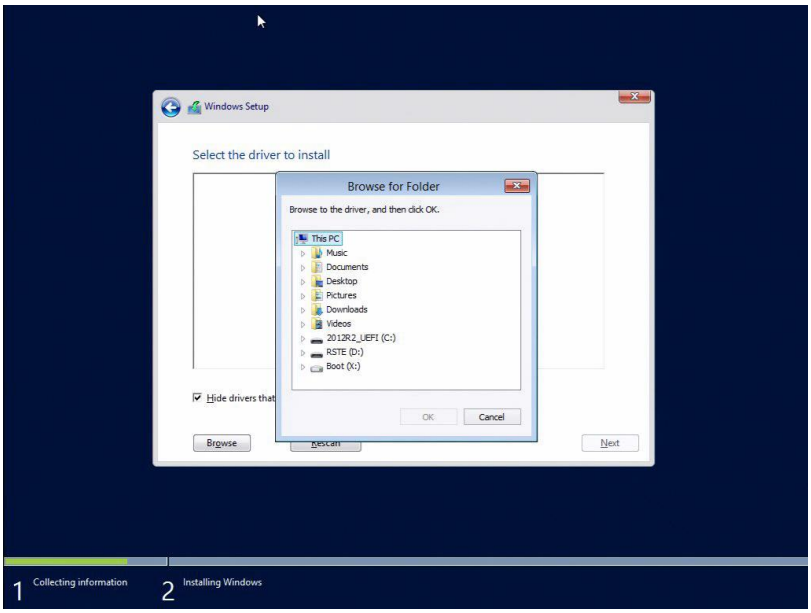
- Intel® VMD has been configured and enabled.
- Intel® VROC has been utilized and the RAID volume has been created.

Figure 5-1. Installation Destination Selection



1. Click Load driver.
2. Click Browse.

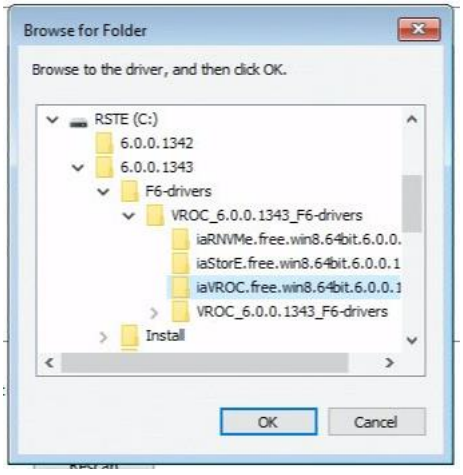
Figure 5-2. Browse Options View



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).

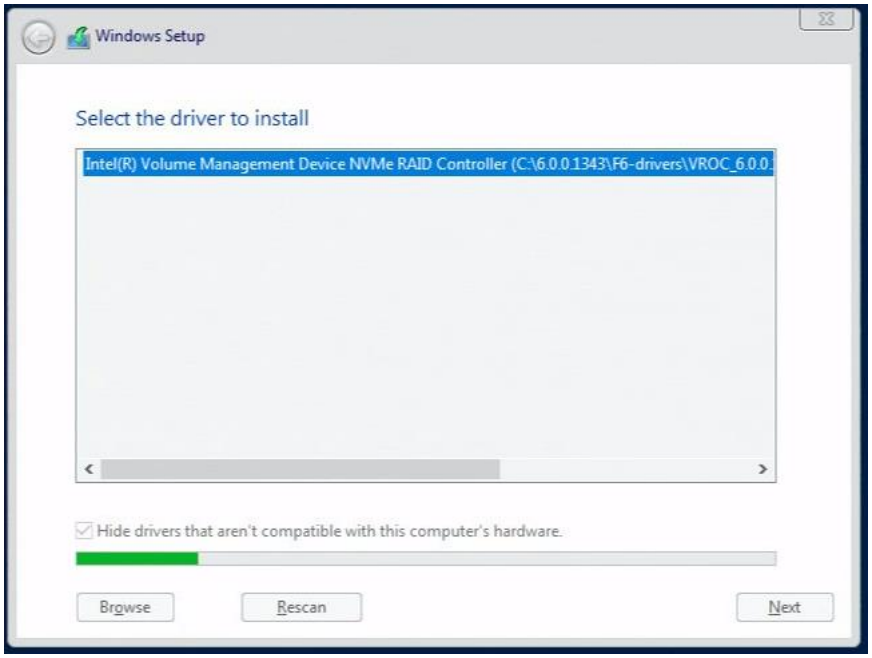
Note: iaRNVMe is the driver designated for Intel® platforms that do not support VMD technology.

Figure 5-3. Drivers Selection



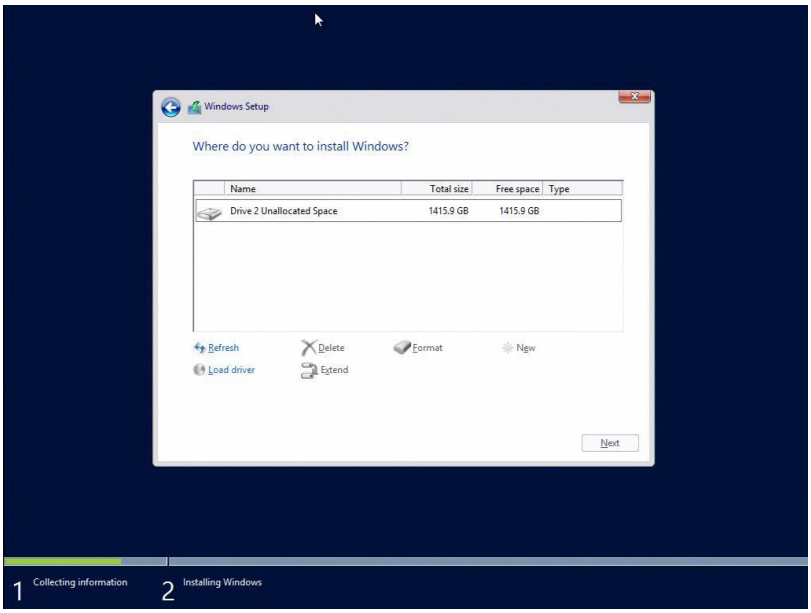
4. Highlight the selected driver and click ***OK*** to install. It requires several minutes to complete installation of the selected driver. Reference the guidance on VMD enabling for installation of Windows* 10 RS5 and Windows* Server 2019 provided in the release notes to prevent this step from timing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

Figure 5-4. 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.

Figure 5-5. Destination Selection Window* Refreshed with Drivers Installed

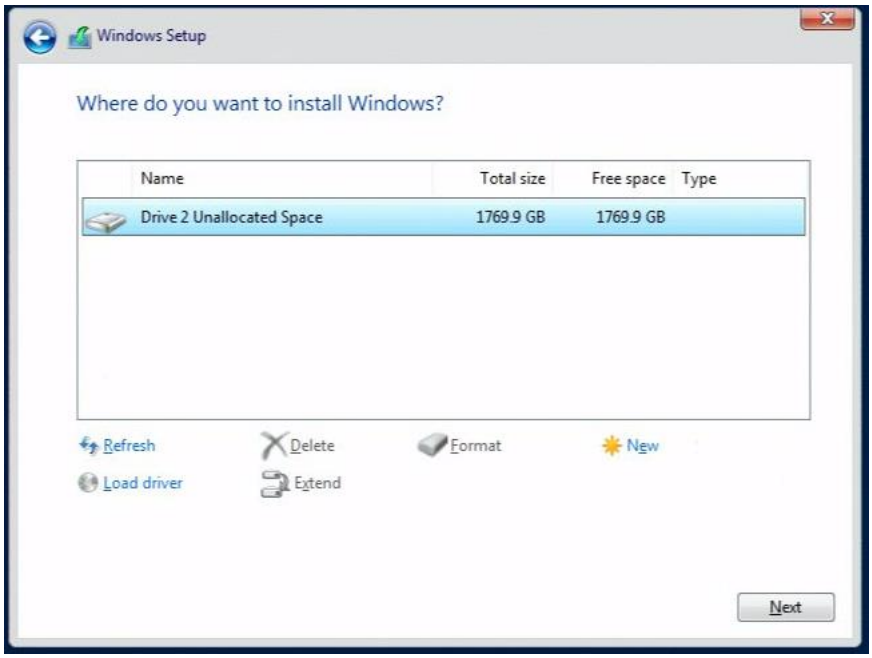


6. After installing the driver, the selection screen may be blank. Click ***Refresh*** to have the system rescan and show your RAID volume.

Note: The order of drive shown in the list is not fixed when multiple drives and RAID volumes are present in the system.

7. Select the desired volume and click ***Next*** to proceed with the installation of your Windows* operating system.

Figure 5-6. Drive Selection



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6 Installing Intel® VROC GUI

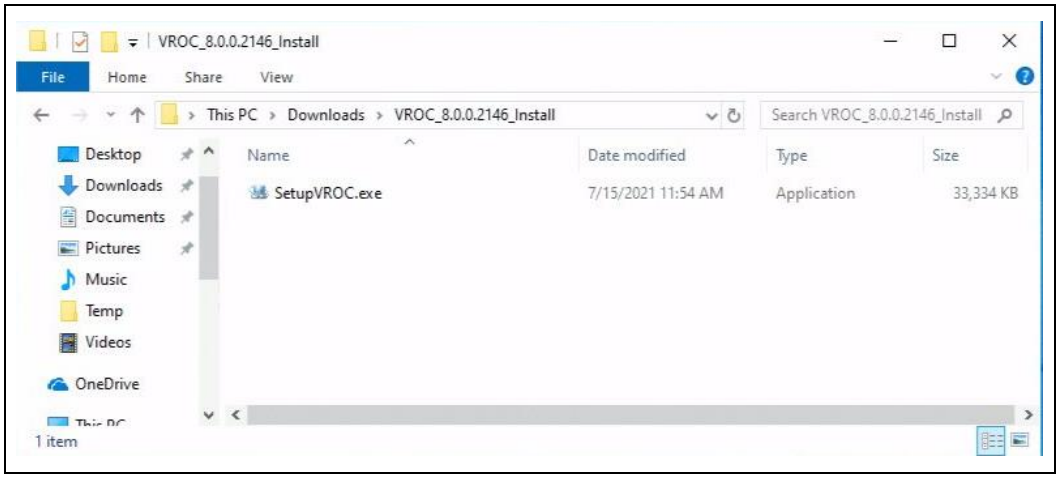
This section discusses the process of installation of the Intel VROC product family that will allow for fully integrated management of the disks installed on your Windows* system.

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.

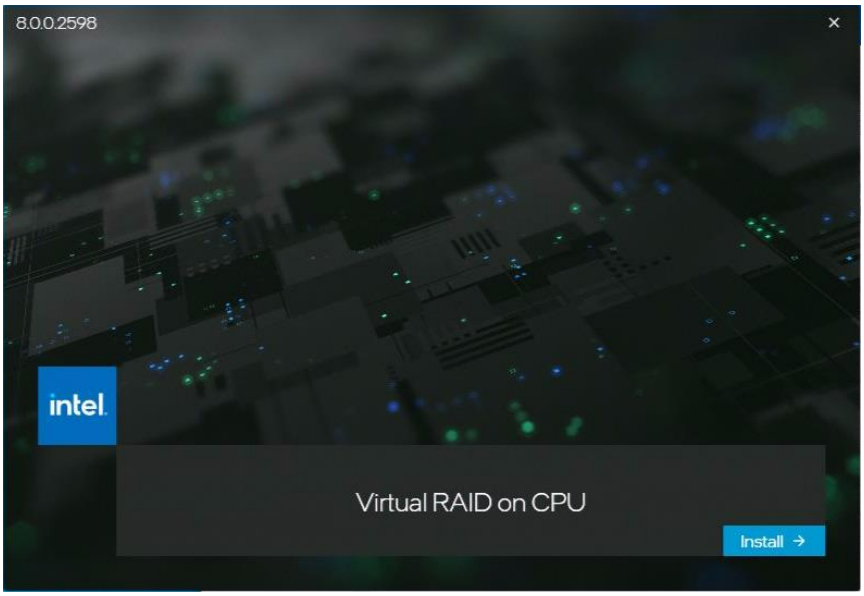
1. In this example you right mouse click ***SetupVROC.exe*** and run as administrator to launch the installer.

Figure 6-1. SetupVROC.exe



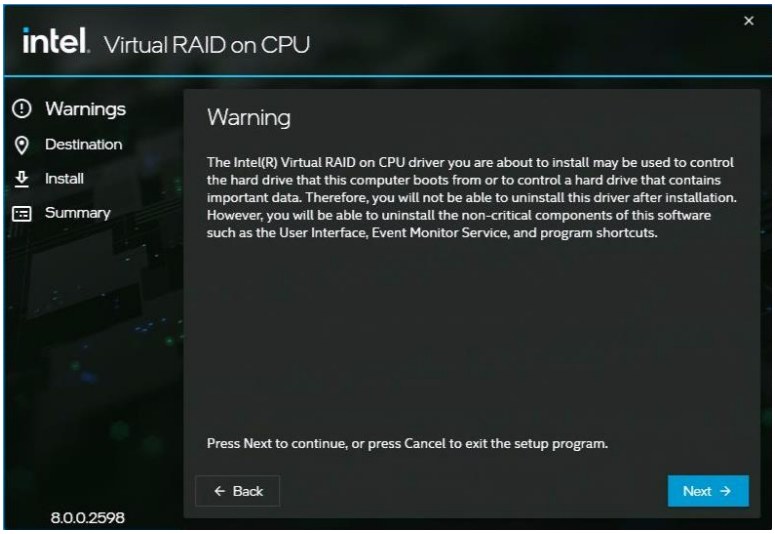
2. The first Window that will appear is the Intel® Virtual RAID on CPU "Welcome" window. Select the "Install" button to continue.

Figure 6-2. Installer Wizard Welcome



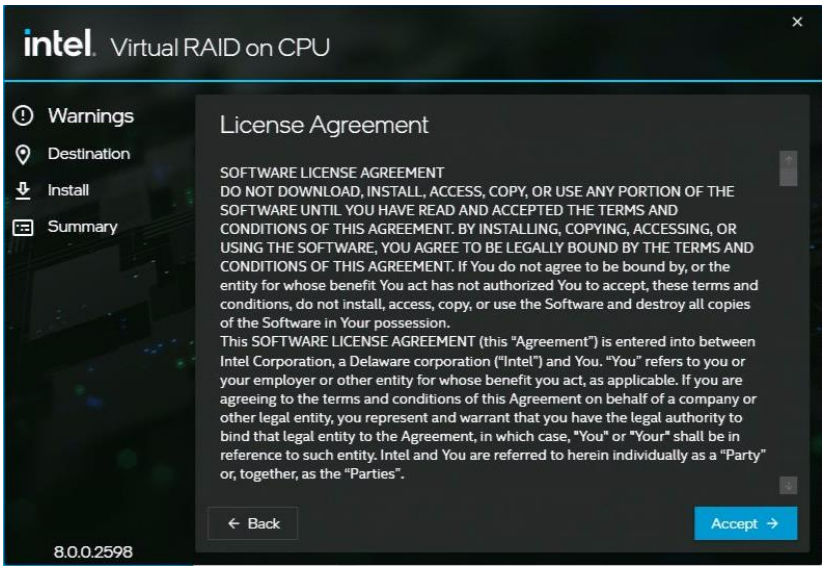
3. The second window is the "Warning" window. Select the "Next" button to continue.

Figure 6-3. Warning



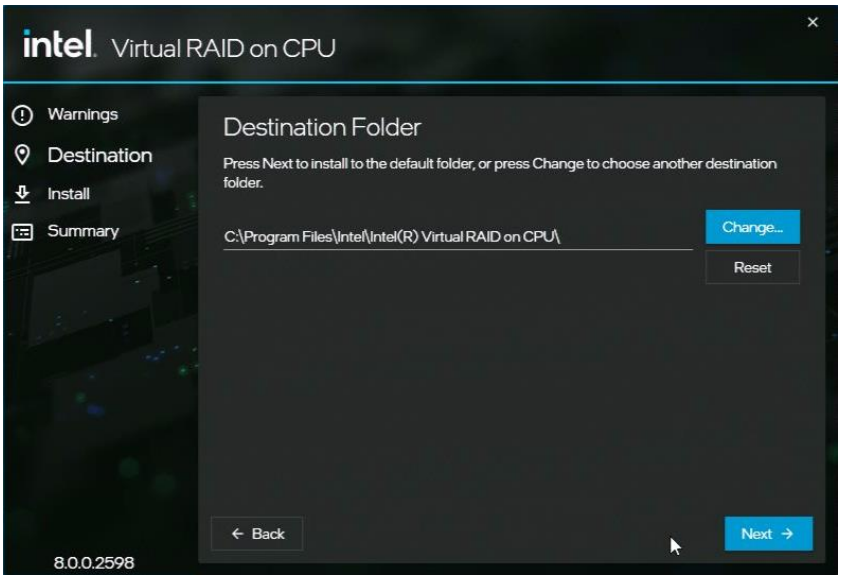
4. Next is the End User License Agreement. Select "Accept" to accept and continue. The full text of this agreement is included in the Appendix.

Figure 6-4. End User License Agreement



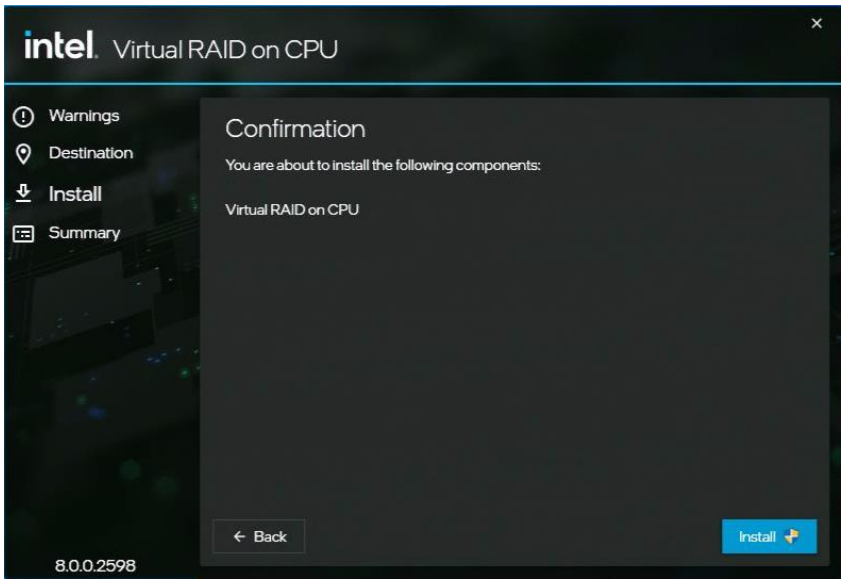
5. The next window is the "Destination Folder". Select "Next" to install to the default folder, or press "Change" to choose another destination folder.

Figure 6-5. Destination Folder for Installation



6. Next window is the "Confirmation" window. Press "Install" to install the selected components.

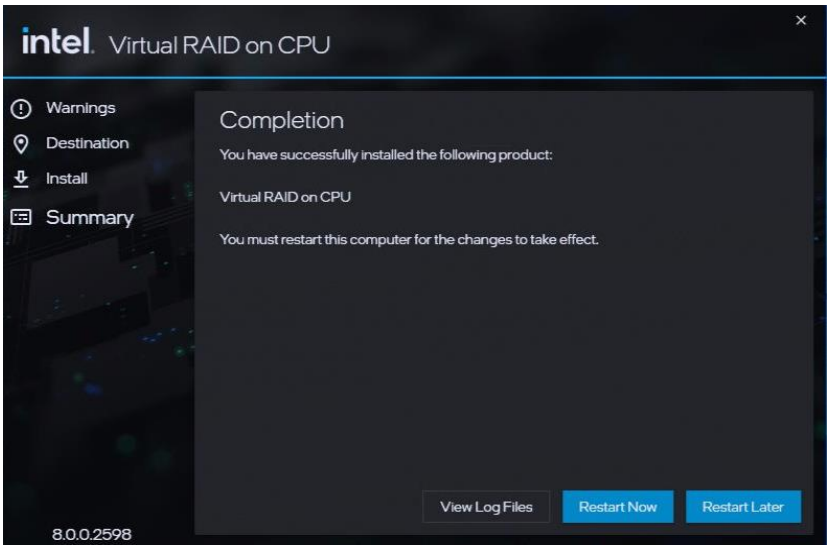
Figure 6-6. Confirmation



Note: If the installer detects that a required package(s) is missing and the platform does not detect a network connection to automatically download and install, it will alert the user via a popup that such required package is missing. You can opt to continue the installation, but the Intel® VROC GUI will not be available until the missing packages are installed.

7. 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.

Figure 6-7. Completion



6.2 Windows* Server 2012 R2 Updates

Support for Windows* Server 2012 R2 has ended in Intel® VROC 8.5. If this operating system is still needed, contact Intel Customer Support for more information on the matter.

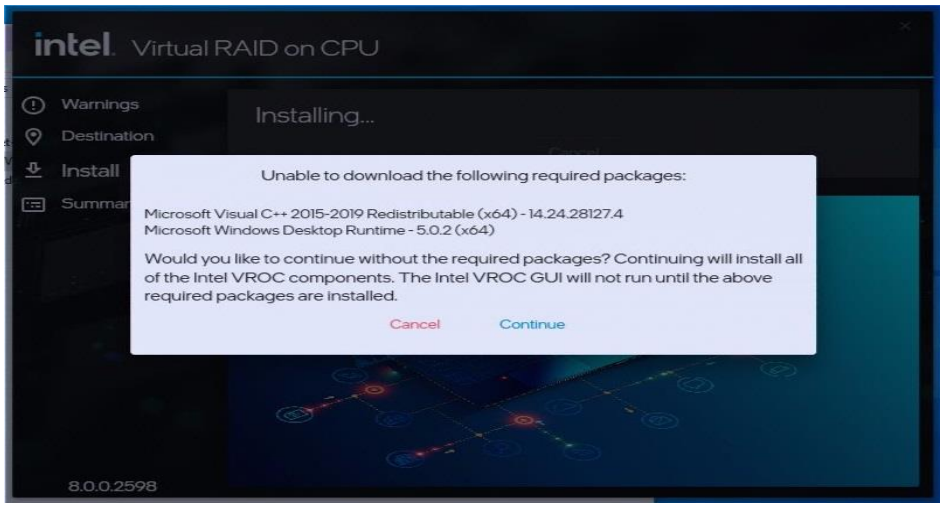
6.2.1 Installing Required Microsoft* Components for VROC GUI

Starting with Intel® VROC 8.0 version, the Intel® VROC GUI requires (at a minimum) the following packages be installed if the Windows* operating system you have installed does not already have them. The VROC GUI installer will present a popup with such details if it does not detect an installed version of either of these 2 components.

1. Microsoft* Windows* Desktop Runtime – 6.0.3 (x64)
2. Microsoft* Visual C++ 2015-2019 Redistributable (x64) – 14.24.28127.4

If the Intel® VROC installer detects a network connection, it will attempt to access, download, and install the missing components automatically. Once installed, you simply continue the VROC installation process.

If the Intel® VROC installer does not detect a network connection, you will need to manually update these. You will know if this happens as you will be presented with the following popup shown in the screenshot below. You can download either of the packages from Microsoft* onto a removable drive and use it to install manually onto the platform you are installing VROC on.

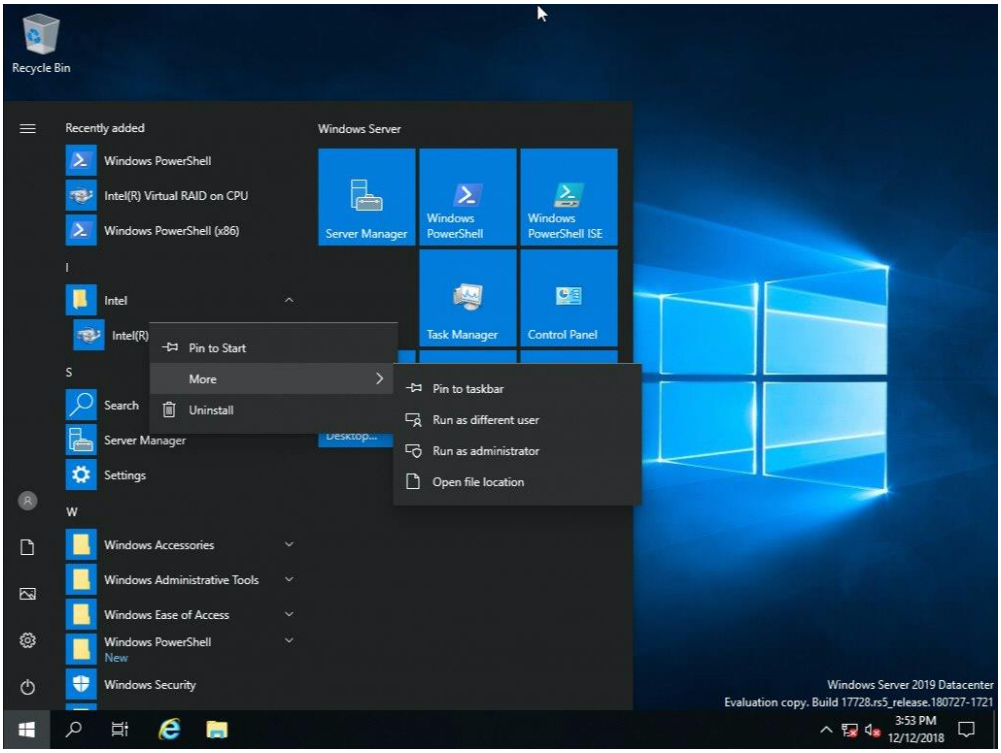


6.3 Opening Intel® VROC GUI

Launch the Intel® VROC GUI as shown in the below figure, by opening the Windows* start menu and locating the application. Then click ***Intel® Virtual RAID on CPU***. You

will need to select ***Run as Administrator*** to access the application and utilize the features. This includes use on the account Administrator.

Figure 6-8. Start Menu Location of Intel® VROC



The GUI will open to the "Home" page.

Note: The Intel® VROC Upgrade 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, refer to the documentation provided with your system.

6.4 The Intel® VROC GUI Components

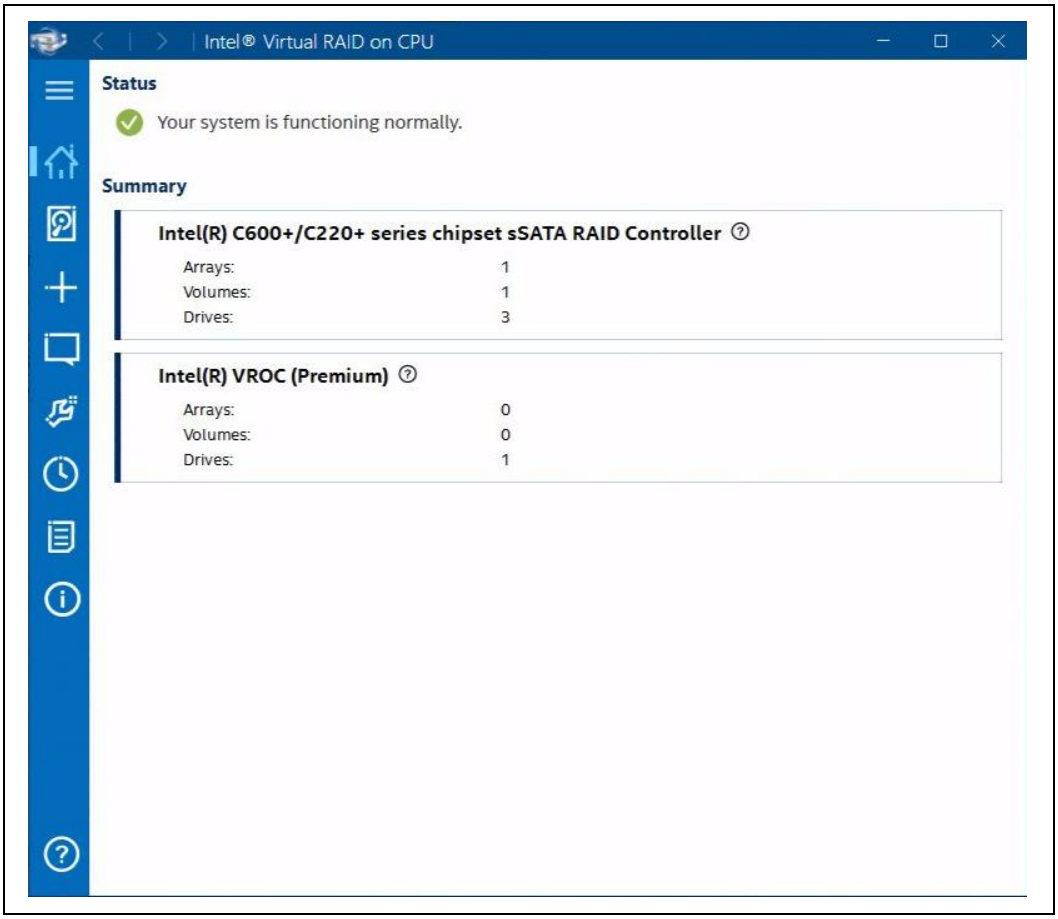
6.4.1 "Home" Page

The home page is divided into several sections:

1. **Navigation:** Clicking on the navigation arrows in top left corner of the app window allows navigation between visited pages at all times and regardless of current opened page. Also, after opening any of the Controller, Array or Volume pages, a breadcrumb path is displayed allowing the user to navigate directly between those pages.

2. **Status bar:** The application displays the overall health and status of the system. This bar showcases one of three states:
   a. The other two states would indicate either a failure in a RAID Volume or Warnings of potential problems detected.
3. **Summary pane:** This area contains a list of RAID controllers detected by the driver. Clicking on any of the controller fields moves the user to a page containing detailed information about the selected controller.
4. **Side menu:** This area contains links that navigate to other pages and menus. Clicking the hamburger button expands the panel.

Figure 6-9. Home Page



6.4.2 "Drives" Page

This page contains a detailed list of all drives detected on the platform. User can find here three areas of interest.

1. Filters section: in here user can search and filter the extensive list of drives that are present in the system. This pane contains three elements:

- Controller type selector – this is a drop-down list which allows for filtering the drives table by the controller type, by selecting one of the available options from the list.
- Keyword search bar – standard text search bar that allows filtering by typed keyword. The field is updated after entering at least three characters.
- Show Selected/Show All button – a button that toggles the drives table to show only the drives selected with the checkbox.

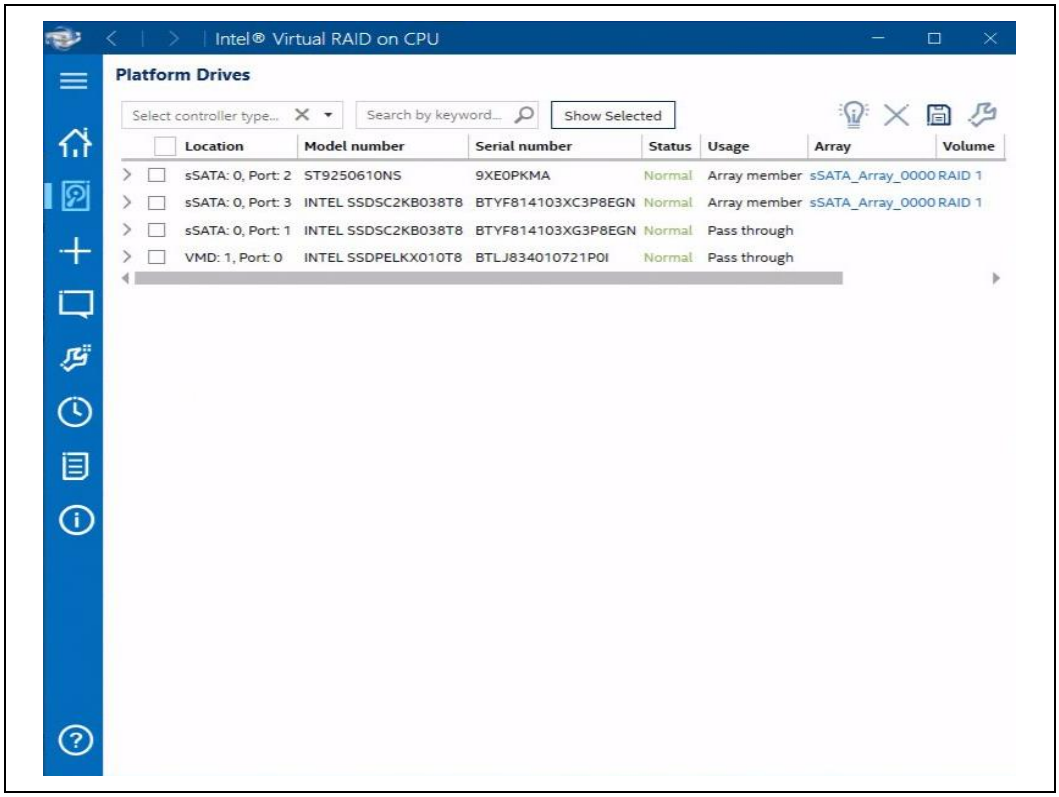
2. Action Buttons: there are four buttons that allow the user to perform specific tasks on drives selected from the drives list – except for the Export to CSV action, which is always available.
   - <Activate LED icon> after clicking this button, the selected drives will start to flash their built-in LEDs, which enables to physically locate them easier within the system. The LED will blink for about 12 seconds.
   - <Eject Drive icon> this button performs the Eject Drive action, which removes a selected drive permanently from the Operating System. This action requires that only one drive under VMD controller is selected. After clicking the button, a prompt will show requesting additional confirmation that this action was deliberate. Ejecting the drive will also activate the LED, to allow prompt removal of hardware.
   - <Export to CSV icon> this action allows the user to export all the detailed information of all the drives to a .csv file. After clicking the button, a new file browse window opens, which allows selecting where to save the file.
   - <More Actions icon> this button opens a side panel which contains six more buttons that trigger additional actions on a selected drive. If prerequisites for an action on any of the drives selected with the checkbox are not met, the button for that action will be unavailable.

Note: The Eject Drive feature is only available for NVMe drives and may not be operational with SATA drives.

3. Drives Table: It is a standard table which allows sorting and filtering.
   - Clicking on any header of a column sorts the table ascending or descending based on the content of the column.
   - Every record has an arrow on the left side which allows to expand a pane with additional information about the drive.

4. Each record has a checkbox which allows for selecting drives from the table. Right-clicking anywhere inside the table enables editing what data and in what order should it be displayed in the table. Those settings will be preserved between runs of the app.

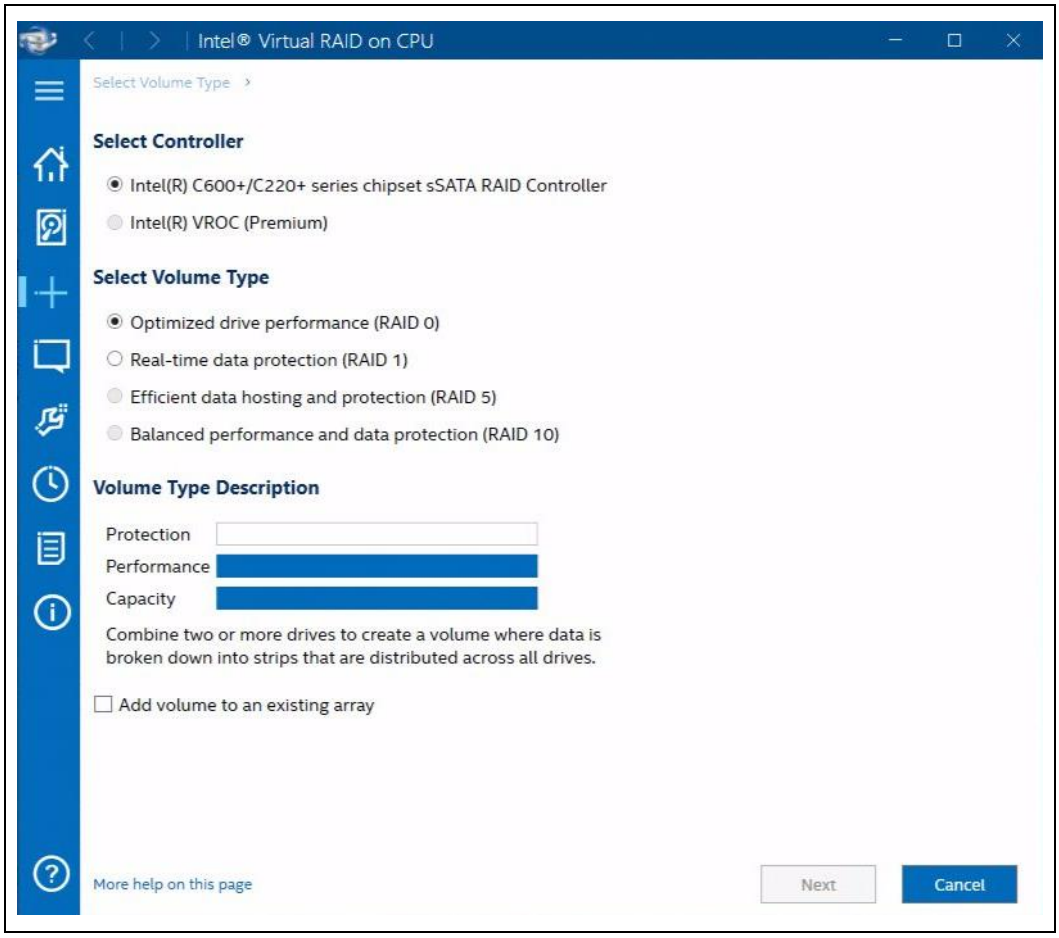
Figure 6-10. Drives Page



6.4.3 "Create Volume" Page

Refer to Figure 6-11 below and Section 7 to follow along an example of the RAID Volume creation process.

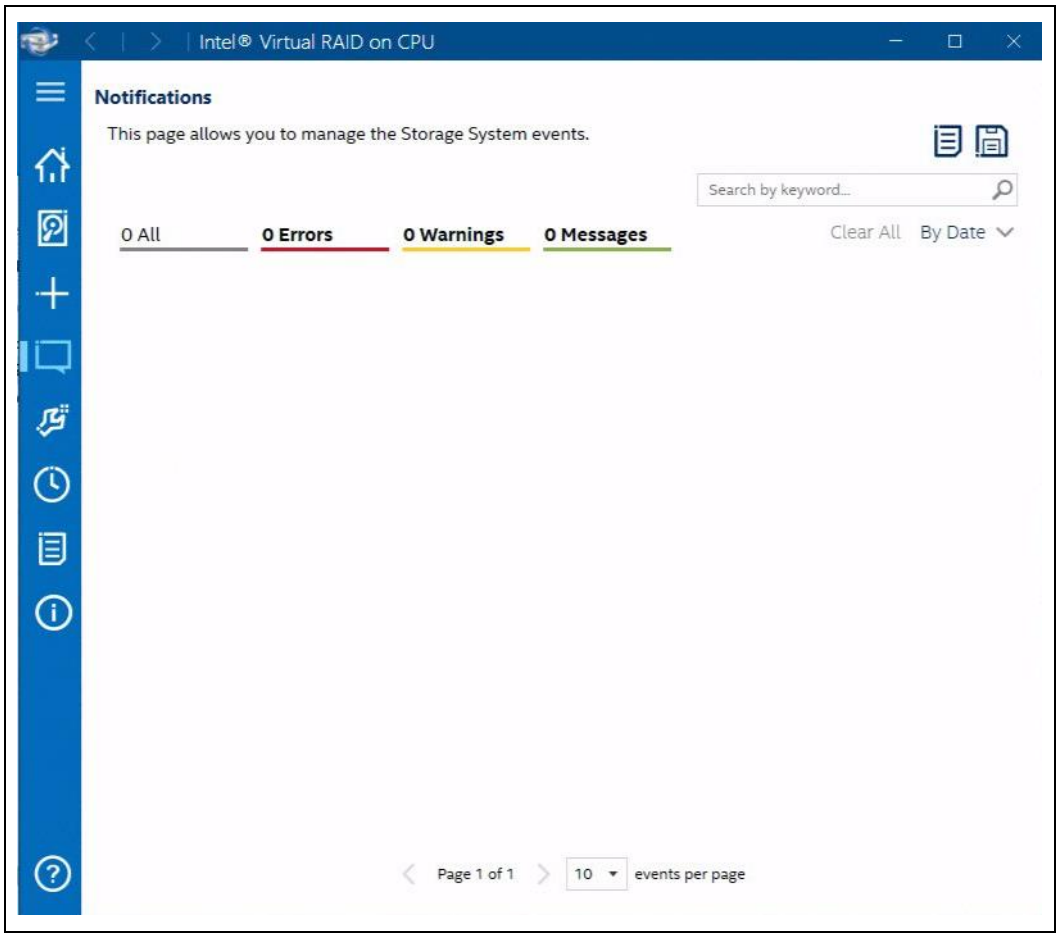
Figure 6-11. Create Volume



6.4.4 "Notifications" Page

If any issues such as errors or warnings with the RAID Volumes occur, all notifications will be present on this page, indicating what is wrong and which RAID Volumes are affected.

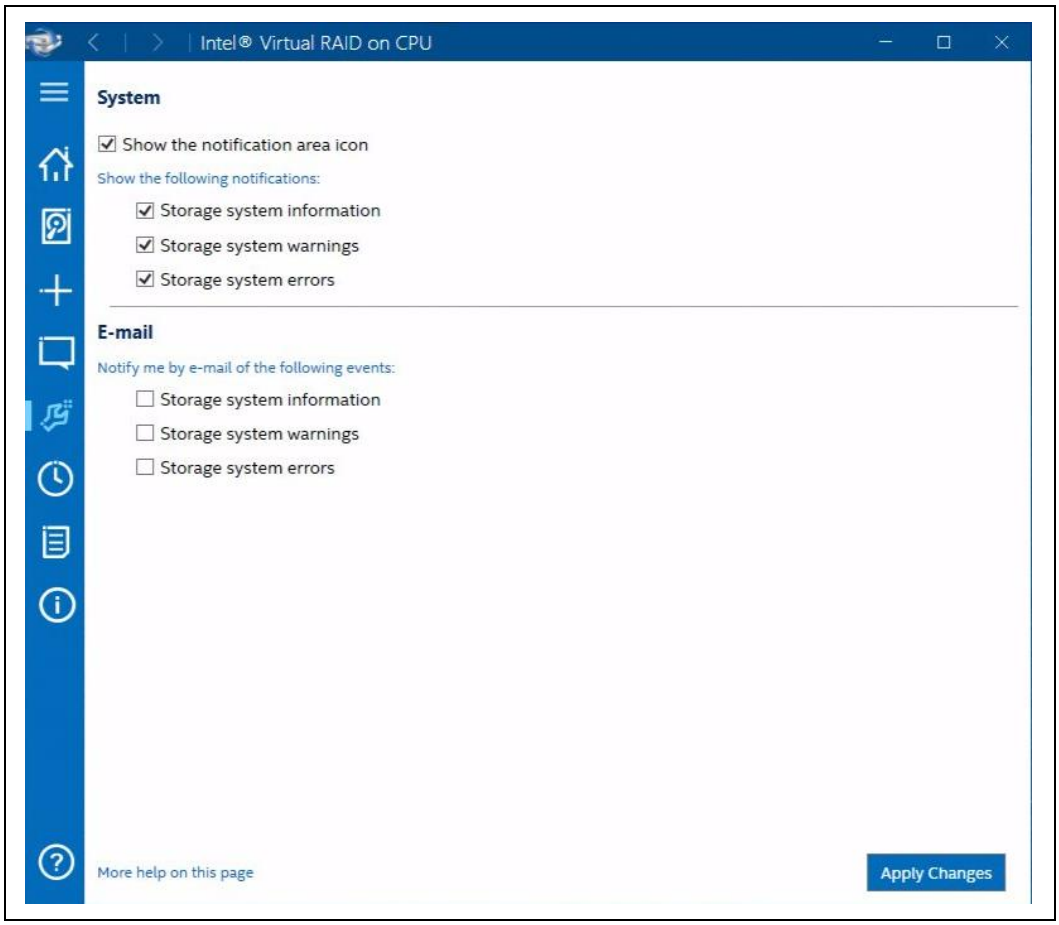
Figure 6-12. Notifications Page



6.4.5 "Preferences" Page

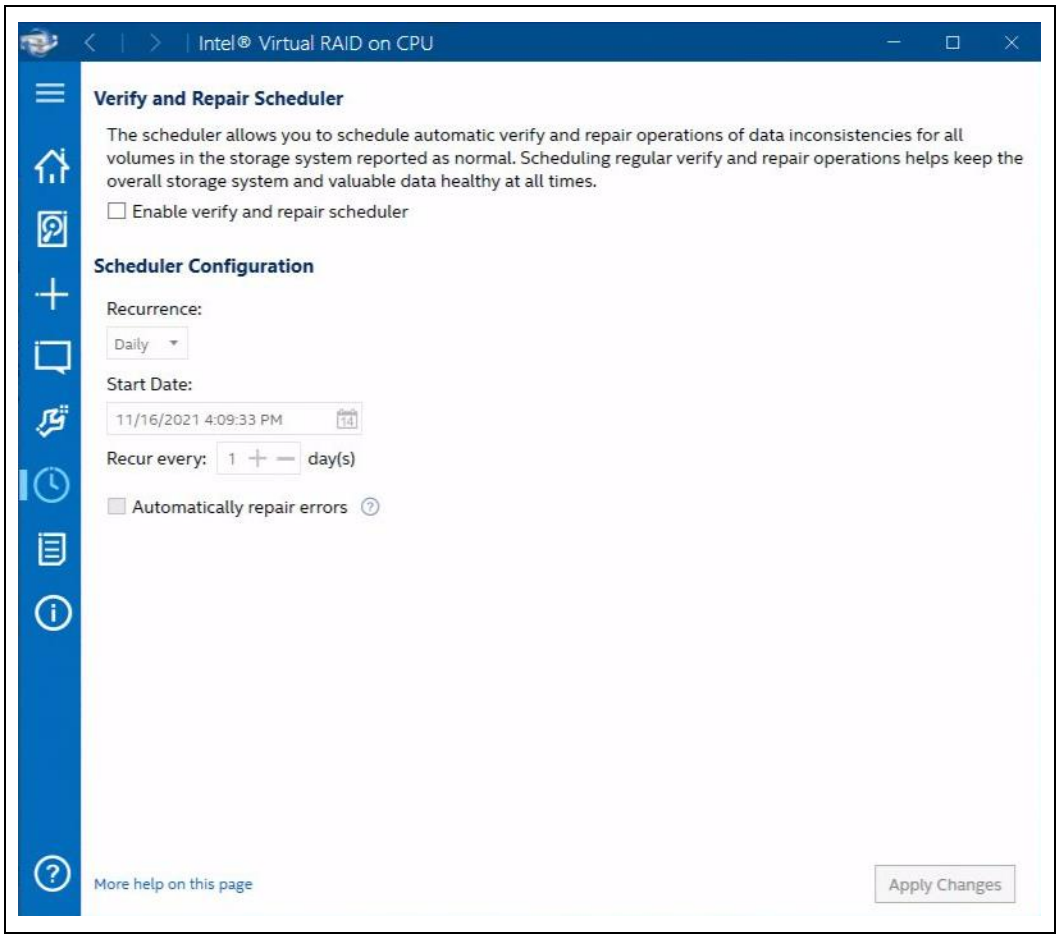
This page allows the user to have the ability to turn notifications on or off in regard to the affected RAID Volumes under Intel® Virtual RAID on CPU.

Figure 6-13. Preferences Page



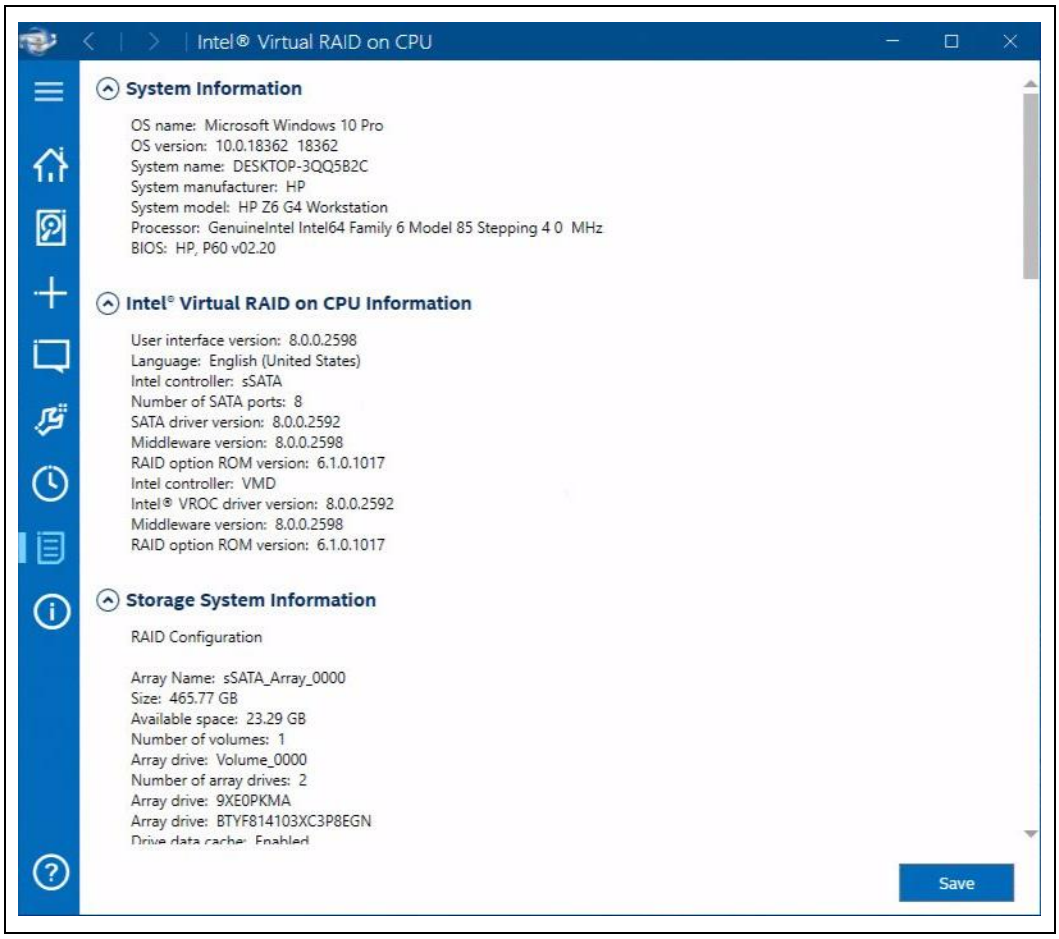
6.4.6 "Scheduler" Page

Figure 6-14. Scheduler Page



6.4.7 "Systems Report" Page

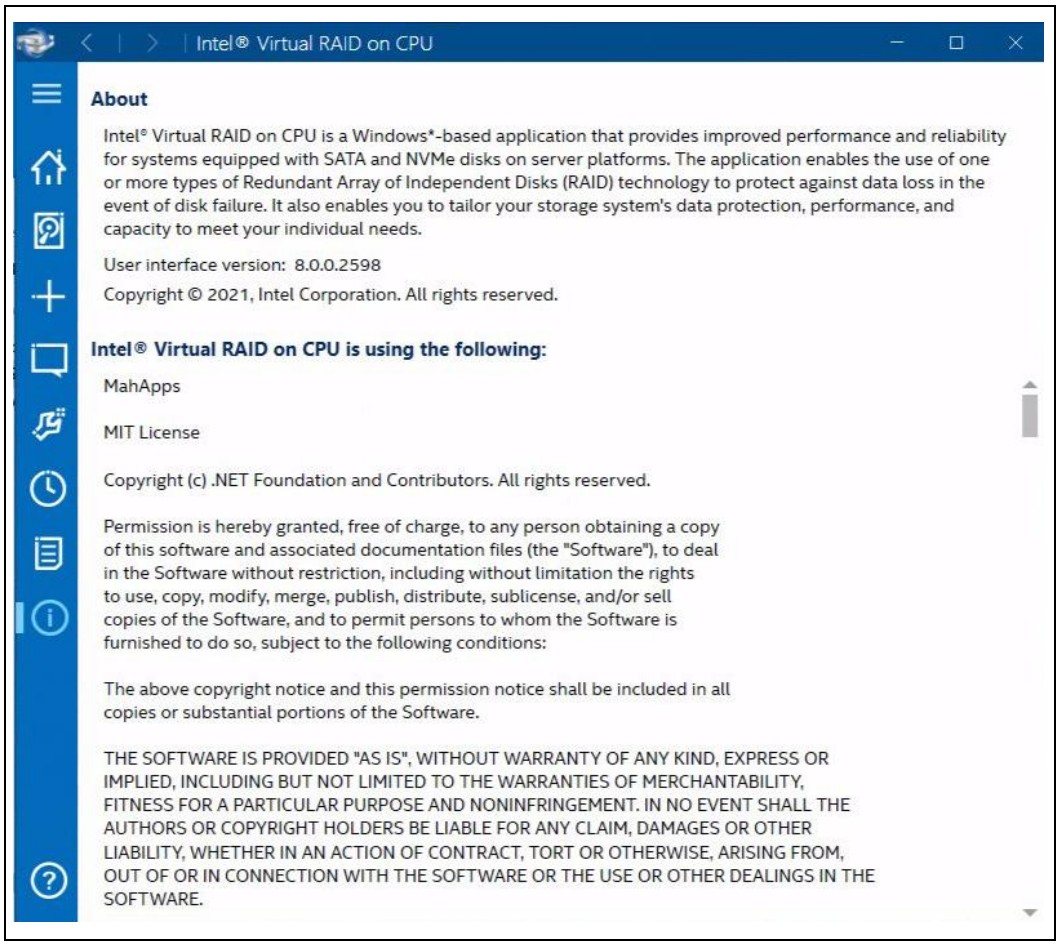
Figure 6-15. Systems Report Page



6.4.8 "About" Page

The "About" page provides explanations for the purpose and functionality that the Intel® VROC product performs, along with licensing information.

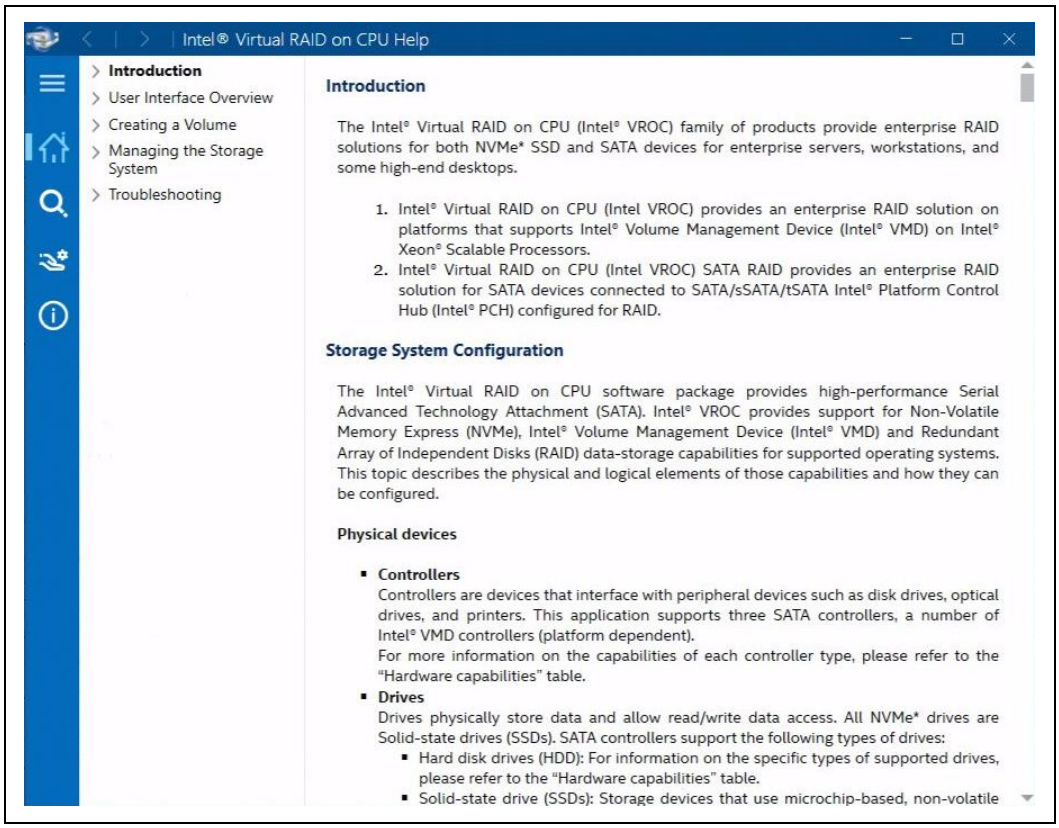
Figure 6-16. About Page



6.4.9 Help Content

The Help Content page provides brief descriptions of the overall functionality of Intel® VROC capabilities and associated devices.

Figure 6-17. Home Page



§§

7 Volume Creation

The following will provide guidance on utilizing the Intel® VROC GUI in the creation of a RAID volume. The system here is presumed to 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 the number of disks to be employed.

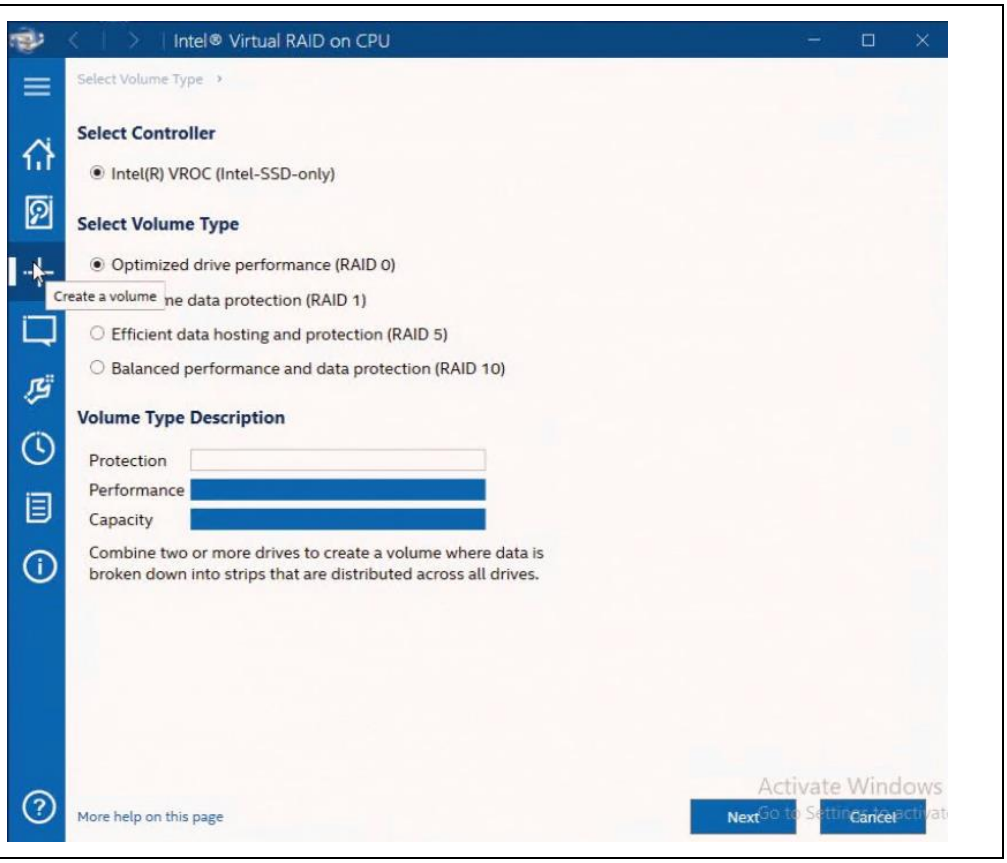
7.1 Creating 2 Drive RAID 0 Data Volume

7.1.1 "Create Volume" Page

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

1. Within the menu pane on the left select the "+" (**Create a Volume)** to begin the process.

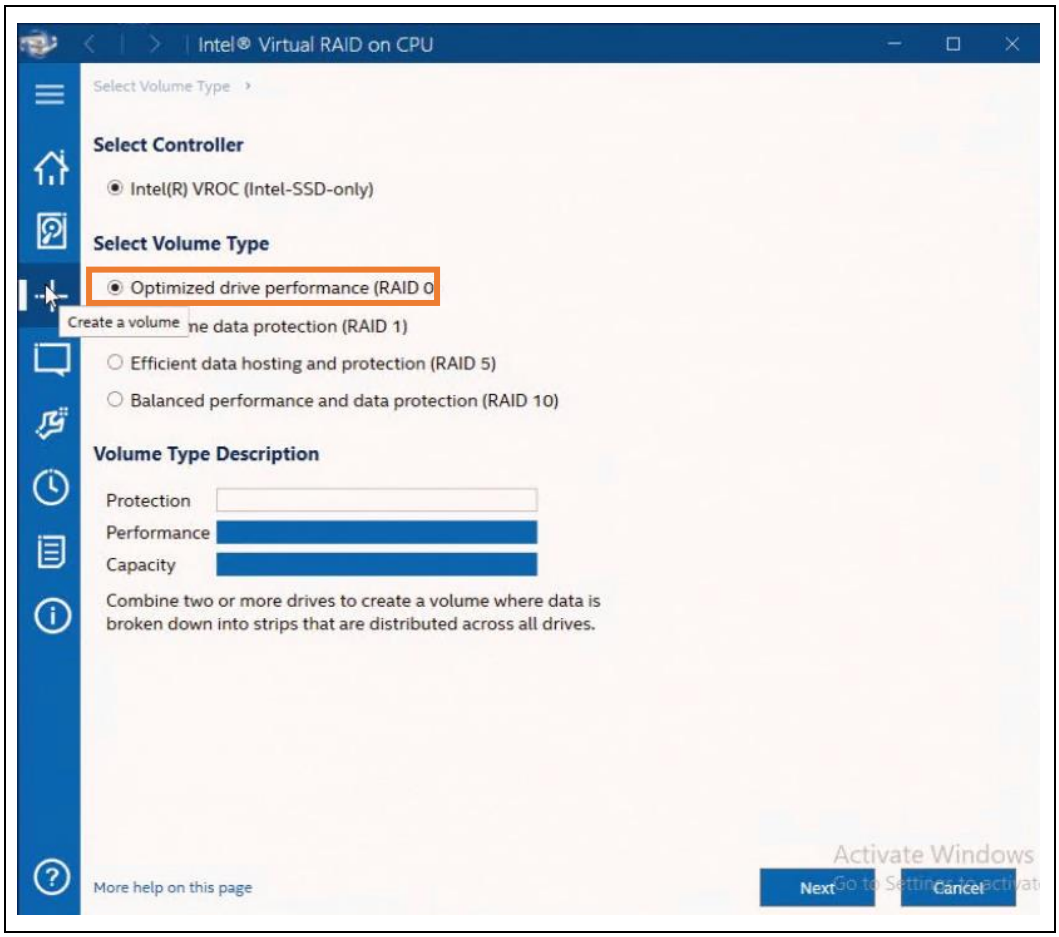
Figure 7-1. Create Volume



7.1.2 Selecting the Controller

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

Figure 7-2. Select Controller



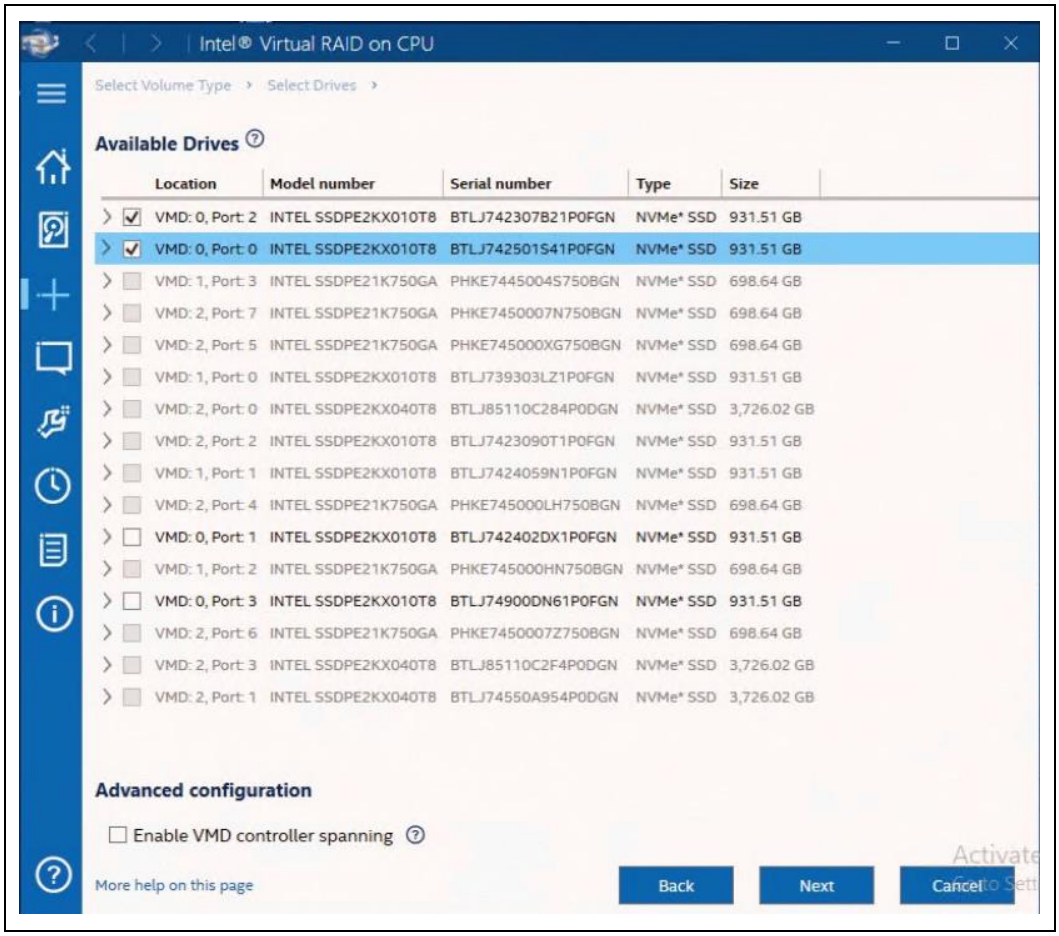
7.1.3 Configure Volume

1. Next select two drives available to be included in the volume:
   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.

If the selected drives are on different Volume Management Domains or CPUs, check the box that reads Enable VMD controller spanning. This will enable selection of additional drives if they are engaged on the system. This feature can only be used with data volumes; not supported for boot volumes.

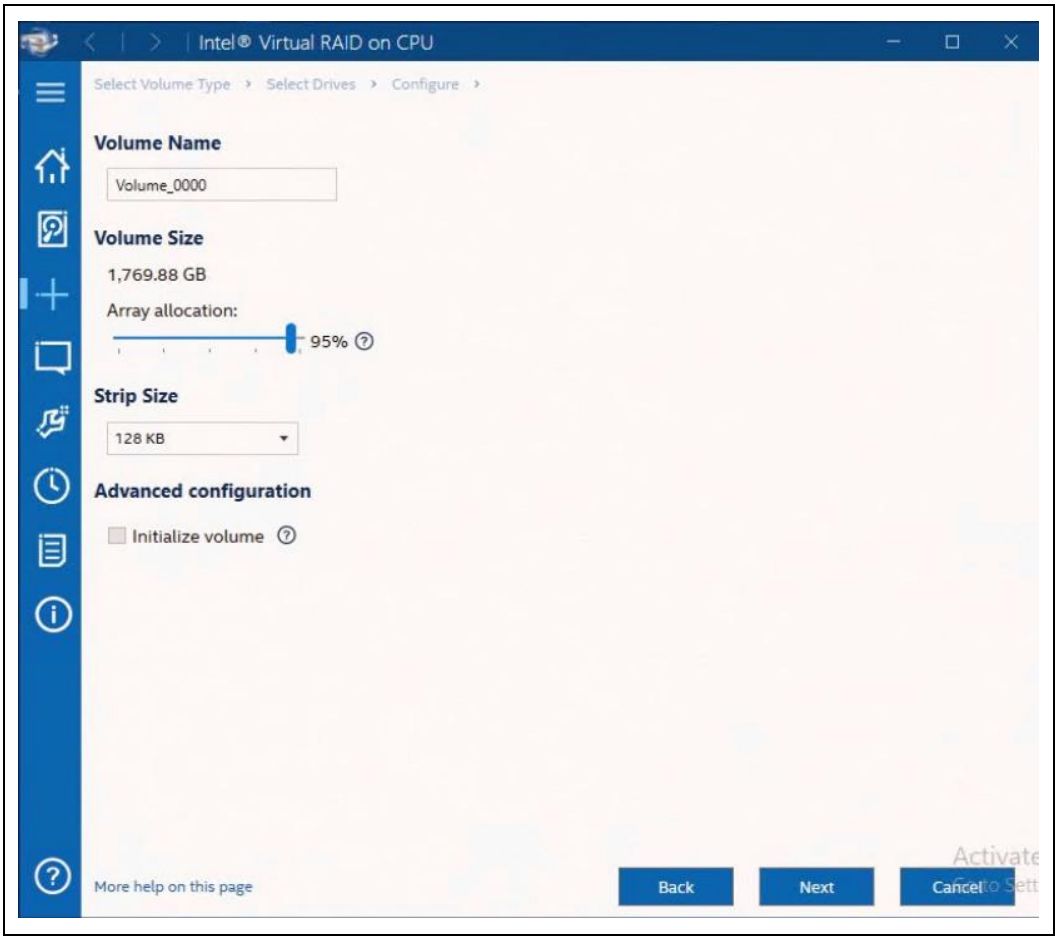
2. Then click **Next.**

Figure 7-3. Configure Volume



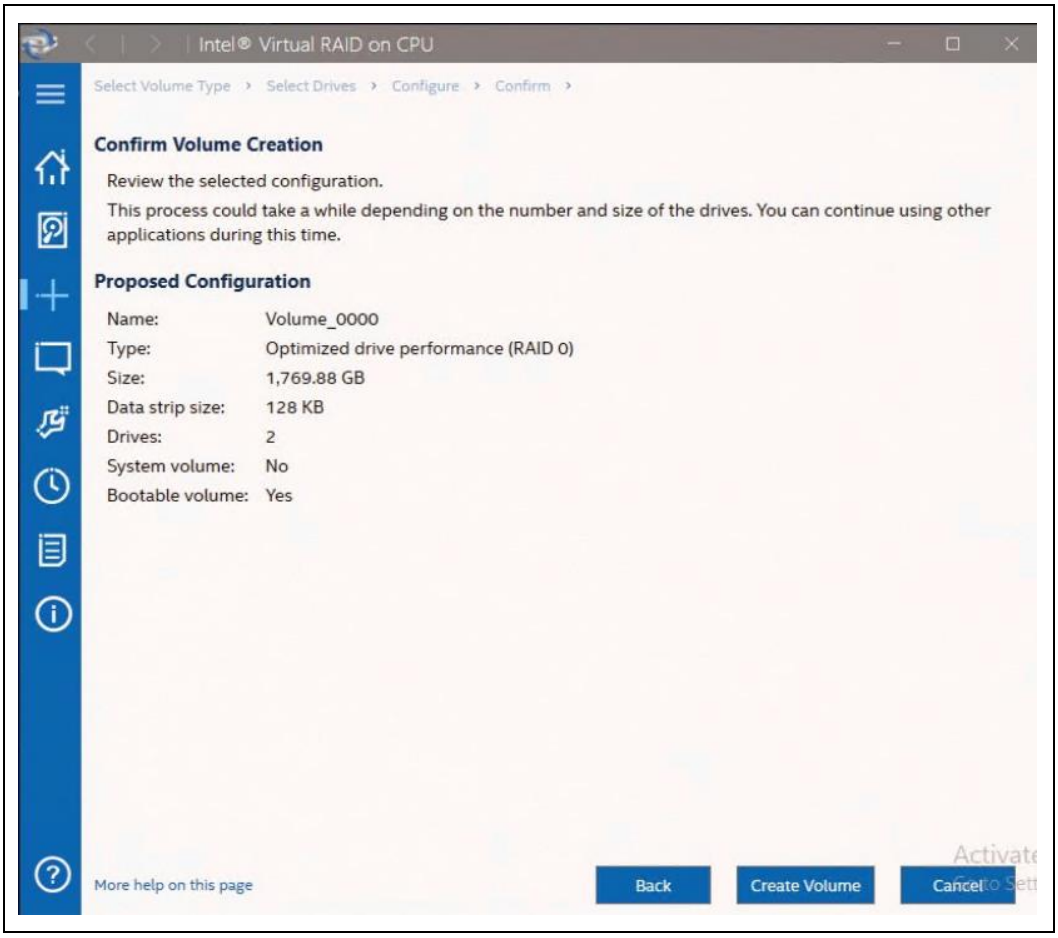
3. To configure the volume, you can first specify the **Name** of the volume. In this example it has been left as default (**Volume_0000**). For this exercise the rest of the options will be kept as default. Then click **Next.**

Figure 7-4. Configure Volume Name and Size



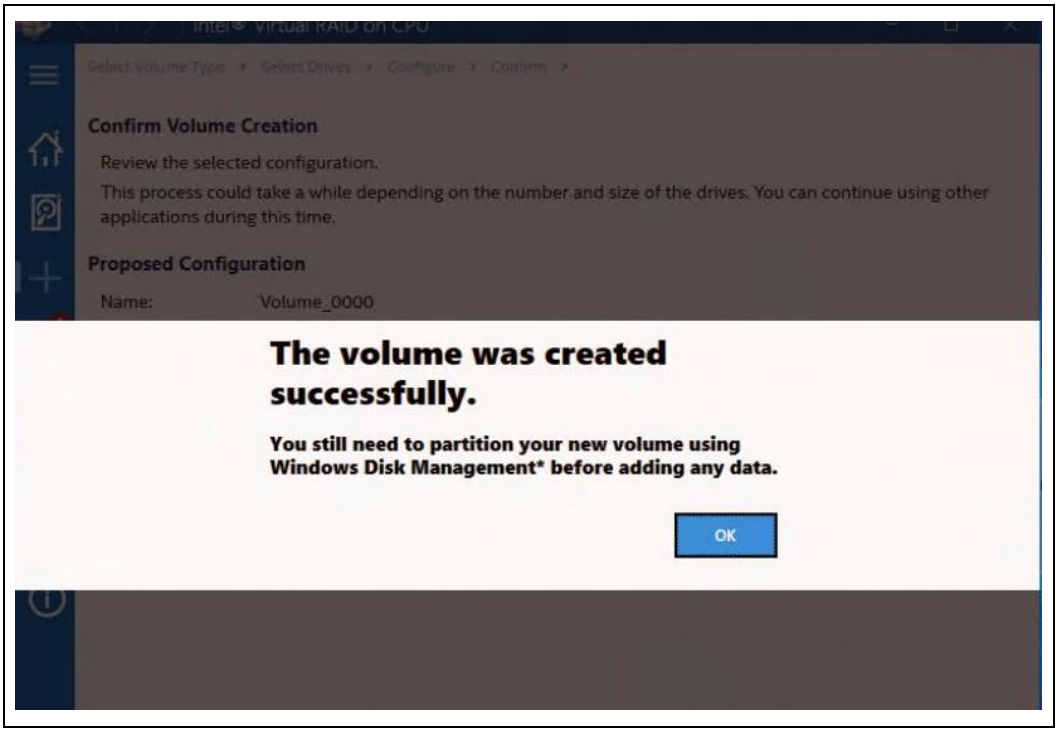
4. Click **Create Volume**.

Figure 7-5. Confirm Volume Creation



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

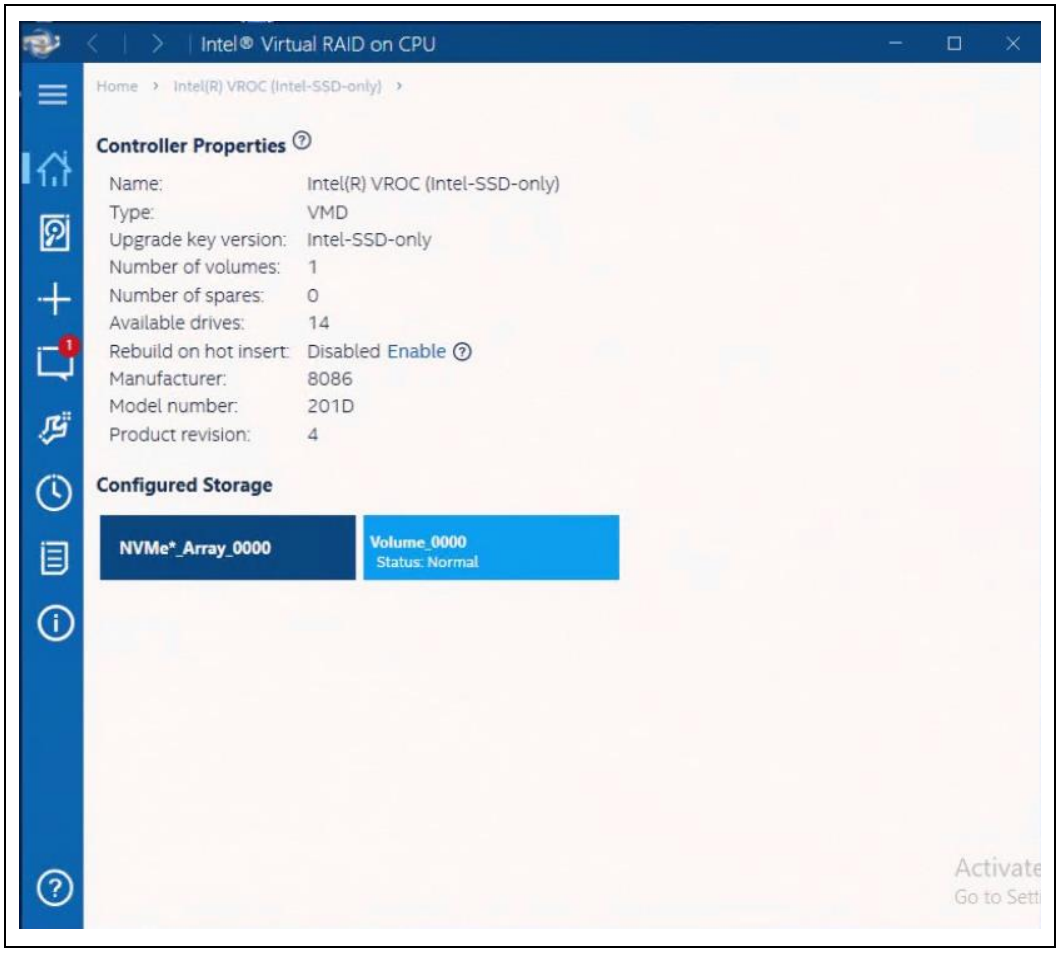
Figure 7-6. Volume Creation Complete



7.1.4 View Volume Properties

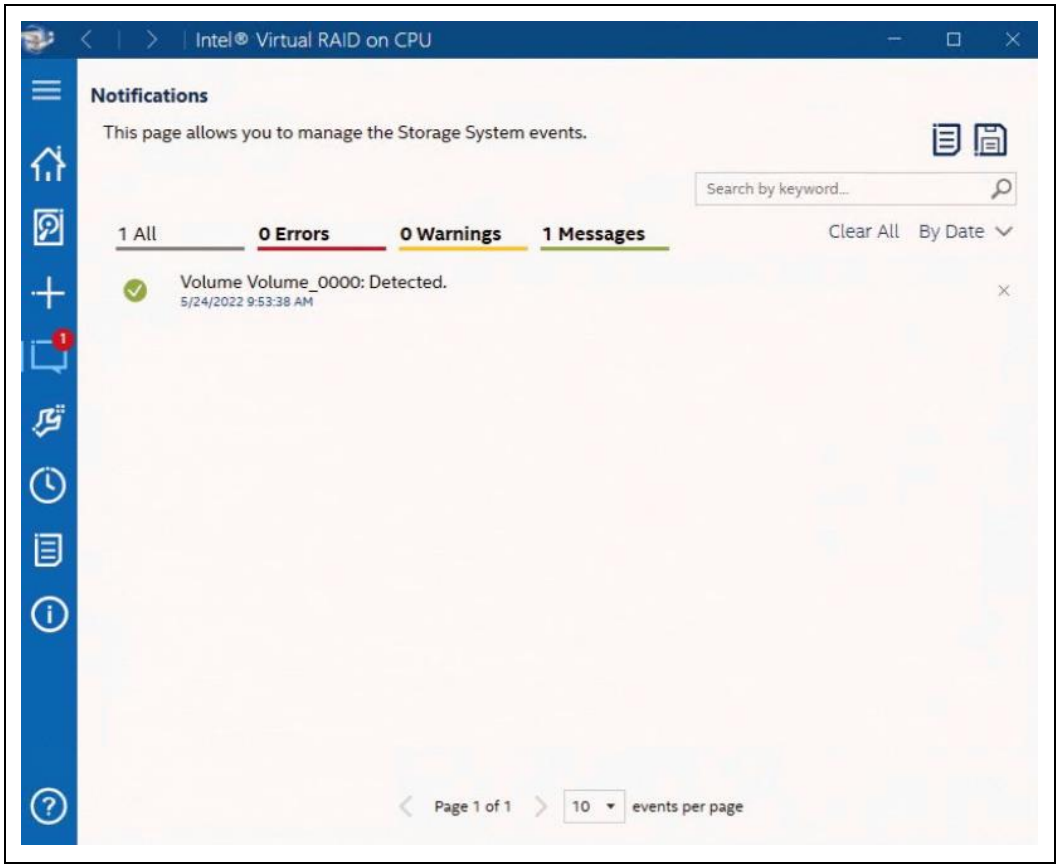
1. RAID volume (**Volume_0000**), the "Properties" pane will refresh to show the current status, properties and available options of the newly created RAID volume.

Figure 7-7. Volume Properties



2. A notification will be logged in the notification page. Formatting and mounting of the volume will still be required just as with any new drive added within a Windows* environment.

Figure 7-8. Volume Creation Complete



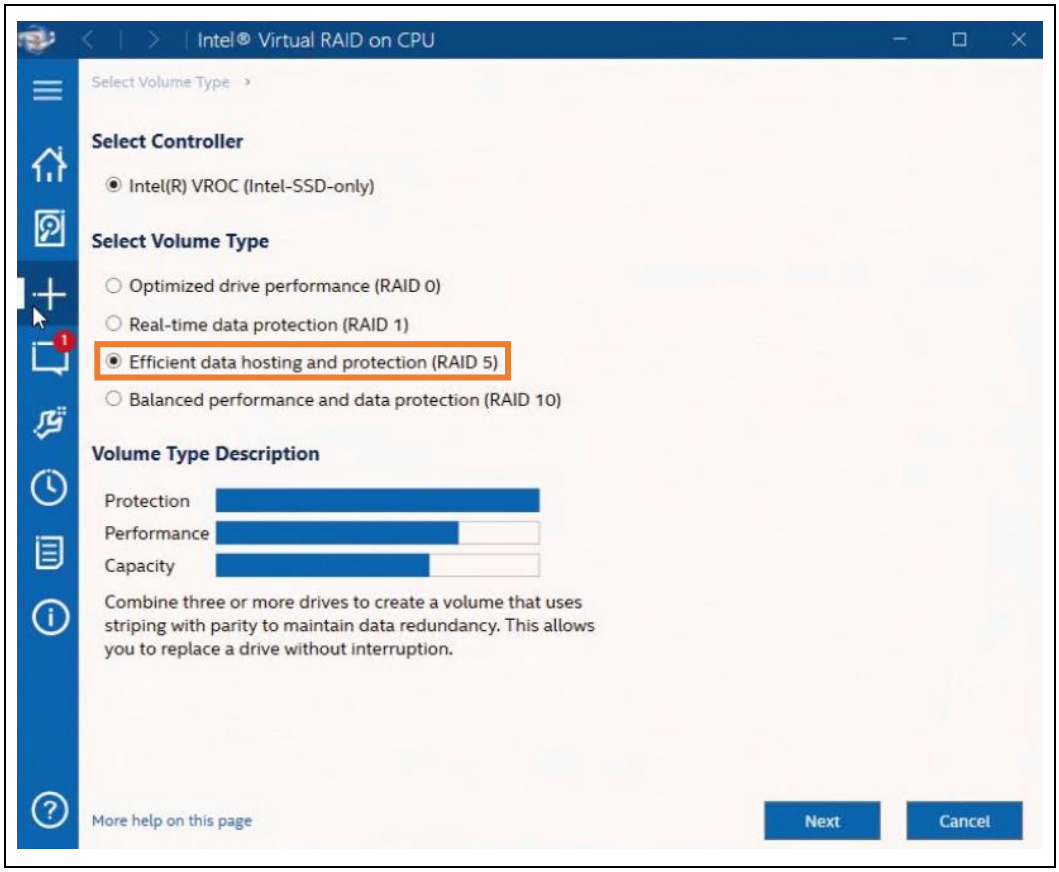
7.2 Creating 3 Drive RAID 5 Data Volume

7.2.1 "Create Volume" for RAID 5

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

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

Figure 7-9. Create Volume and Select Controller

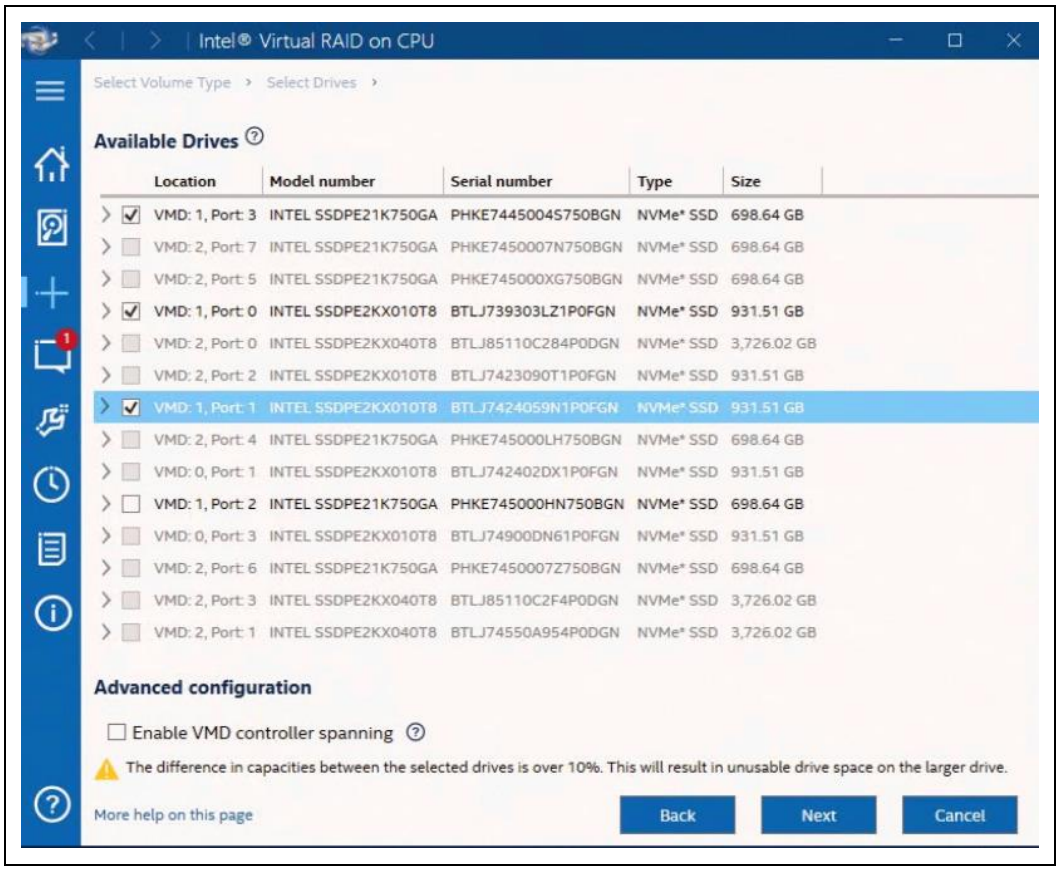


3. Next select three available drives to be included in the volume. As this system has direct connections for the NVMe drives to the board, there are 2 drives per Intel® VMD controller. The volume must be spanned across them. This will light up the WARNING: RAID volume spanned across Intel® VMD controllers 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. Spanning is not a requirement to span across Intel® VMD domains but it is an option.

7.2.2 "Available Drives" for RAID 5

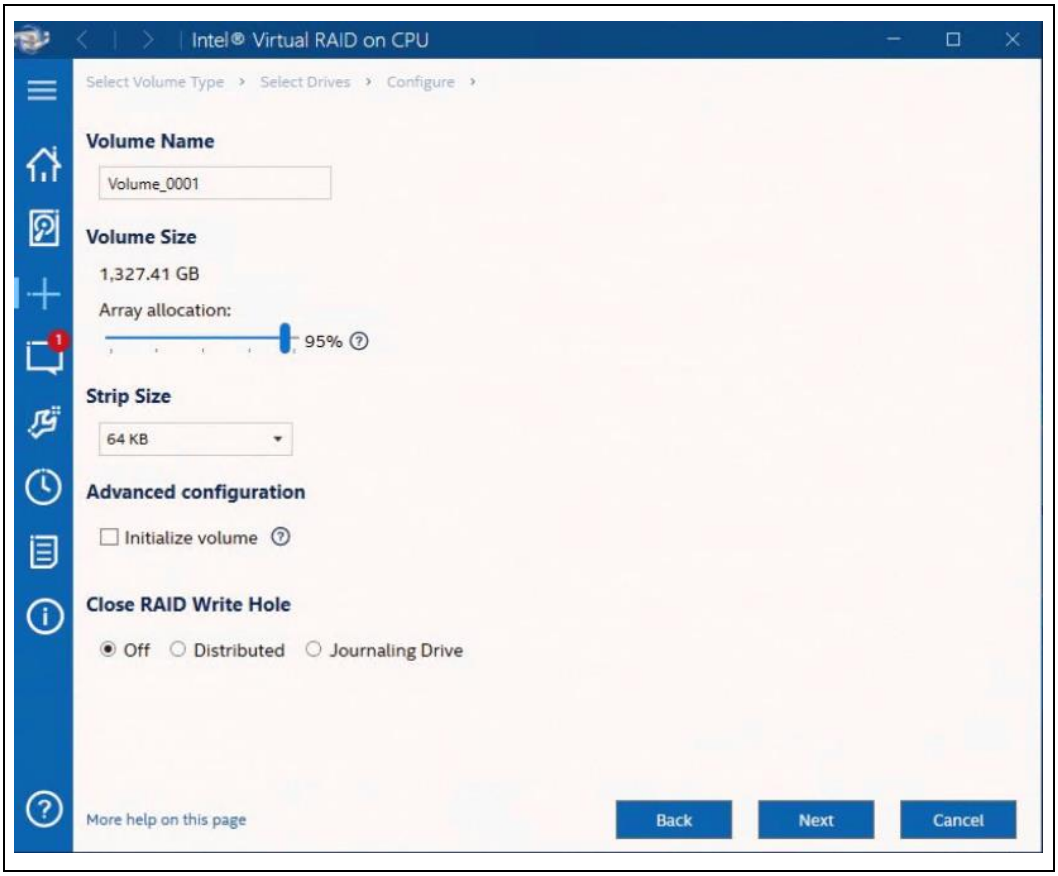
Figure 7-10. Available Drives for RAID 5



7.2.3 "Configure Volume Name and Size" for RAID 5

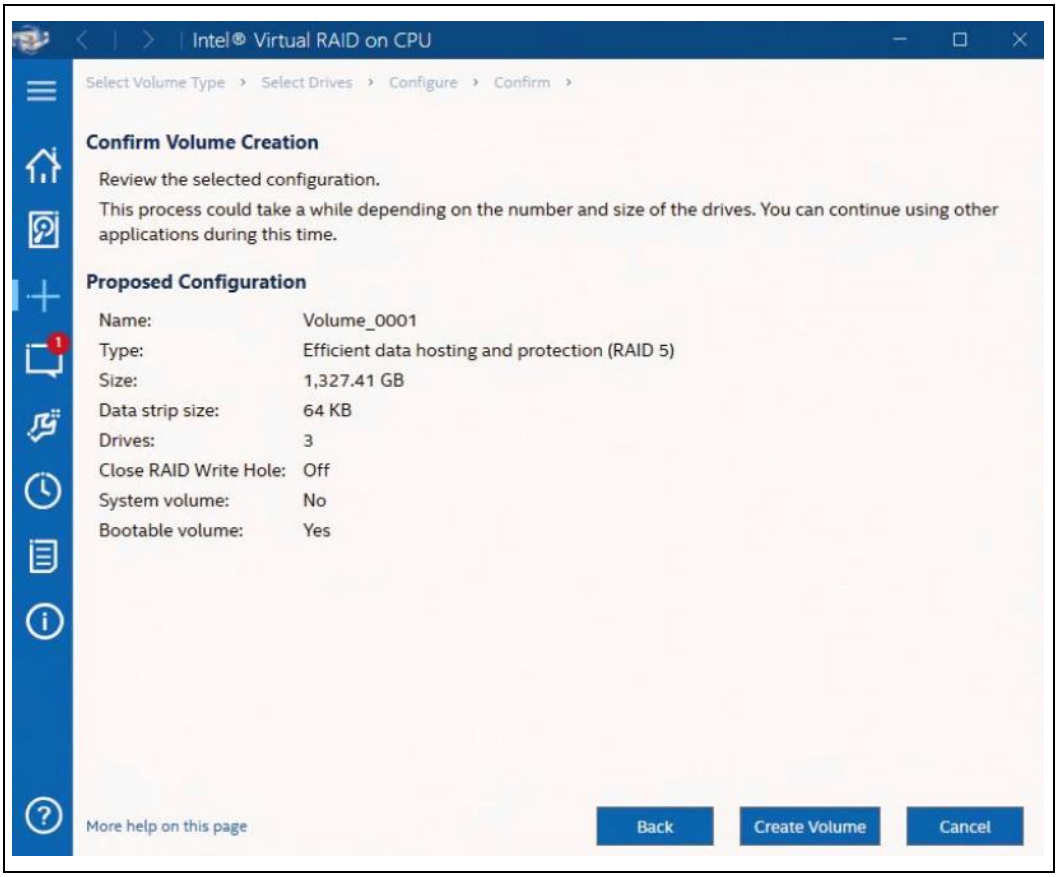
1. To configure the volume, you can first specify the **Name** of the volume. In this example it has been left as default (**Volume_0001**).
2. For RAID 5 volumes, the option to enable RAID Write Hole closure is available. This is a mean of allowing for data integrity to be maintained even if a power 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 is enabled during the volume creation to prevent risk of data loss.

Figure 7-11. Configure Volume Name and Size



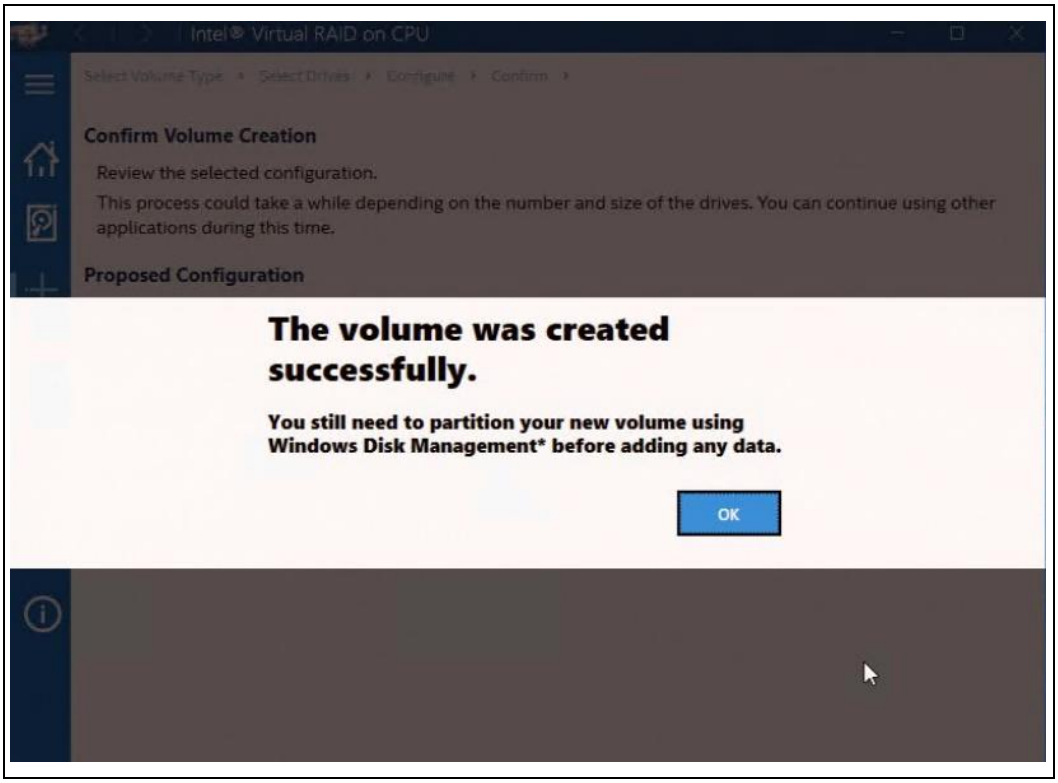
3. Click **Create Volume**.

Figure 7-12. Confirm Volume Creation



4. Click **OK** to finish.

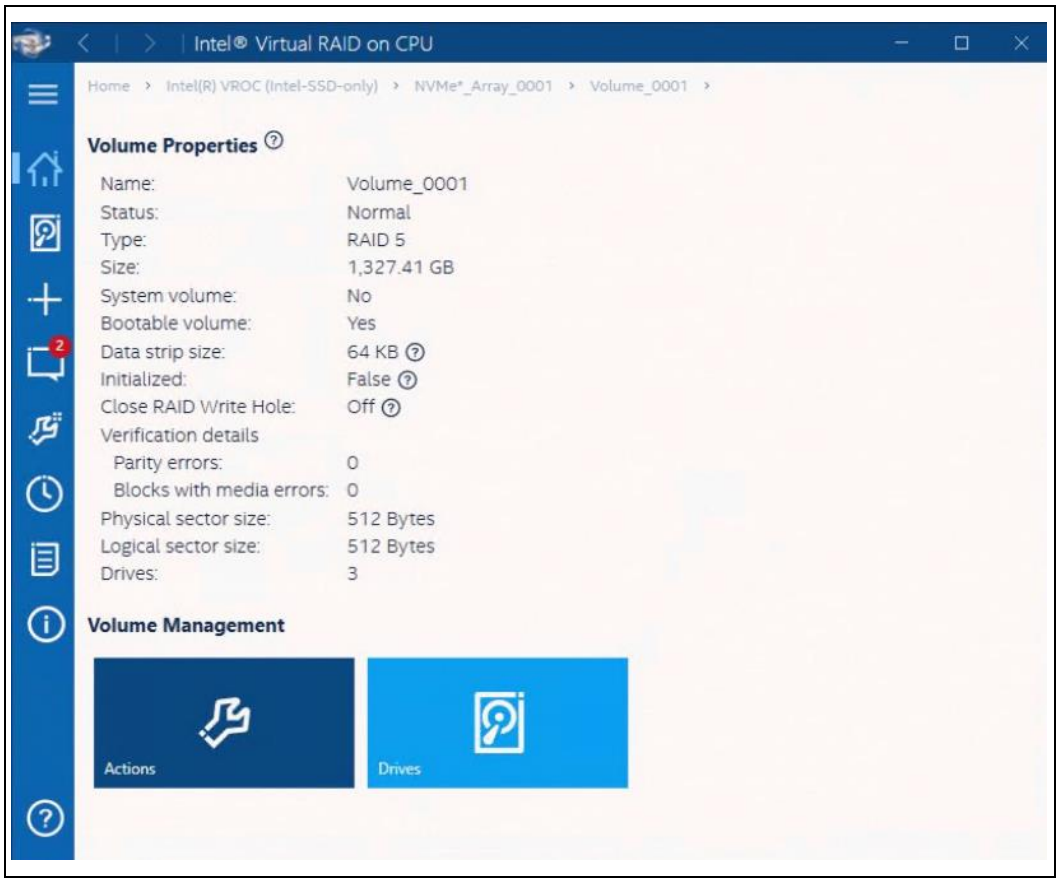
Figure 7-13. Volume Creation Complete



5. After the "OK" button has been clicked, the following landing page will be displayed. All volume properties can be viewed here.

7.2.4 View RAID 5 Volume Properties

Figure 7-14. RAID 5 Volume Properties



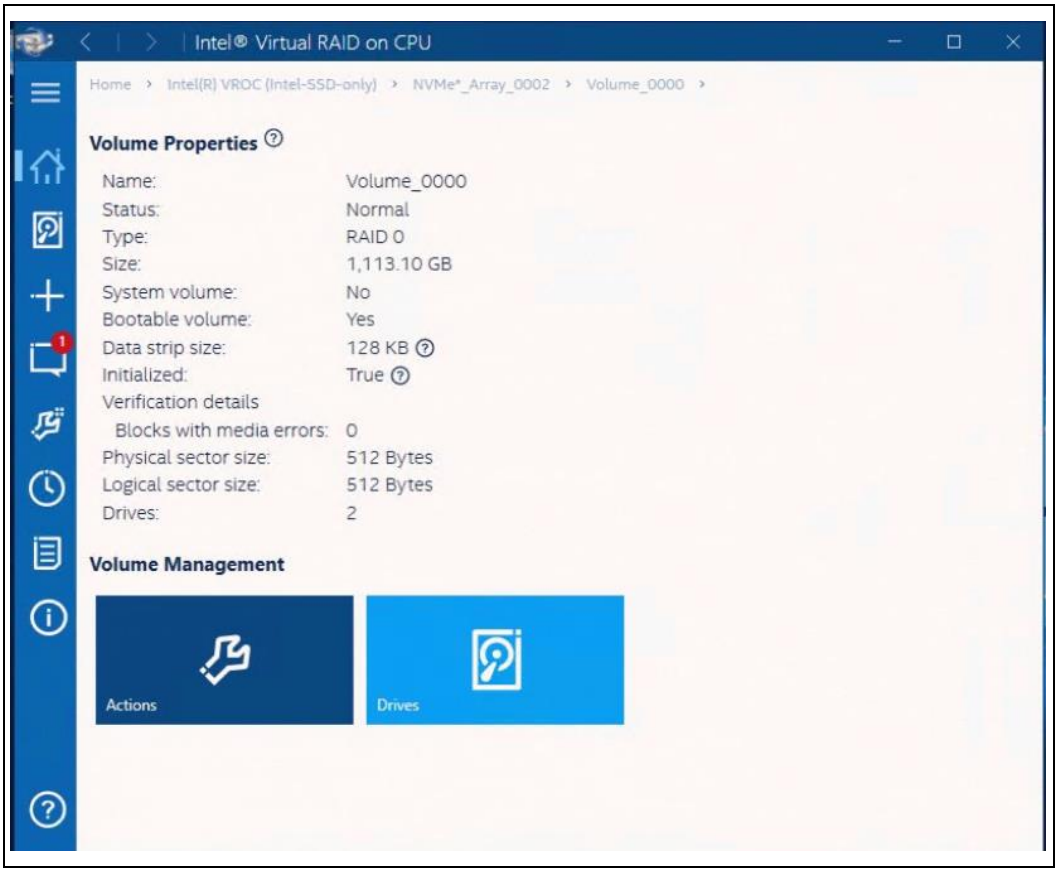
7.3 Creating Matrix RAID Configuration

7.3.1 Creating a Matrix RAID

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 to have room for the second volume on the array. When completed, the Intel® VROC GUI should show as follows. Next, click **Create Volume**.

Figure 7-15. Existing RAID 0

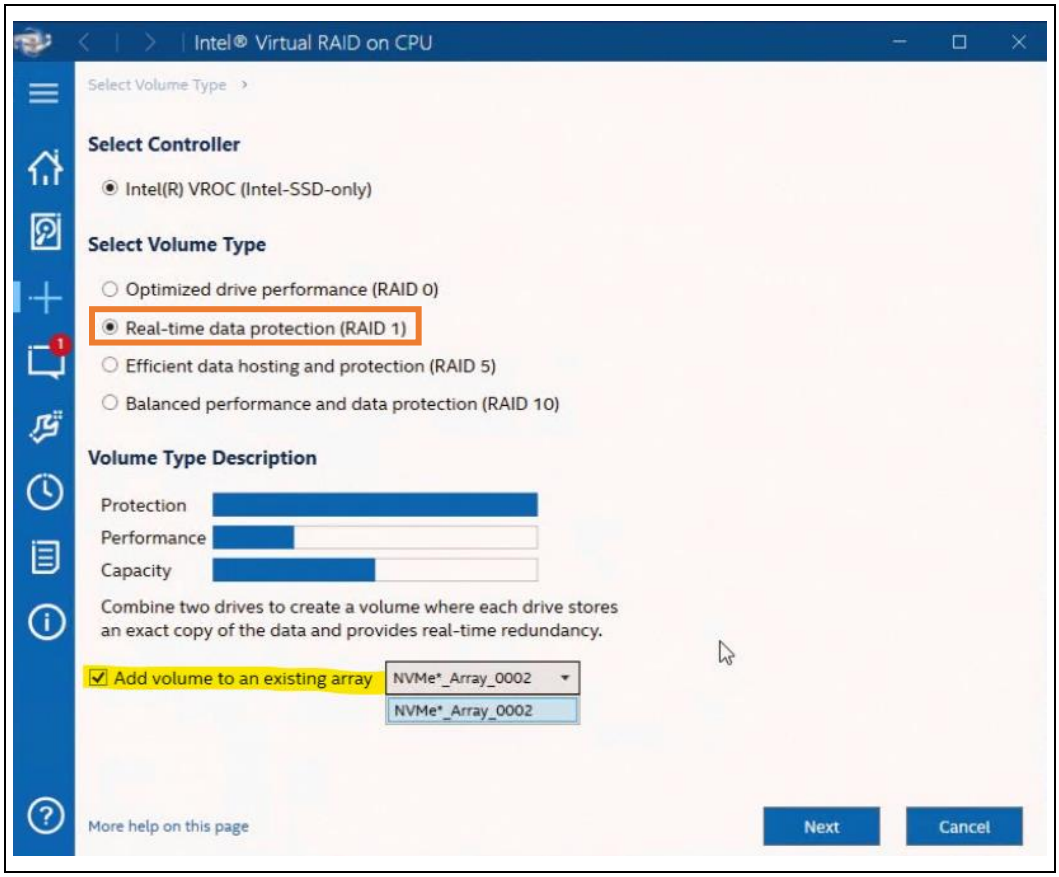


7.3.2 Creating a Matrix Volume

1. Select the **NVMe Devices** controller if not already selected. Then select **Real-time data protection (RAID 1)**. Finally, select **Next** to continue.
2. 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.

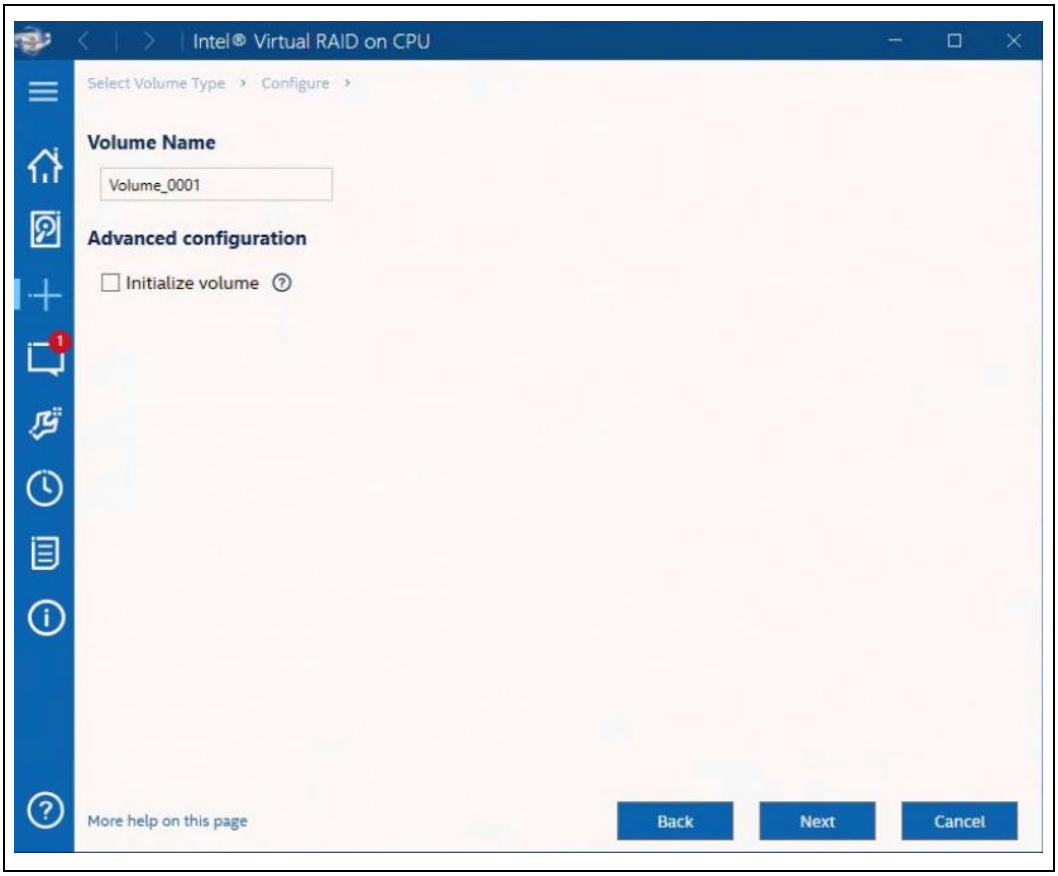
Figure 7-16. Create Volume



7.3.3 Configuring Matrix Volume Name

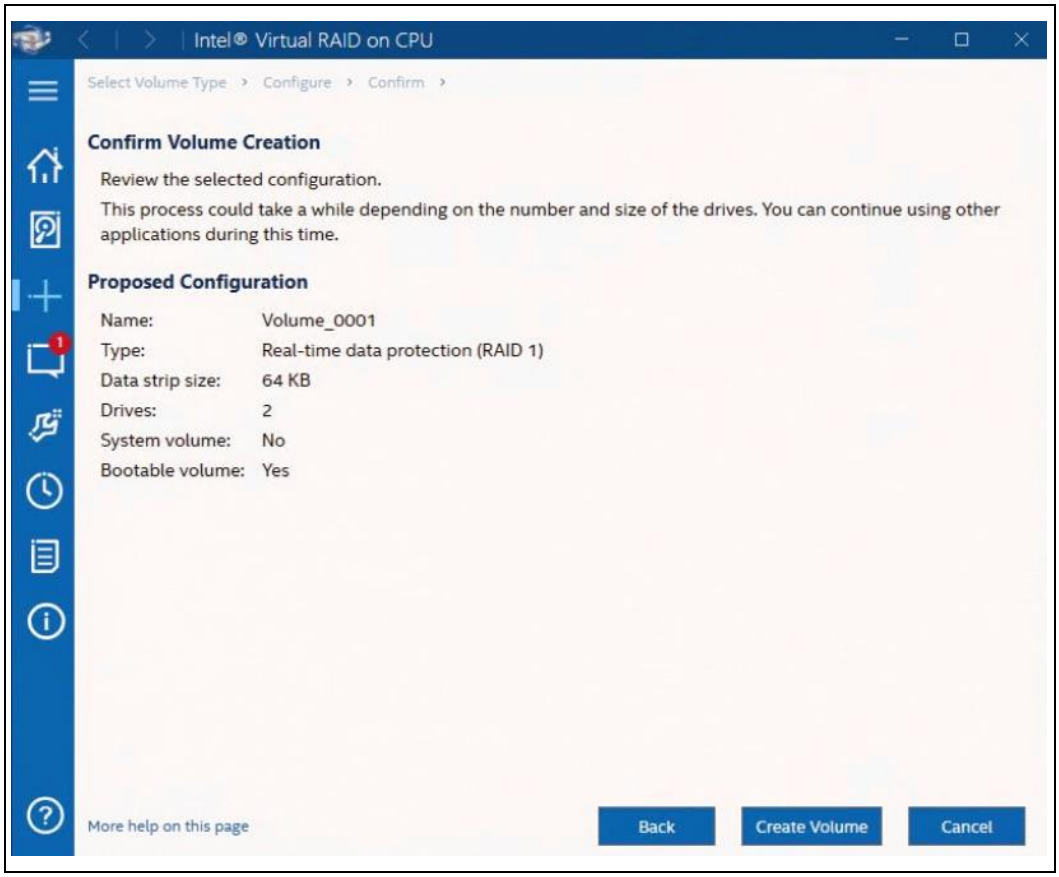
1. Specify the **Name** of the volume or simply leave as default value. In this example it has been left as default (**Volume_0001**). Then click **Next**.

Figure 7-17. Configure Volume



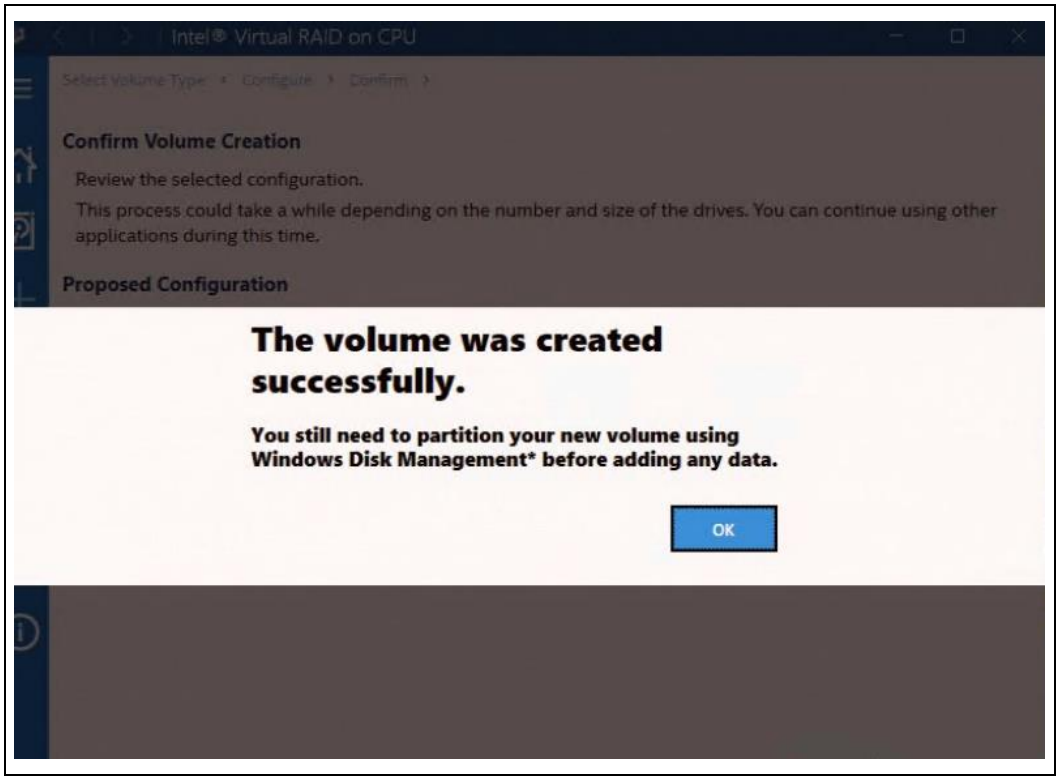
2. Click **Create Volume**.

Figure 7-18. Confirm Volume Creation



3. Click **OK** to finish.

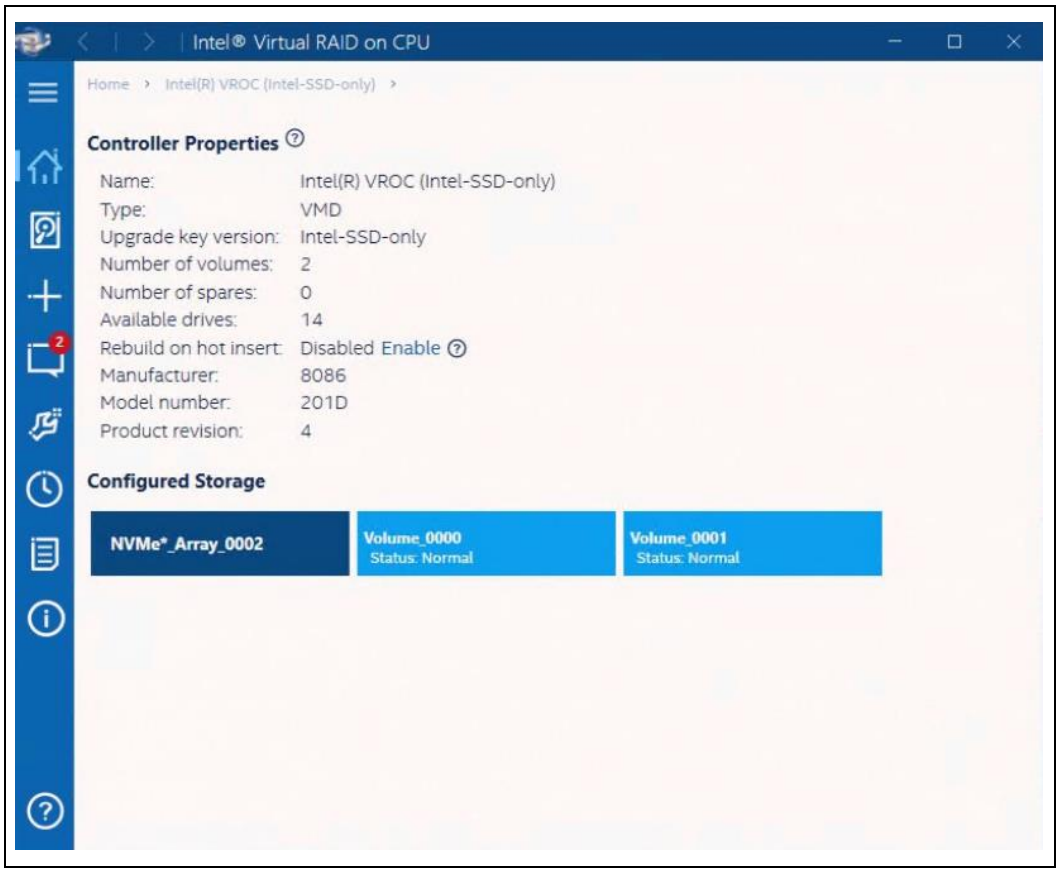
Figure 7-19. Volume Creation Complete



7.3.4 Viewing the Created Matrix Volumes

1. Under the Controller Properties page, both new Array and the RAID Volumes (Volume_0000 and Volume_0001) will appear. Clicking on either volume will navigate to its property's page.

Figure 7-20. Volumes Selection



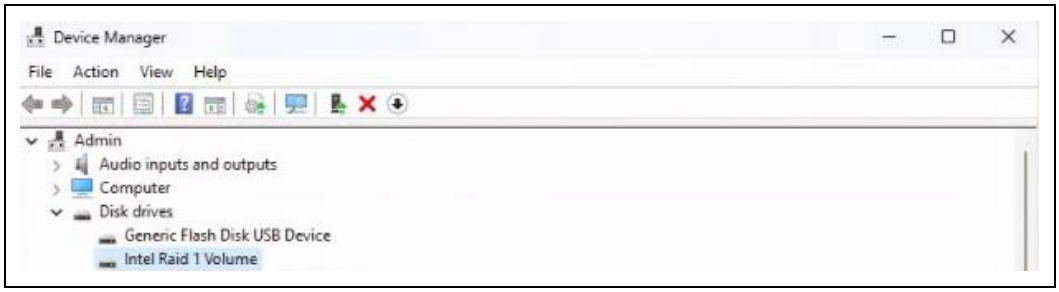
7.4 Viewing RAID Volumes in Windows* Control Panel Applets

7.4.1 RAID Volumes in Device Manager

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 **Device Manager**. The newly created RAID volume should be shown under **Disk drives**.

Figure 7-21. Computer Management

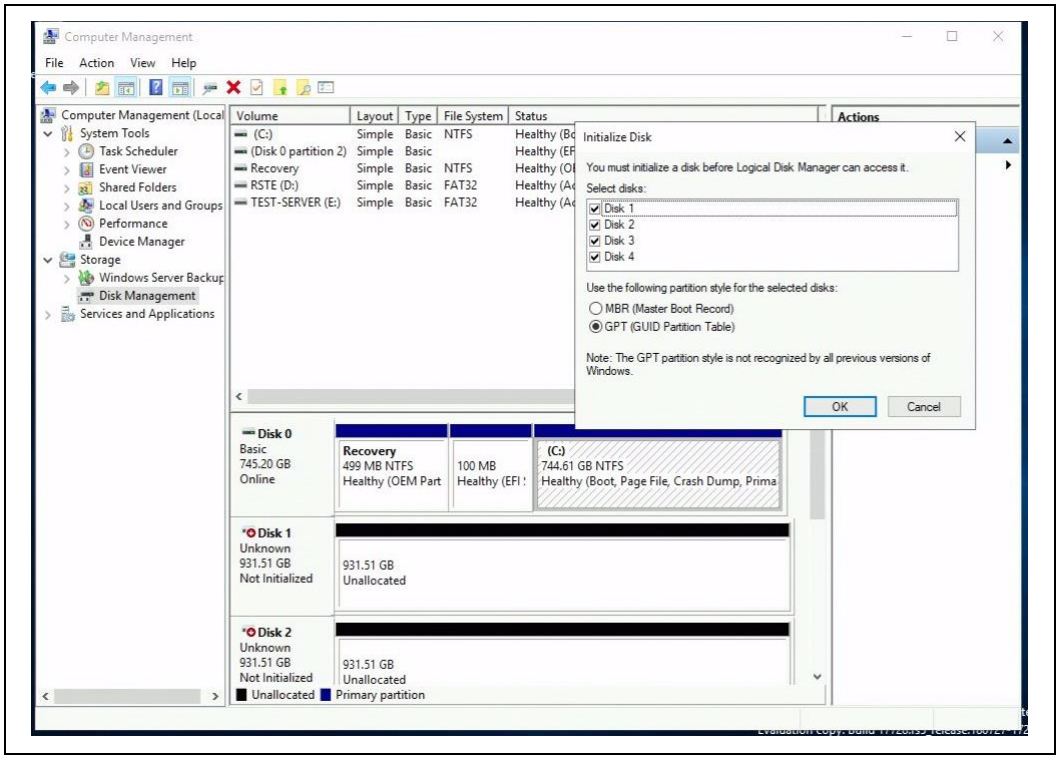


7.4.1 "Disk Management" Page

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

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

Figure 7-22. Disk Management



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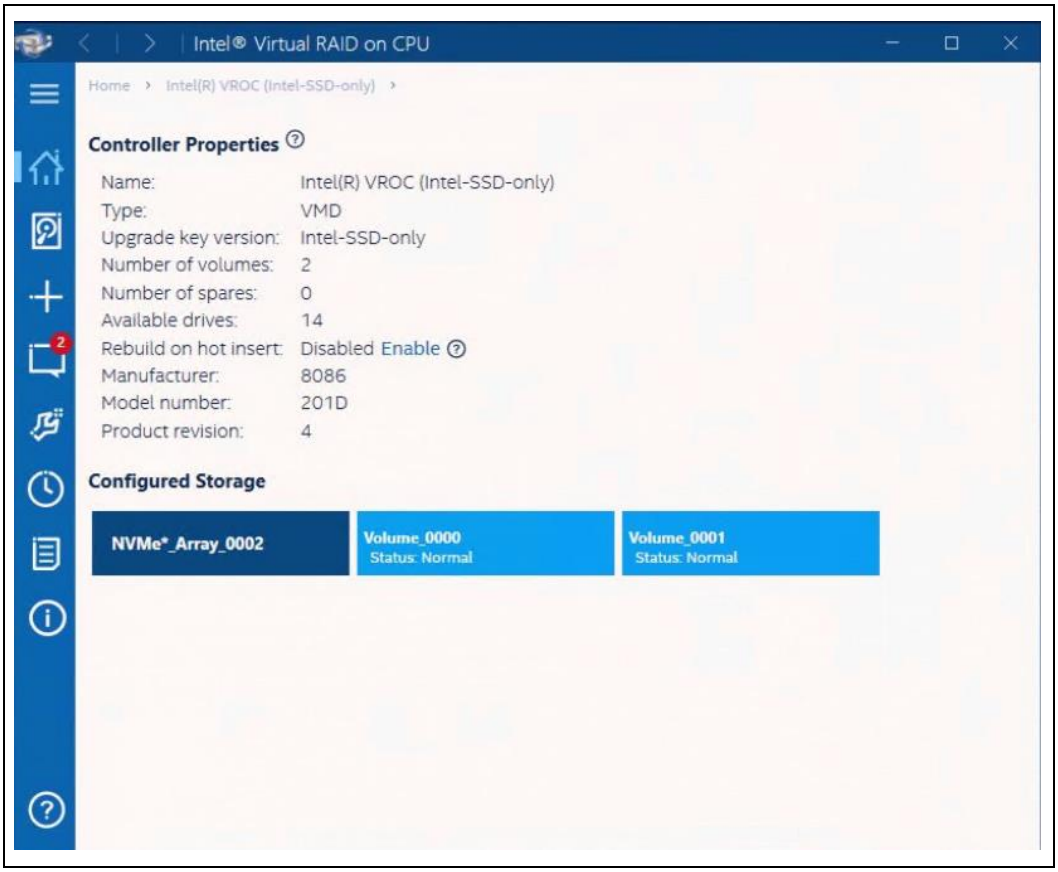
8 Deleting a Volume

Follow the steps through the RAID volume deletion process. From the home page, select the RAID Volume to be deleted.

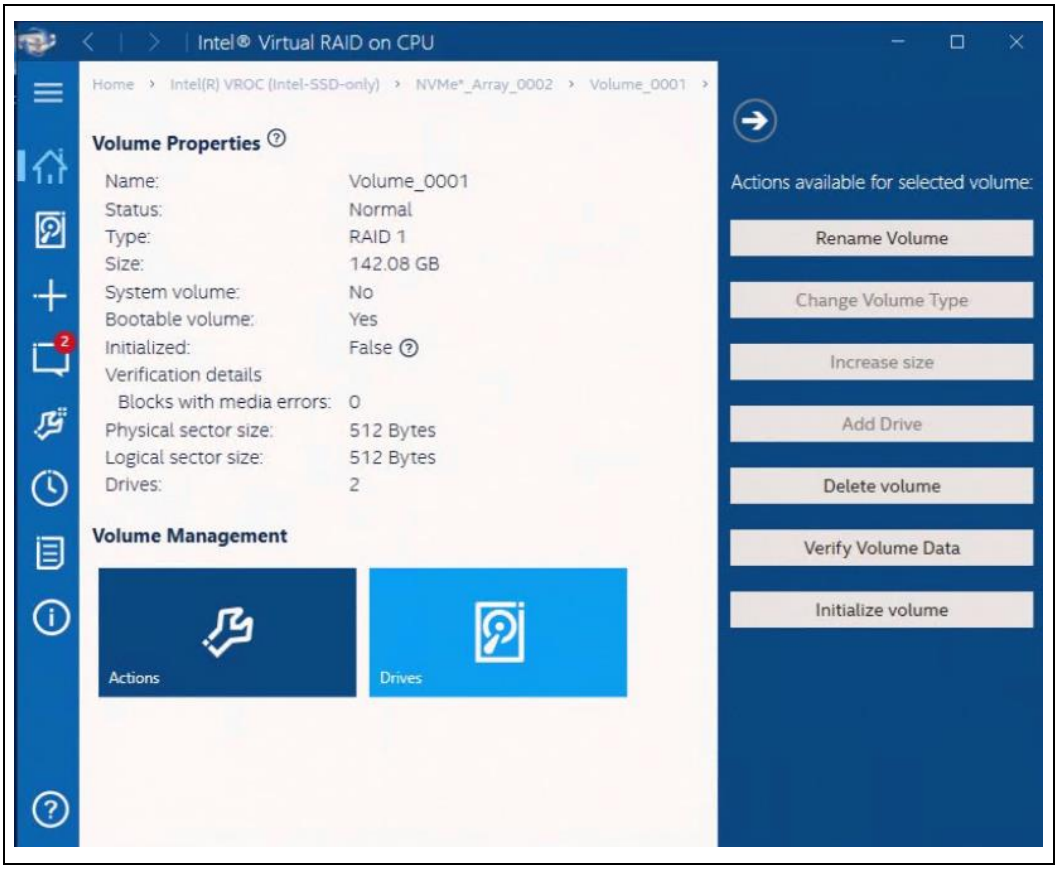
Figure 8-1. Delete Volume



1. Then under the **Volume Management** select **Actions**.

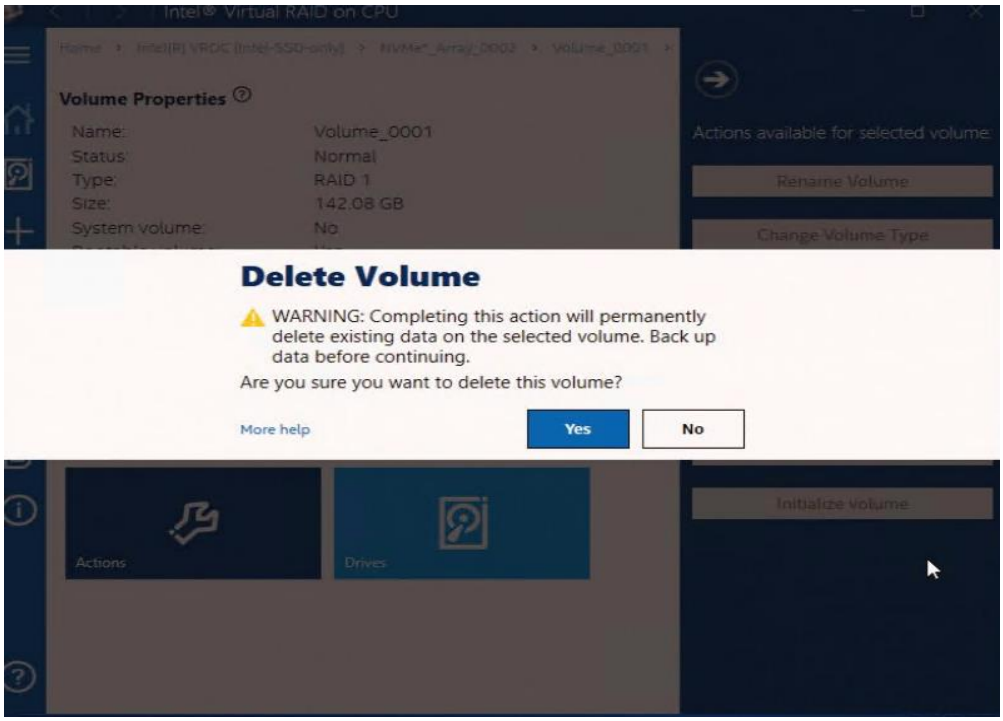
Note: The Delete Volume option is only available if you have a volume selected. Take care in selection for deletion of volumes, as the data cannot be recovered.

Figure 8-2. Delete Volume Continued



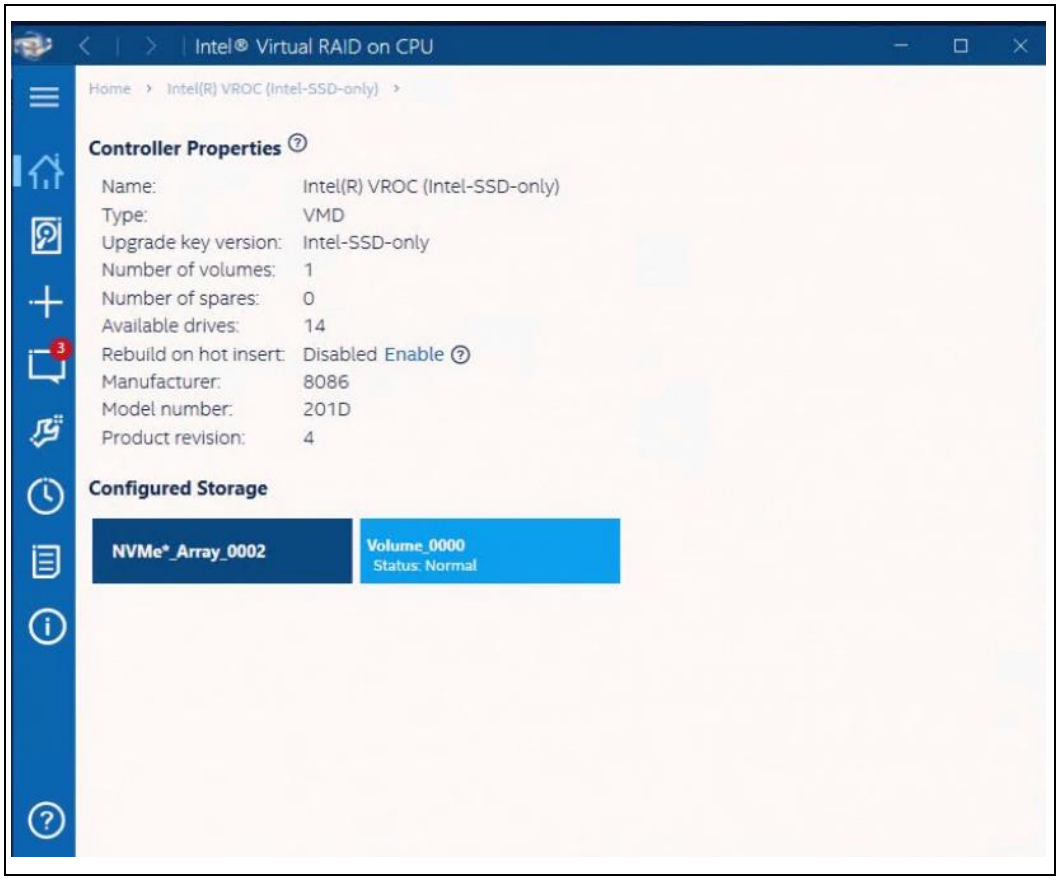
2. Select Yes at the warning to complete the process.

Figure 8-3. Confirm Deletion



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

Figure 8-4. Volume Removed



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9 Intel® VROC Trial Period

The Intel® VROC package comes with a 90 days 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

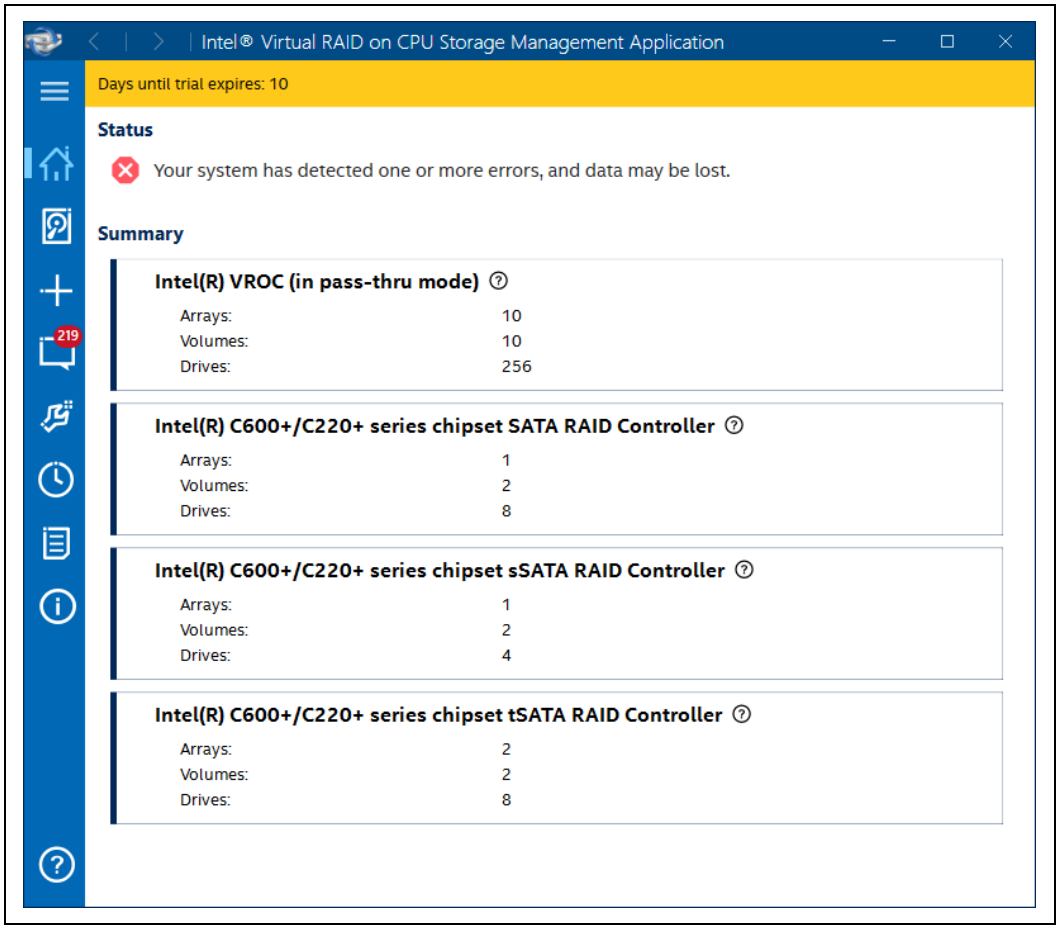
Since this Intel® VROC Trial Period mode only applies to platforms that do not have Intel® VROC Upgrade Keys installed, the System Report will report that Intel® VROC is in Pass-thru mode.

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.

9.2.1 Trial Status Notification Band

The status of the trial is displayed in the Intel® VROC GUI Home page as presented in the yellow band:

Figure 9-1. 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, as seen in the Figures 9-2 and 9-3 below.

Figure 9-2. VMD During Trial Status

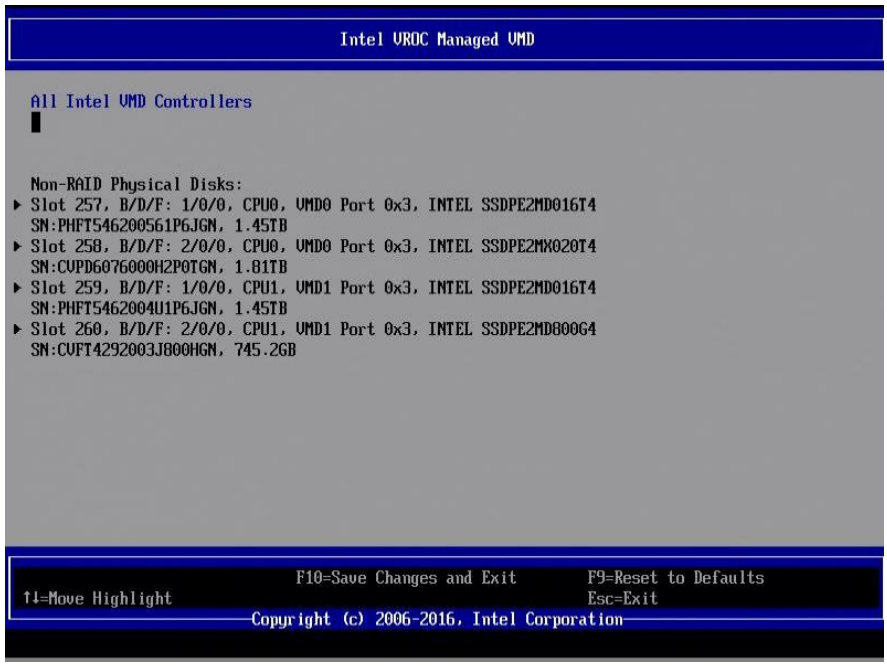
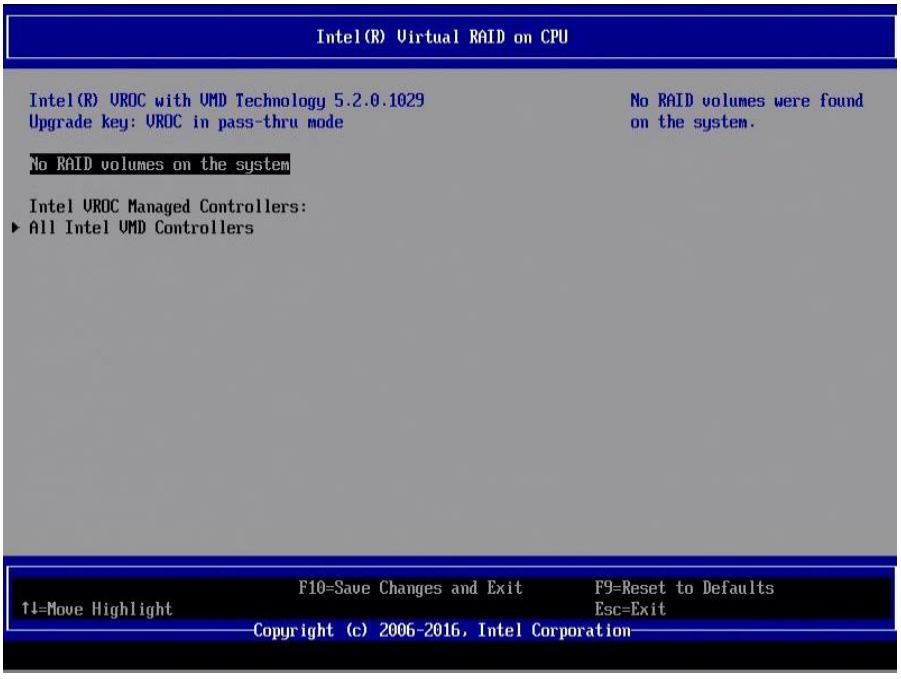


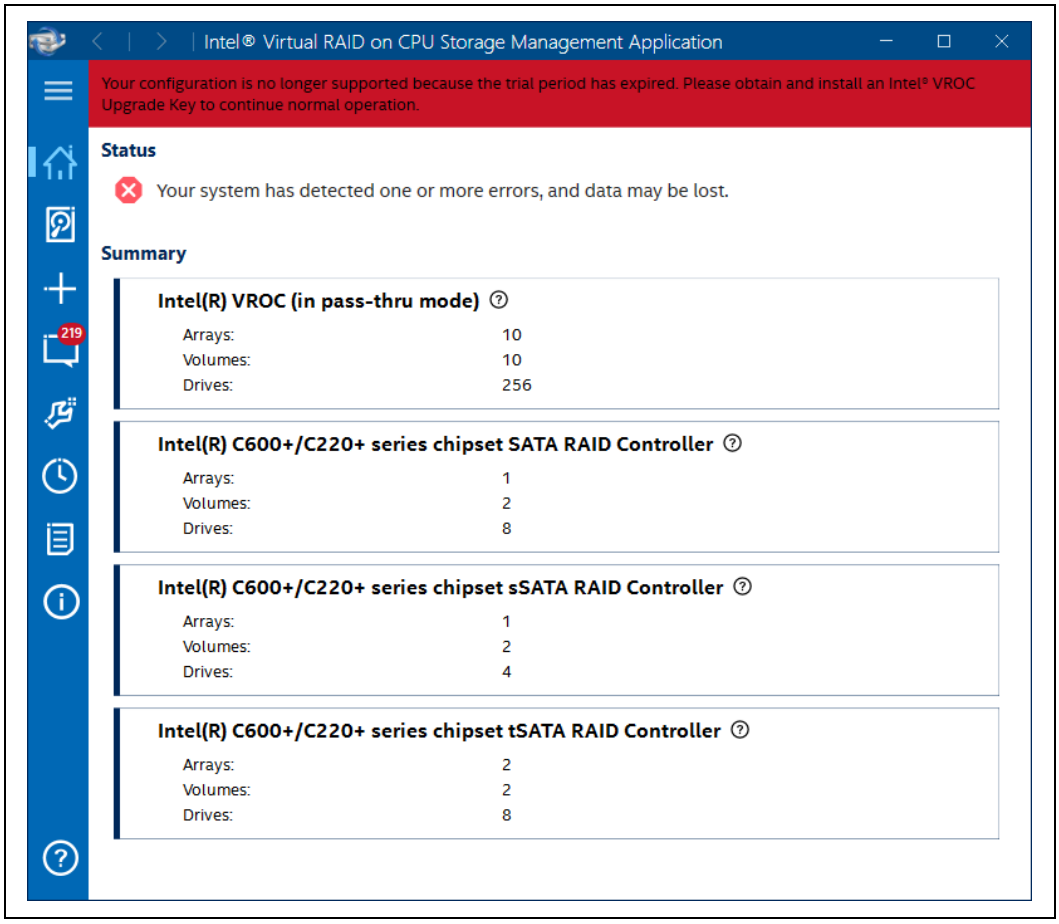
Figure 9-3. VROC During Trial



9.2.2 Trial Period Expiration Notification

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

Figure 9-4. Trial Period Expired



Note: After 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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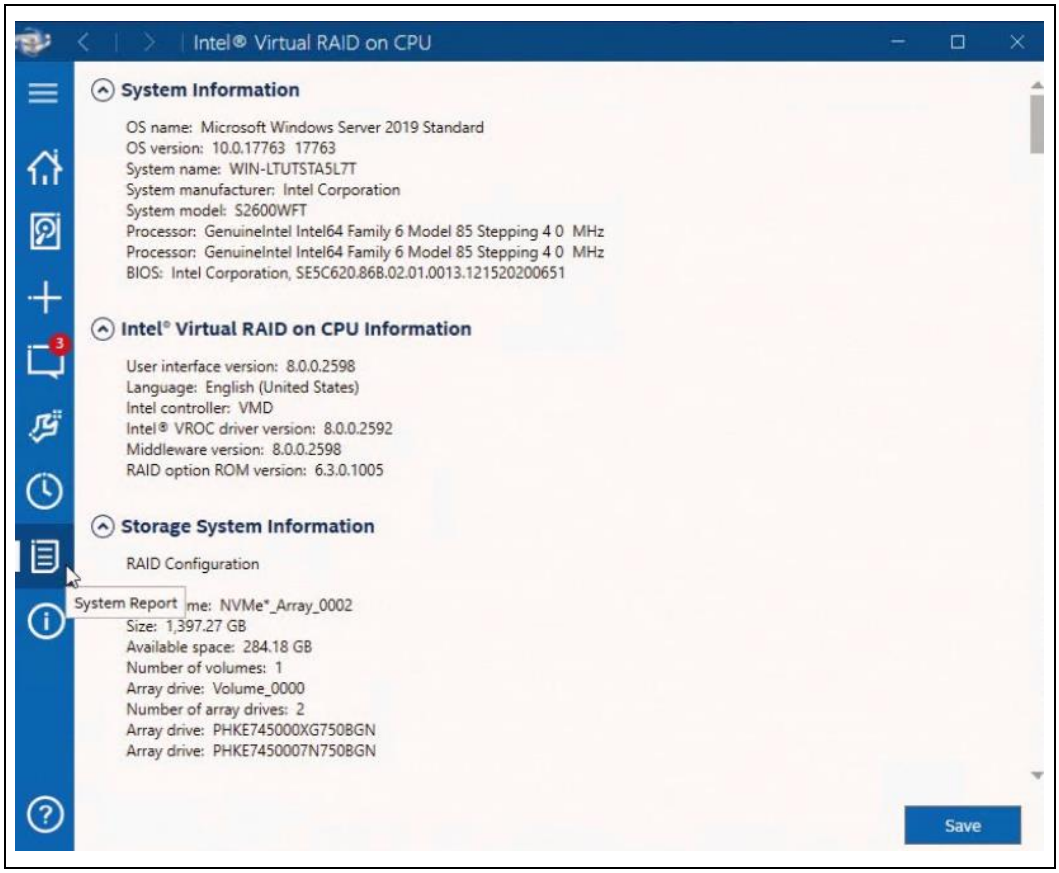
10 Troubleshooting

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

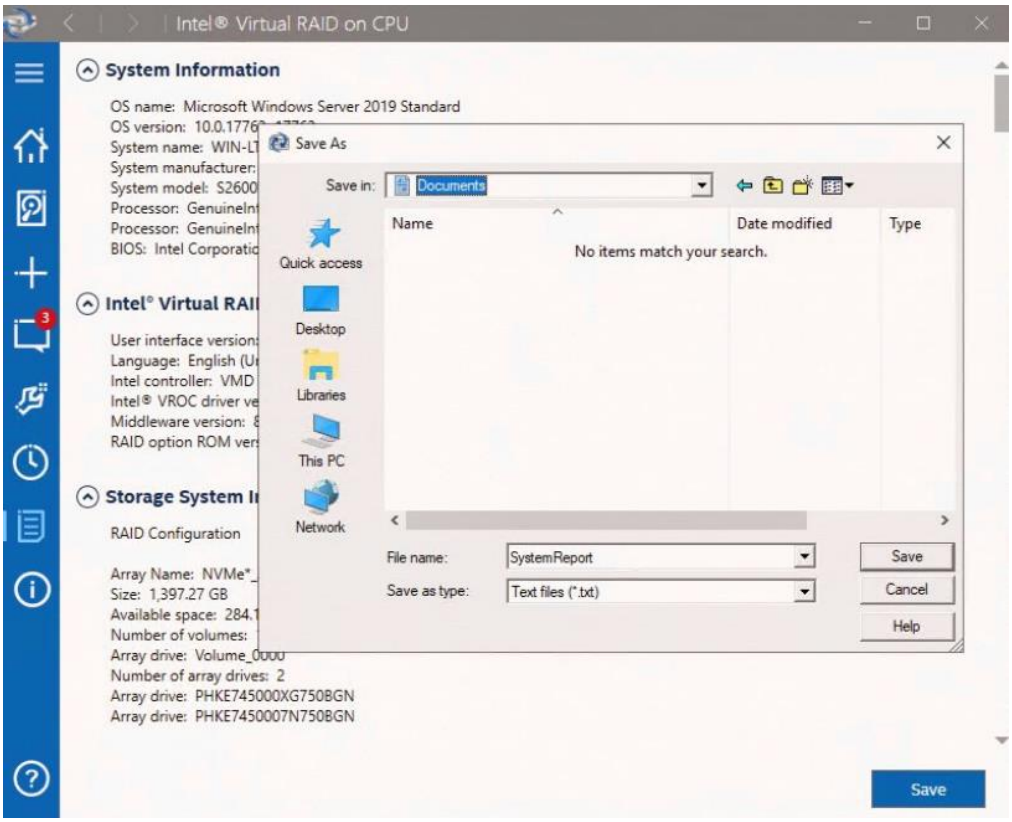
1. Troubleshooting issues on a system may be required. One of the tools that is helpful in doing so is called a system report. To generate a **System Report,** select the system report icon on the left menu pane.

Figure 10-1. System Report



2. 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 8.0 product family.
3. Click **Save** at the bottom left corner of the **System Report**.

Figure 10-2. Save



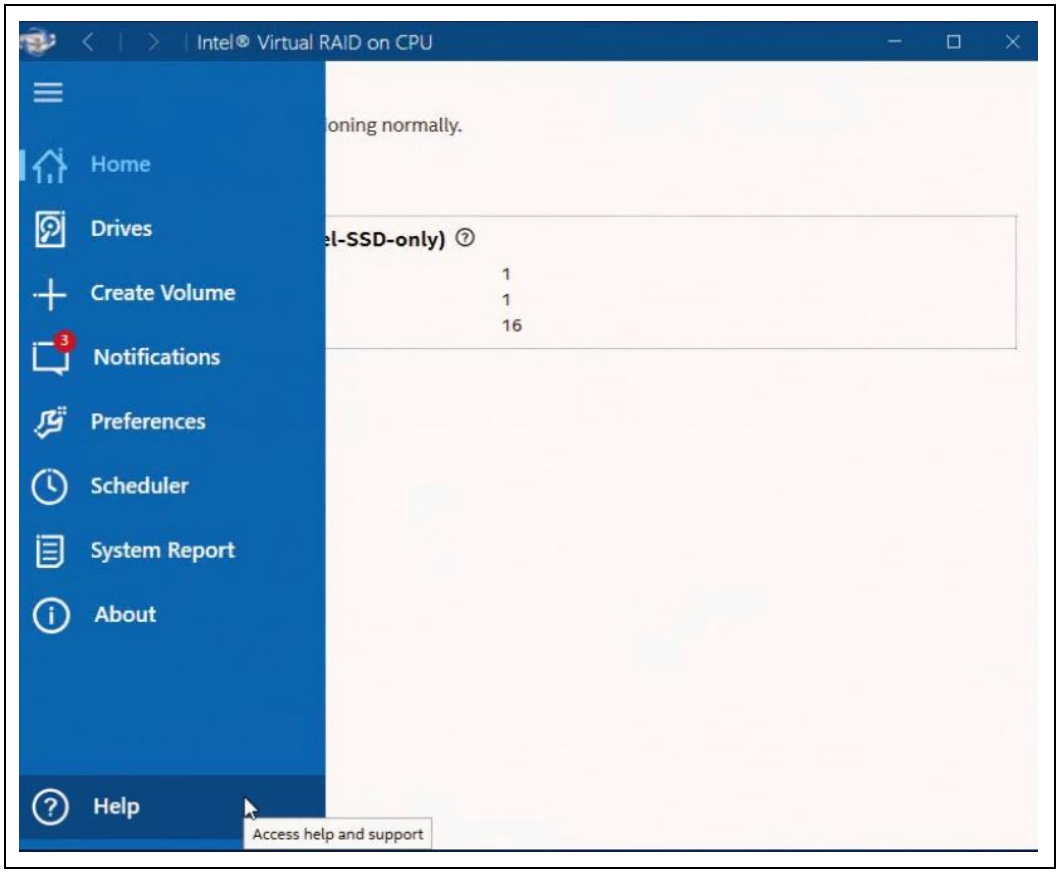
Windows* will allow the user to select where to save the file, the default is to save in the user's documents folder. This may be altered at the discretion of the user. Once the location and name have been set, click **Save** to save the file.

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

10.2 Help Section

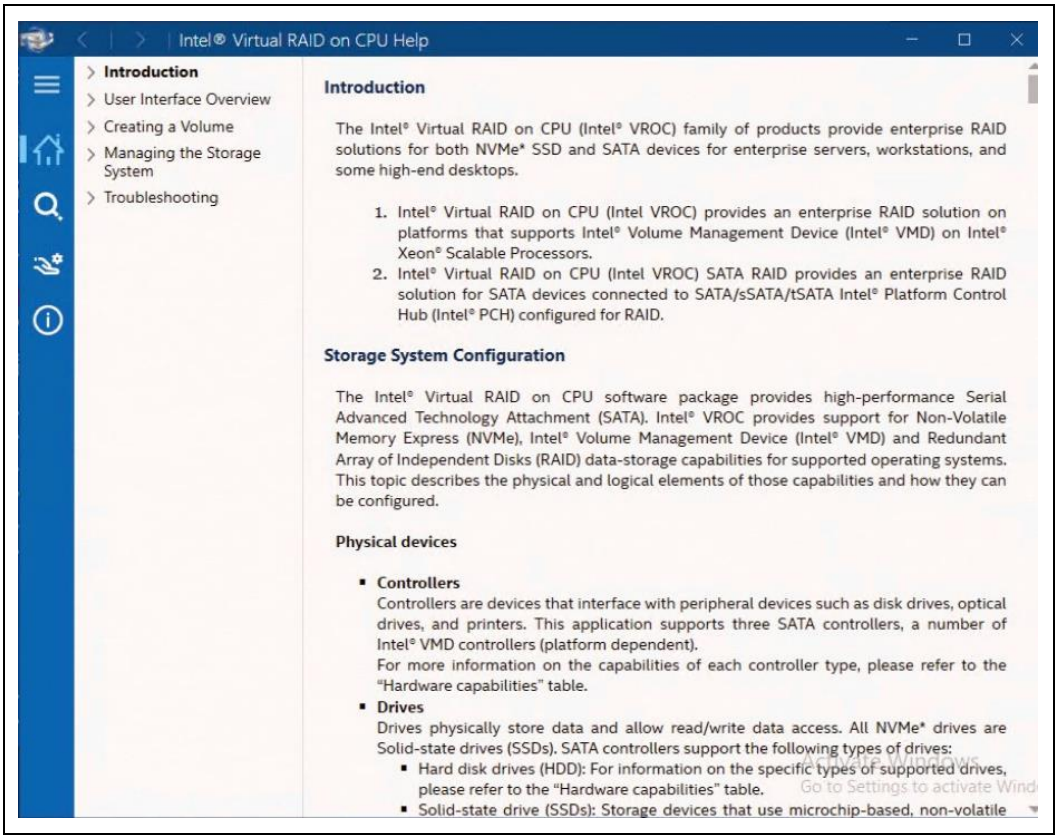
The left pane indicates the "Help" tab on the bottom marked with a white "?".

Figure 10-3. Help



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

Figure 10-4. Introduction



10.3 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.

10.3.1 Failed Volumes

Table 10-1: Failed Volumes in Windows* GUI

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 VROC 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® Virtual RAID on CPU*** 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® Virtual RAID on CPU** 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® Virtual RAID on CPU** 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.*

Note: Intel makes no guarantee of successful recovery from a failed state. This must be treated as a last chance effort and there is no guarantee that there will not be some data loss. Intel always recommends recovering a Failed RAID Volume by recreating the RAID volume from scratch and restore the data from the latest platform image backup.

Table 10-2: Failed Volumes in Intel® VROC Pre-OS

RAID 0 A RAID 0 volume is reported as failed when one of its members is disconnected or has failed. In the latter case, the volume and its data are no longer accessible. In the former case, the volume and its data can be recovered from the VROC pre-OS.	
Cause	**Solution**
One or more missing array disks	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, boot to the system BIOS by pressing the appropriate key.* 3. *Once inside the BIOS, navigate to the VROC HII menu. This menu is displayed as Intel® Virtual RAID on CPU for NVMe devices, and Intel® VROC SATA/sSATA Controller for SATA devices and sSATA devices respectively.* 4. *Select the failed RAID0 volume inside the appropriate HII menu.* 5. *The user should see an option called "Reset to Normal". Select this option.* 6. *Confirm resetting the volume to Normal.* 7. *Exit the HII and re-enter the HII. Confirm that the previously failed RAID0 volume now shows "Normal" status.*
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 as if the array disk was only missing, and then attempt a data recovery. If the read/write data access consistently fails, the disk will likely return to a failed state immediately. The procedure for resetting the array to normal: 1. *Power off the user's computer and reconnect the missing disk.* 2. *Turn on the user's computer. During the system startup, boot to the system BIOS by pressing the appropriate key.* 3. *Once inside the BIOS, navigate to the VROC HII menu. This menu is displayed as Intel® Virtual RAID on CPU for NVMe devices, and Intel® VROC SATA/sSATA Controller for SATA devices and sSATA devices respectively.* 4. *Select the failed RAID0 volume inside the appropriate HII menu.* 5. *The user should see an option called "Reset to Normal". Select this option.* 6. *Confirm resetting the volume to Normal.* 7. *Exit the HII and re-enter the HII. Confirm that the previously failed RAID0 volume now shows "Normal" status.* This procedure deletes the failed volume if resetting the array to normal doesn't work: 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, boot to the system BIOS by pressing the appropriate key.* 3. *Once inside the BIOS, navigate to the VROC HII menu. This menu is displayed as Intel® Virtual RAID on CPU for NVMe devices, and Intel® VROC SATA/sSATA Controller for SATA devices and sSATA devices respectively*.

	4. *Select the failed RAID0 volume. The user should see an option called "Delete". Select this option using the up and down arrow keys and confirm deleting the volume when asked.* 5. *Create a new RAID0 volume from the HII using the new disk and the old member disks that are still working. 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 or become missing.	
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. The procedure for resetting the array to normal: 1. *Power off the user's computer.* 2. *Turn on the user's computer. During the system startup, boot to the system BIOS by pressing the appropriate key.* 3. *Once inside the BIOS, navigate to the VROC HII menu. This menu is displayed as Intel Virtual RAID on CPU for NVMe devices, and Intel® VROC SATA/sSATA Controller for SATA devices and sSATA devices respectively.* 4. *Select the failed RAID5 volume inside the appropriate HII menu.* 5. *The user should see an option called "Reset to Normal". Select this option.* 6. *Confirm resetting the volume to Normal.* 7. *Exit the HII and re-enter the HII. Confirm that the previously failed RAID5 volume now shows "Normal" status.* This procedure deletes the failed volume if resetting to normal doesn't work: 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, boot to the system BIOS by pressing the appropriate key.* 3. *Once inside the BIOS, navigate to the VROC HII menu. This menu is displayed as Intel® Virtual RAID on CPU for NVMe devices, and Intel® VROC SATA/sSATA Controller for SATA devices and sSATA devices respectively.* 4. *Select the failed RAID5 volume. The user should see an option called "Delete". Select this option using the up and down arrow keys and confirm deleting the volume when asked.* 5. *Create a new RAID5 volume from the HII using the new disk and the old member disks that are still working. If the failed disk was part of the system volume, the user will also need to reinstall the operating system.*
Two or more array disks are missing (with up to one disk failed)	In most cases, the volume can be recovered successfully and any data on the volume will remain intact. However, the user must keep in mind the state of the array between becoming degraded (losing 1 disk only) and becoming failed (losing the second and all subsequent disks).

	If the array has not been written to after it originally became degraded, the user can follow the procedure outlined below for resetting the array to normal to recover the array and the data: 1. *Power off the user's computer and reconnect the missing disk.* 2. *Turn on the user's computer. During the system startup, boot to the system BIOS by pressing the appropriate key.* 3. *Once inside the BIOS, navigate to the VROC HII menu. This menu is displayed as Intel® Virtual RAID on CPU for NVMe devices, and Intel® VROC SATA/sSATA Controller for SATA devices and sSATA devices respectively.* 4. *Select the failed RAID5 volume inside the appropriate HII menu.* 5. *The user should see an option called "Reset to Normal". Select this option.* 6. *Confirm resetting the volume to Normal.* 7. *Exit the HII and re-enter the HII. Confirm that the previously failed RAID5 volume now shows "Normal" status.* If the array has been written to after the first disk became missing and before the second and subsequent disks became missing, but all disks still work (and their metadata remains unchanged from the point of removal), the user can follow the below procedure to restore the RAID5 to normal without losing data: 1. *Power off the user's computer. Replace any missing disks in their original location if possible.* 2. *Turn on the user's computer. During the system startup, boot to the system BIOS by pressing the appropriate key.* 3. *Once inside the BIOS, navigate to the VROC HII menu. This menu is displayed as Intel® Virtual RAID on CPU for NVMe devices, and Intel® VROC SATA/sSATA Controller for SATA devices and sSATA devices respectively.* 4. *Select the failed RAID5 volume. The user should see an option called "Reset to Degraded". Select this option using the up and down arrow keys.* 5. *The user will be presented with a menu to select the disks they wish to include in the degraded array. The disks to include in this array are the disks that were included in the originally degraded array. The user should select every disk from the original normal array besides the first disk that was removed from the system.* 6. *The system will detect that the first missing disk is now present and will begin rebuilding the RAID5 to that disk from the metadata on the disks the user chose to include in the degraded array when it was reset to degraded. The array status will change to "Rebuilding".* 7. *After the rebuild process the data should be recovered. The array status will change to "Normal".* If up to 1 disk has failed, and any number of other disks were subsequently removed from the system (and the working disks' metadata remains unchanged from the point of removal) the user can follow the below procedure to restore the RAID5 to normal without losing data: 1. *Power off the user's computer. Replace any missing disks in their original location if possible. Replace the failed disk with a new disk that is the same size or larger as the failed disk.* 2. *Turn on the user's computer. During the system startup, boot to the system BIOS by pressing the appropriate key.* 3. *Once inside the BIOS, navigate to the VROC HII menu. This menu is displayed as Intel® Virtual RAID on CPU for NVMe*

	devices, and Intel® VROC SATA/sSATA Controller for SATA devices and sSATA devices respectively. 4. *Select the failed RAID5 volume. The user should see an option called "Reset to Degraded". Select this option using the up and down arrow keys.* 5. *The user will be presented with a menu to select the disks they wish to include in the degraded volume. The disks to include in this volume are the disks that were included in the originally degraded volume. The user should select every working disk from the original volume. Confirm "Reset to Degraded" when asked. The volume status will change to "Degraded".* 6. *Now, the user will leave the HII menu and re-enter the HII. There should be a new option called "Rebuild" under the now degraded RAID5 volume.* 7. *Select the "Rebuild" option, and the user is presented with a menu containing all of the non-RAID disks on the system that are managed by VMD. Select the new disk and confirm the rebuild process when asked. The RAID5 volume will begin rebuilding the data on the working member disks to the newly inserted disk. The volume status will change to "Rebuilding".* 8. *After the rebuild process the data should be recovered. The volume status will change to "Normal".*
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)	In most cases, the volume can be recovered successfully and any data on the volume will remain intact. However, the user must keep in mind the state of the array between becoming degraded (losing 1 disk only) and becoming failed (losing the second disk). If the array has not been written to after it originally became degraded, the user can follow the procedure outlined below for resetting the array to normal to recover the array and the data: 1. *Power off the user's computer and reconnect the missing disk.* 2. *Turn on the user's computer. During the system startup, boot to the system BIOS by pressing the appropriate key.* 3. *Once inside the BIOS, navigate to the VROC HII menu. This menu is displayed as Intel® Virtual RAID on CPU for NVMe devices, and Intel® VROC SATA/sSATA Controller for SATA devices and sSATA devices respectively.* 4. *Select the failed RAID10 volume inside the appropriate HII menu.* 5. *The user should see an option called "Reset to Normal". Select this option.* 6. *Confirm resetting the volume to Normal.* 7. *Exit the HII and re-enter the HII. Confirm that the previously failed RAID10 volume now shows "Normal" status.* If the array has been written to after the first disk became missing and before the second disk became missing, but all disks still work (and their metadata remains unchanged from the point of removal), the user can follow the below procedure to restore the RAID10 to normal without losing data: 1. *Power off the user's computer. Replace any missing disks in their original location if possible.*

	2. *Turn on the user's computer. During the system startup, boot to the system BIOS by pressing the appropriate key.* 3. *Once inside the BIOS, navigate to the VROC HII menu. This menu is displayed as Intel® Virtual RAID on CPU for NVMe devices, and Intel® VROC SATA/sSATA Controller for SATA devices and sSATA devices respectively.* 4. *Select the failed RAID10 volume. The user should see an option called "Reset to Degraded". Select this option using the up and down arrow keys.* 5. *The user will be presented with a menu to select the disks they wish to include in the degraded array. The disks to include in this array are the disks that were included in the originally degraded array. The user should select every disk from the original normal array besides the first disk that was removed from the system.* 6. *The system will detect that the first missing disk is now present and will begin rebuilding the RAID10 to that disk from the metadata on the disks the user chose to include in the degraded array when it was reset to degraded. The array status will change to "Rebuilding".* 7. *After the rebuild process the data should be recovered. The array status will change to "Normal".*
Three or four array disks missing	In most cases, the volume can be recovered successfully and any data on the volume will remain intact. However, the user must keep in mind the state of the array between becoming degraded (losing 1 disk only) and becoming failed (losing the second disk and any subsequent third or fourth disks). Refer the above instructions for recovering a RAID10 with two missing disks. The same process applies for three/four missing disks.
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 as if the array disk was only missing, and then attempt a data recovery. If the read/write data access consistently fails, the disk will likely return to a failed state immediately. The procedure for resetting the array to normal: 1. *Power off the user's computer and reconnect the missing disk.* 2. *Turn on the user's computer. During the system startup, boot to the system BIOS by pressing the appropriate key.* 3. *Once inside the BIOS, navigate to the VROC HII menu. This menu is displayed as Intel® Virtual RAID on CPU for NVMe devices, and Intel® VROC SATA/sSATA Controller for SATA devices and sSATA devices respectively.* 4. *Select the failed RAID10 volume inside the appropriate HII menu.* 5. *The user should see an option called "Reset to Normal". Select this option.* 6. *Confirm resetting the volume to Normal.* 7. *Exit the HII and re-enter the HII. Confirm that the previously failed RAID10 volume now shows "Normal" status.* This procedure deletes the failed volume if resetting the array to normal doesn't work: 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, boot to the system BIOS by pressing the appropriate key.* 3. *Once inside the BIOS, navigate to the VROC HII menu. This menu is displayed as Intel® Virtual RAID on CPU for NVMe devices, and*

	Intel® VROC SATA/sSATA Controller for SATA devices and sSATA devices respectively. 4. *Select the failed RAID10 volume. The user should see an option called "Delete". Select this option using the up and down arrow keys and confirm deleting the volume when asked.* 5. *Create a new RAID10 volume from the HII using the new disk and the old member disks that are still working. If the failed disk was part of the system volume, the user will also need to reinstall the operating system.*

10.3.2 Degraded Volumes

Table 10-3: Degraded Volumes in Windows* GUI

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.

Table 10-4: Degraded Volumes in Intel® VROC Pre-OS

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, which the user can verify by entering the VROC HII menu in the BIOS.* 3. *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:* 4. *If a NVMe or SATA disk is compatible, available and normal, follow this procedure to rebuild the volume:* 5. *Turn off the system. Boot to the system BIOS by pressing the appropriate key. Navigate to the VROC HII menu. This menu is displayed as Intel® Virtual RAID on CPU for NVMe devices, and Intel® VROC SATA/sSATA Controller for SATA devices and sSATA devices respectively.* 6. *The rebuild operation starts immediately in the pre-OS. The user can verify the rebuild process is happening by checking the RAID status in the HII menu. The status will show "Rebuilding".* 7. *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. *Power off the user's computer and replace the faulty disk with a new disk that is the same size or larger as the faulty disk.*

	2. *Turn on the user's computer. During the system startup, boot to the system BIOS by pressing the appropriate key.* 3. *Once inside the BIOS, navigate to the VROC HII menu. This menu is displayed as Intel® Virtual RAID on CPU for NVMe devices, and Intel® VROC SATA/sSATA Controller for SATA devices and sSATA devices respectively.* 4. *Select the failed raid volume. The user should see an option called "rebuild" under the option menu of the raid volume. Select "rebuild"* 5. *The user will be presented with a list of all non-RAID disks on the system that are managed by VMD. Select the newly inserted disk that replaced the faulty one. The user will be asked to confirm the rebuild, click yes.* 6. *The rebuild will start automatically. The array status will change from "degraded" to "rebuilding" in the HII.* 7. *Once the rebuild is complete, the array status will change to "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.

10.3.3 Other Volume States

Table 10-5: Other Volume States in Windows* GUI

Incompatible	
Cause	**Solution**
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.
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.*

10.3.4 Disk Events

Table 10-6: 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.

10.3.5 Software Errors

Table 10-7: Software Errors

Message	Cause	Solution
An unknown error occurred while running this application. If the problem persists, 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® Virtual RAID on CPU 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.

Message	Cause	Solution
The ***Intel® Virtual RAID on CPU*** 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® Virtual RAID on CPU*** 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.
An error occurred due to insufficient resources, and the operation could not be completed. Try again later.	The ***Intel® Virtual RAID on CPU*** 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. 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.

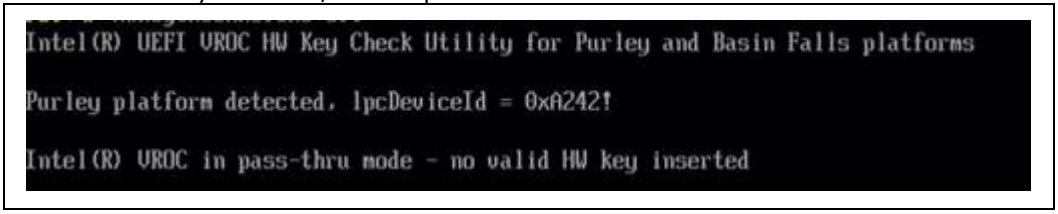
10.4 Troubleshooting Using the UEFI Shell

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.

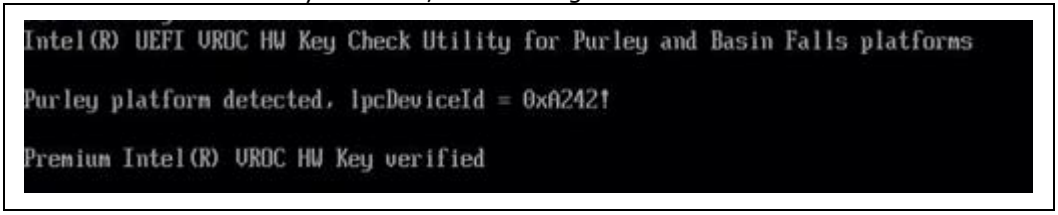
10.4.1 HWKeyCheckVROCRS.efi

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:



10.4.2 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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