

REDHAWK Linux®
Version 9.2
Release Notes

June 2023

0898003-9.2



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1.0. Introduction

This document provides release information and installation instructions for Concurrent Real-Time Inc.'s RedHawk™ Linux® operating system Version 9.2.

1.1 Product Description

RedHawk Linux is a real-time version of the open source Linux operating system. Modifications are made to standard Linux version 6.1 to support the functionality and the performance required by complex real-time applications. RedHawk uses a single kernel design to support a single programming environment that directly controls all system operation. This design allows deterministic program execution and response to interrupts while simultaneously providing high I/O throughput and deterministic file, networking, and graphics I/O operations. RedHawk is the ideal Linux environment for the deterministic applications found in simulation, data acquisition, industrial control and medical imaging systems.

Included with RedHawk is Rocky Linux®, version 9.2. Note, however, that RedHawk can also be installed on *any* Rocky-compatible version 9.2 distribution, (e.g., Oracle). In addition, RedHawk 9.2 also supports the popular Ubuntu distribution; see Appendix A, *Ubuntu Support*, for more information.

The RedHawk installation media provide additional real-time kernels and libraries for accessing RedHawk specific kernel features. Optionally, the NightStar™ RT development tool set is available for developing real-time applications, and the Frequency-Based Scheduler can be used to schedule cyclic applications driven from a real-time clock or other external interrupt source. The Performance Monitor module allows you to get detailed CPU utilization of each process on such a scheduler.

The RedHawk kernel integrates both open source patches and Concurrent Real-Time developed features derived from the real-time UNIX® implementations that Concurrent Real-Time has supported in its over 50 years of experience developing real-time operating systems.

RedHawk is included with each Concurrent Real-Time iHawk™ system. iHawks are symmetric multi-processor (SMP) systems available in a variety of architectures and configurations, though only 64-bit capable iHawks can run RedHawk 9.2 as it is only available in a 64-bit version.

Support for SMP is highly optimized. A unique concept known as *shielded CPUs* allows a subset of processors to be dedicated to tasks that require the most deterministic performance. Individual CPUs can be shielded from interrupt processing, kernel daemons, interrupt bottom halves, and other Linux tasks. Processor shielding provides a highly deterministic execution environment that guarantees processes fast and dependable response to external events.

RedHawk Linux matches the level of POSIX® conformance of other Linux distributions based on the 6.1 series of kernels. Linux on the Intel® x86 and ARMv8-A architectures has defined a defacto binary standard which allows shrink-wrapped Linux applications that are designed to run on the Intel x86 and ARMv8-A platforms to run on Concurrent Real-Time's iHawk platforms.

NightStar RT, RedHawk Architect and RedHawk KVM-RT are optional products available to run on RedHawk Linux.

NightStar RT is Concurrent Real-Time's powerful real-time tool set that provides a robust graphic interface for non-intrusive control, monitoring, analysis, and debugging of real-time multiprocessing applications. All tools can be run natively on the same system as the application or remotely.

The NightStar RT tools include the following:

- NightView™ source-level debugger – allows multi-language, multi-processor, multi-program and multi-thread monitoring and debugging from a single graphical interface.
- NightTrace™ run-time analyzer – analyzes the dynamic behavior of a running application.
- NightSim™ periodic scheduler – allows the user to easily schedule applications that require periodic execution.
- NightProbe™ data monitor – used to sample, record or modify program data in multiple running programs.
- NightTune™ performance tuner – used for analyzing system and application performance.

RedHawk Architect is a powerful tool with an easy-to-use GUI that lets a developer choose the Linux and application modules to be included in target images. Target images can be scaled from complete workstations to dedicated servers and even down to small embedded applications. RedHawk Architect provides deployment tools for installing onto hard drives, flash memories, optical media or even USB flash.

RedHawk KVM-RT is a Real-Time Hypervisor solution that utilizes QEMU/KVM and RedHawk real-time features to extend RedHawk's real-time determinism to guest RedHawk virtual machines.

1.2 Product Media

The tables below list the optical media discs that are delivered with RedHawk Linux Version 9.2 for each Concurrent Real-Time system.

WARNING

While much of the software on the RedHawk media is licensed under the GNU GPL license, some components are not. Therefore, the media cannot be freely copied.

Product Media

Processor Type:	Intel and AMD x86_64 64-bit	
Model:	iHawk Intel-based systems	[HQxxx]
	iHawk AMD-based systems	[HRxxx]
	iHawk ARM-based systems	[HAxxx]
	ImaGen Intel-based systems	[HQ0G1]
	ImaGen AMD-based systems	[HR0G1]
Operating System Discs:		
Rocky 9.2 (64-bit)	(1 BD)	[WA-ROCK, WA-ROCK-ARM64 Version 9.2]
Rocky 9.2 Updates (64-bit)	(1 BD)	[LXUPDATE -ROCK Version 9.2]
RedHawk Linux OS (64-bit)	(1 DVD)	[WA-EM64T-AMD64, WA-ARM64 Version 9.2]
Software Updates for RedHawk (1 DVD or 1 CD, if present)		
Optional Discs:		
RedHawk Linux Frequency-Based Scheduler for x86_64 Systems	[WU1210-JA Version 9.2]	
NightStar RT for RedHawk	[WU1220-LDV, WU1220-LDVF Version <i>x.x</i> (<i>x.x</i> =latest version)]	
RedHawk Architect (64-bit)	[W-RHLE-E64] Version 9.2	
RedHawk KVM-RT (64-bit)	[WU1602-KVM-RT] Version 1.3	

1.3 Version Numbers

All RedHawk Linux version numbers take the following form:

$$major.minor[.update]$$

where:

major is the product's major version number
minor is the product's minor version number
update is the update's incremental version number

For example, 8.0 is the initial release of major version 8, and 8.2 is a subsequent release to version 8.0. Both 8.0 and 8.2 constitute complete product releases and do not require a previous release to be currently installed on the system; both are available on optical media from Software Distribution.

Individual kernel updates available via the RedHawk Updates website (see the "System Updates" section below) are not a complete product and can only be installed as an update to the matching *major.minor* release. For example; a 9.2.1 kernel update can only be installed on a system currently running RedHawk Linux version 9.2.

1.4 System Updates

As RedHawk Linux updates are issued, they are made available for downloading from Concurrent Real-Time's Software Portal.

Instructions for downloading updates from the website are provided in the section "Software Updates" on page 57.

1.5 Syntax Notation

The following notation is used throughout this document:

<i>italic</i>	Books, reference cards, and items that the user must specify appear in <i>italic</i> type. Special terms may also appear in <i>italic</i> .
list bold	User input appears in list bold type and must be entered exactly as shown. Names of directories, files, commands, options and man page references also appear in list bold type.
list	Operating system and program output such as prompts, messages and listings of files and programs appears in list type.
[]	Brackets enclose command options and arguments that are optional. You do not type the brackets if you choose to specify these options or arguments.
hypertext links	When viewing this document online, clicking on chapter, section, figure, table and page number references will display the corresponding text. Clicking on Internet URLs provided in <i>blue</i> type will launch your web browser and display the web site. Clicking on publication names and numbers in <i>red</i> type will display the corresponding manual PDF, if the file is available and accessible.

2.0. Documentation

2.1 RedHawk Linux Documentation

Table 2-1 lists the documentation provided with RedHawk Version 9.2 as PDF files. After installing RedHawk Linux documentation, the files are available for viewing:

- under `/usr/share/doc/ccur` if the `ccur-docs` package is installed
- from Concurrent Real-Time's documentation web site at <http://redhawk.concurrent-rt.com/docs>

Table 2-1 RedHawk Linux Documentation

RedHawk Linux Operating System Documentation	Document Number
<i>RedHawk Linux Version 9.2 Release Notes</i>	0898003-9.2
<i>RedHawk Linux User's Guide</i>	0898004-780
<i>Real-Time Clock & Interrupt Module (RCIM) User's Guide</i>	0898007-620
Optional RedHawk Product Guides	
<i>RedHawk Linux Frequency-Based Scheduler (FBS) User's Guide</i>	0898005-350
Optional RedHawk Product Documentation Sets	
<i>RedHawk Architect Release Notes</i>	0898600-9.2
<i>RedHawk Architect User's Guide</i>	0898601-9.2
<i>KVM-RT Release Notes</i>	0898603-1.3
<i>KVM-RT User's Guide</i>	0898604-1.3

The Optional RedHawk Product Documentation Sets include Concurrent Real-Time's user guides as PDF files along with additional vendor documentation PDFs that facilitate using these RedHawk products.

The latest documentation for all Concurrent Real-Time software products, including updated Release Notes and User Guides, can be accessed from Concurrent Real-Time's documentation web site at <http://redhawk.concurrent-rt.com/docs>.

2.2 Vendor Documentation

Some RedHawk optional products include vendor documentation that facilitates using these RedHawk products.

Commercial off-the-shelf (COTS) documentation applicable to your iHawk system is included with the system. Contact the vendor's sales office to purchase additional copies.

3.0. Prerequisites

3.1 Software

No previously installed software is required in order to install RedHawk Linux. The complete RedHawk Linux installation consists of the following software:

- Rocky 9.2 with updates
- RedHawk Linux operating system (with optional updates)
- NightStar RT for RedHawk tools (optional)
- RedHawk Linux Frequency-Based Scheduler (FBS) (optional)
- RedHawk Architect (optional)
- RedHawk KVM-RT (optional)

These packages operate only in a 64-bit environment. The operating environment on a system depends upon the processor type and the support included in the software for that processor. Refer to “Product Media” on page 2 for details.

NOTE

In RedHawk 9.2, real-time extensions and features are optionally available to 32-bit compatibility-mode applications running under a 64-bit operating system (i.e., x86_64).

3.2 Hardware

- Any Concurrent Real-Time iHawk or ImaGen system
- Real-Time Clock and Interrupt Module (RCIM)
- A Blu-ray optical media reader is required to install the system

4.0. Changes in this Release

This section describes enhancements and other changes introduced in RedHawk Version 9.2.

4.1 Changes in RedHawk Version 9.2

4.1.1 Based on Rocky Linux 9.2

Rocky Linux is a community enterprise operating system designed to be compatible with Enterprise Linux. CentOS has reached its End Of Life and therefore CentOS is no longer supported.

4.1.2 Based on kernel.org 6.1.19-rt8

Incorporates changes from kernel.org's 6.1.19-rt8 release.

4.1.3 NVIDIA Distribution Changes and Driver Updates

The RedHawk 9.2 kernel will no longer pre-include a proprietary NVIDIA driver. Instead, Concurrent will provide add-on NVIDIA driver discs that install the proprietary NVIDIA drivers. In addition, no CUDA software will be included on the RedHawk 9.2 installation disc. Instead, Concurrent will provide add-on CUDA discs that install the proprietary CUDA software.

Detailed instructions are provided in the Release Notes which is included with the add-on discs as a PDF file.

At the time of this writing, Concurrent's latest add-on NVIDIA driver disc installs the NVIDIA version 525.85.12 driver and the latest add-on CUDA disc installs the CUDA 12.1 version.

4.1.4 Onload Driver

Onload (formerly named OpenOnload) driver is currently not available but will be as soon as a version compatible with the 6.1 kernel becomes available. The driver is still available for earlier kernels.

4.1.5 Ubuntu Support

RedHawk 9.2 is supported on the Ubuntu 22.04 (Jammy Jellyfish) distribution. Ubuntu 22.04 is the newest version with long term support (LTS). Note that RedHawk 9.2 is only supported on Ubuntu 22.04, it is not supported on earlier versions of Ubuntu.

4.1.6 Python 2 Not Supported

Rocky has officially removed Python 2 in their Rocky 9.x releases, therefore, RedHawk 9.2 is also removing support for Python 2 and only supporting Python 3. All Concurrent products intended to run on RedHawk 9.2 will now require Python3.

Ubuntu 22.04 does not install Python 2 by default. While it is still possible to download and install Python 2 packages for Ubuntu 22.04, RedHawk 9.x will still only use Python 3. Concurrent strongly encourages all users to upgrade any remaining Python 2 code to Python 3.

4.1.7 Yellowpages/NIS removed

All support for Yellowpages/NIS has been removed in Rocky 9.X releases.

4.1.8 NUMA Memory Shielding is deprecated

NUMA Memory Shielding is deprecated in this release and will be completely removed in RedHawk 10. To continue to use this feature in RedHawk 9.x you must pass the kernel parameter *enable_deprecated_memshielding* in the kernel command line. For information on adding a kernel parameter, see **blscfg(1)** on Rocky, and **ccur-grub2(1)** on Ubuntu systems.

4.1.9 New **mlock** flags prevent kernel memory migration

RedHawk has provided additional flags that can be passed to the **mlock2(2)**, **mlockall(2)** and RedHawk's **mlockall_pid(2)** system calls to prevent kernel daemons from migrating memory. The new flags are *MCL_NOAUTOMIGRATE* and *MLOCK_NOAUTOMIGRATE*.

The *MLOCK_NOAUTOMIGRATE* flag is to be used with the **mlockall(2)** and the **mlockall_pid(2)** system calls while the *MLOCK_NOAUTOMIGRATE* flag is provided for **mlock2(2)**.

The flags will stop three types of automatic kernel page migrations:

- Automatic NUMA Balancing
- Memory Compaction
- Kernel Samepage Merging

See the **noautomigrate(7)** man page for more information on the automatic kernel page migrations and the flags.

4.1.10 Intel: Performance and Efficiency cores

The latest generation Intel CPU chips, starting with the 11th generation, come with Performance cores and Efficiency cores. For optimal real-time performance, applications should be run on the Performance cores.

4.1.11 Building debug kernels

A **debug** kernel config file is included in the kernel source tree for users desiring to build debug kernels. Pre-built debug kernel binaries are no longer provided with the releases. Debug kernels are built with extensive debugging facilities enabled that can be very useful during kernel driver development.

4.1.12 New RedHawk System Analysis and Tuning Tools

New tools are available to analyze the hardware topography of a RedHawk system and tune the system. The tools are documented via the **--help** option. Some also have a graphical user interface (**-gui**) version.

cpustat and **cpustat-gui** display the CPUs in a topology tree and can display information on CPU packaging, dies, cores, cache, and memory, the shielding and downing of CPUs, the CPU affinity of IRQs and tasks, and a brief view of IO bridges and devices.

irq-affinity may be used to display or make changes to the CPU affinity of IRQs.

task-affinity may be used to display or make changes to the CPU affinity of tasks.

hwtopo and **hwtopo-gui** display the hardware topology of the system.

4.1.13 Turbostat is available on RedHawk

The **turbostat (8)** command which reports various measurements on X86 processors is now available on RedHawk systems. Note that running **turbostat** may affect real-time performance. See the Known Issues on page 52 for more information.

5.0. Installation Procedures

Use the installation procedures provided here to generate or regenerate a system.

NOTE: Upgrades from earlier releases (RedHawk 7.x , RedHawk 8.x) are *not* supported.

NOTE: Resources to assist users supplying their own Red Hat software are available in the Concurrent Real-Time Software Documentation Library <http://redhawk.concurrent-rt.com/docs/>. Look under the corresponding RedHawk Linux Release for the link labeled: Installing on RHEL.

Review the following points before installing the software:

- Concurrent Real-Time recommends these procedures be followed as documented here; however, advanced users may decide to make other choices based on onsite requirements.
- The installation media in use is accessed at various times and must be kept in the drive during the installation until you are instructed to install different media.

Before you start:

- **Main Memory Size** — You need to know the system’s main memory size in order to properly set up the file system swap size. If you are not sure of the main memory size, access the system’s BIOS to ascertain this information.
- **Network Addresses** — If you do not plan to configure networking via DHCP, you will need to have the following information for your system before beginning the installation:
 - IP address - gateway address
 - netmask address - primary and secondary DNS addresses
- **Firmware Settings** — Firmware settings should be reviewed before installation and whenever problems involving non-working devices are encountered. Exercise caution before changing default settings. Concurrent Real-Time makes the following recommendations:
 - “Linux” should be specified for the “Installed OS” setting (or its equivalent) if it is an available option. If not, use the default “other.”
 - Only the default settings for memory functions and PCI timing functions are supported.
 - ACPI support should be enabled, but care should be taken before changing other ACPI options from their defaults. ACPI sleep states should *not* be enabled in the firmware or in any custom kernel build.
 - Ensure that the drive to be used for installations and updates is bootable and that the boot order is correctly set in the firmware so that you will boot to the installer from a disc.
 - Concurrent recommends using UEFI for all RedHawk 9.x systems.

5.1 Installing Rocky Software

The version of Rocky Linux that is appropriate to your system's architecture (x86_64 or ARM) must be installed on the system first by *specifically completing the steps below*.

Installation of Rocky is accomplished in two parts:

- Installing Rocky
- Installing Rocky Updates

If you already have a Rocky system installed at the 9.2 version level you can skip directly to "Installing Rocky Updates" on page 26.

5.1.1 Installing Rocky

This section typically takes between 40-70 minutes to complete.

1. Power on the system, if needed, to open the Blu-ray disc drawer.
2. Insert the Rocky Installation Disc in the drive and power down the system.
3. Power on the system and boot from the disc.
4. After a short delay, the following screen should appear. Initially the option to test the media is highlighted; press the **Up Arrow** to highlight **Install Rocky Linux 9.2** and press **Enter**.



NOTES

If the installation GUI does not launch:

If you wish to use GUI mode but it does not launch, refer to section 7.1.4 on page 48 for some boot options that may allow the GUI to launch. Some NVIDIA cards require specifying the display resolution before the install GUI will start. If successful, continue to follow the installation directions below.

In addition to GUI mode, Rocky can be installed in text mode or by using VNC.

In text mode, aids at the bottom of the screen describe how to navigate through the text mode screens and make selections. The instructions given in the steps below can be applied to both GUI and text mode installation; however, the number and order of the configuration screens differ slightly between the two modes.

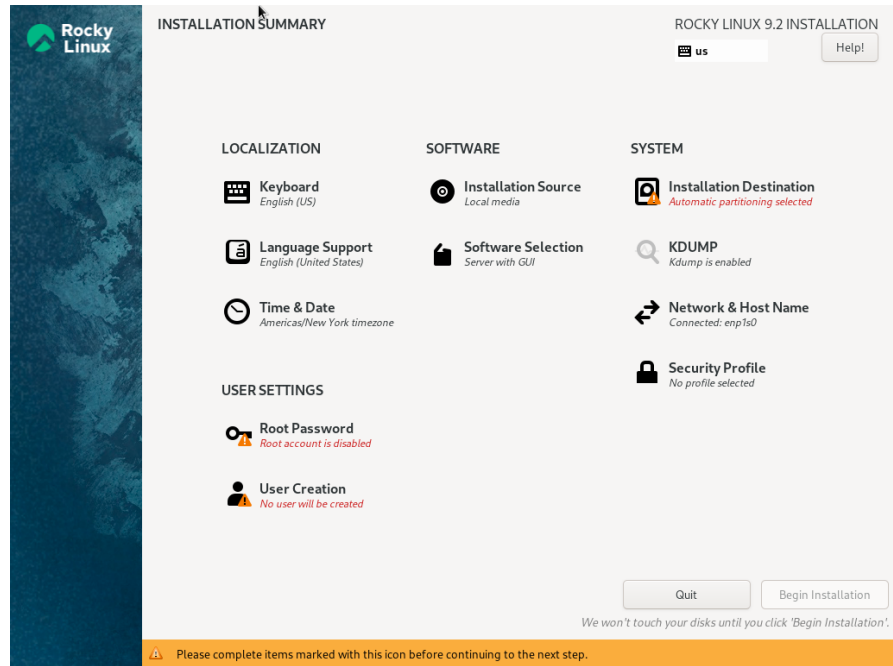
If you wish to use VNC for the installation instead of the GUI or text modes, refer to section 7.1.4, "Installing Remotely Over VNC" on page 48 for full instructions.

If your system contains disk drives or devices that are not supported by the Rocky installation program, you will need to obtain the necessary driver(s) in order to install Rocky Linux. A diskette containing the driver may be included with your system or it may be available on the Rocky installation media. If not available, contact the driver manufacturer for an updated driver or call Concurrent Real-Time Support (see "Direct Software Support" on page 57).

For this type of installation, type `linux dd` at the `boot:` prompt. Insert the diskette in the drive when instructed to do so.

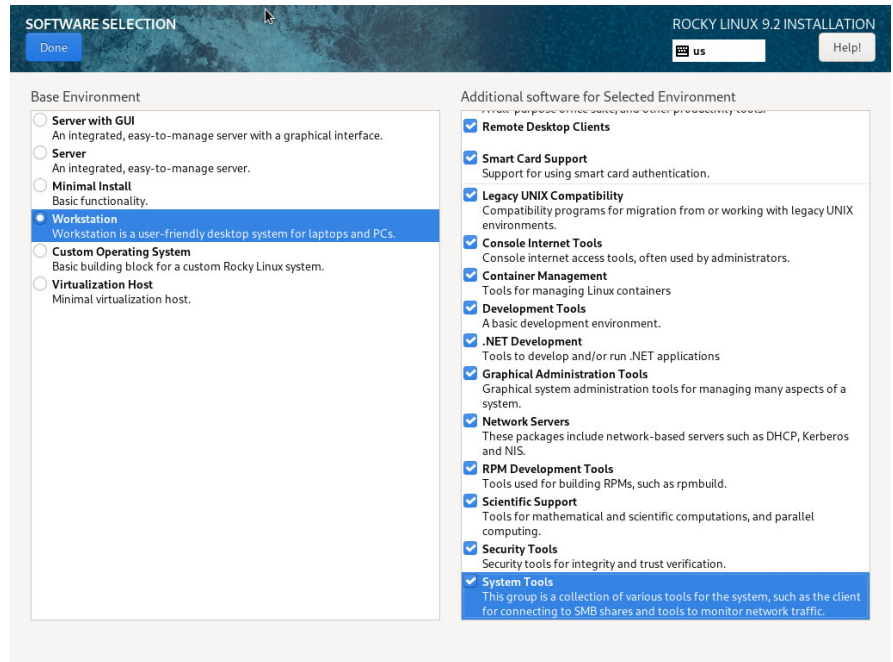
If your hard drive is not recognized and no driver diskette is supplied, a screen appears stating that no hard drives are found, would you like to select drivers. The installation disc contains a number of device drivers. Select **Yes**, then **Add Device** to display a list of drivers. Select the desired driver and proceed through the screens, completing this action by selecting **Done**.

5. Once the installation has started you will be presented with the welcome screen. Select your desired language and press **Continue** to proceed.
6. You will now be presented with the **Installation Summary** page, which is the main launching point for all installation activities.



Click on the settings under **Localization** if you wish to make any site-specific changes to the date, time, language and keyboard settings.

7. Click on **Software Selection** to select the package installation profile for the installation. The following screen will be displayed.

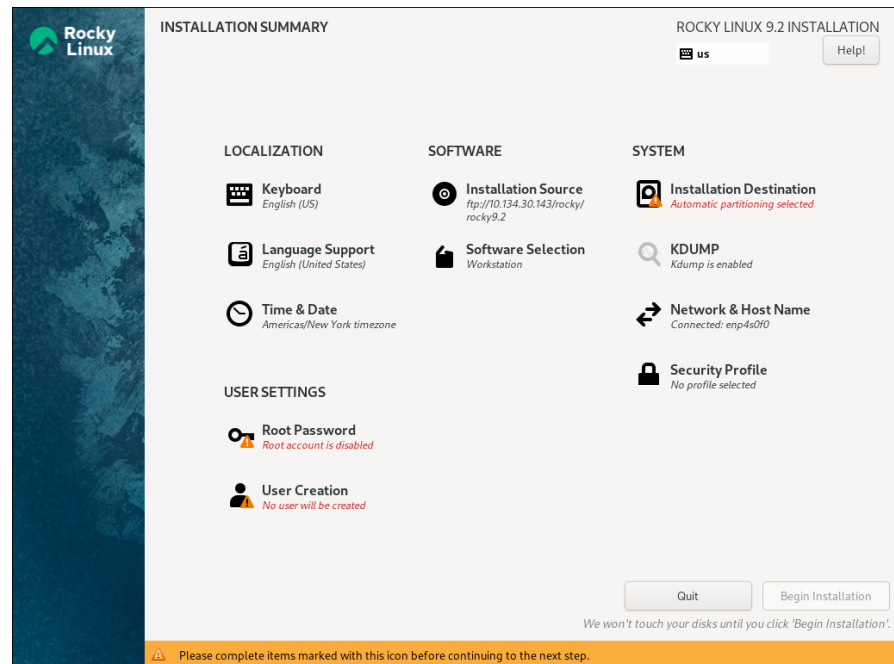


Choose **Workstation** and select all of the **Additional software for Selected Environments** categories displayed on the right side of the screen.

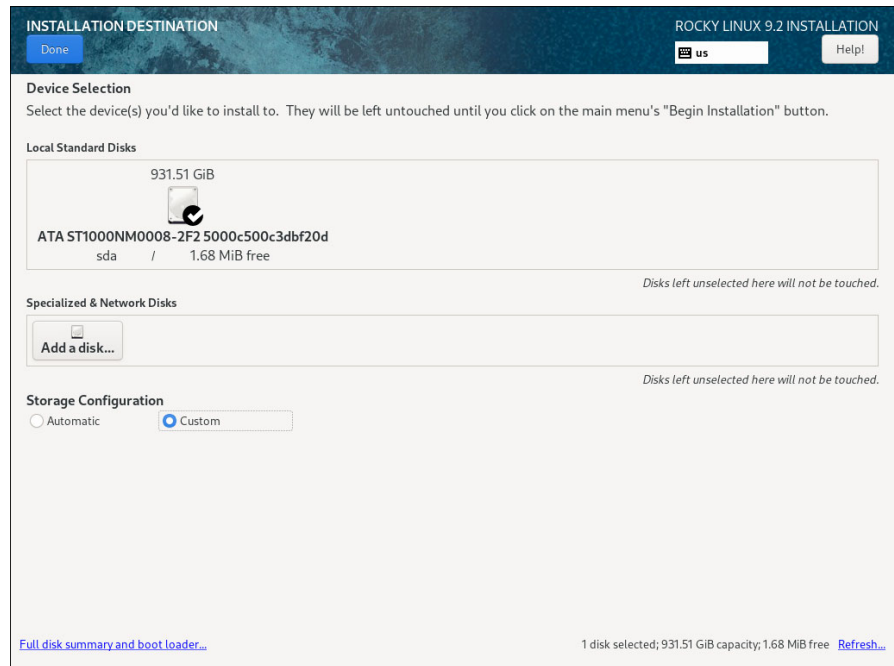
NOTE

Click on the top software and then repeat pressing the down arrow on the keyboard, followed by the space bar, until all software are selected. Note that the list will continue to scroll across multiple pages of add-ons and will stop scrolling only after reaching the last add-on.

Then press **Done** in the upper left corner to complete software selection and return to the **Installation Summary** page. The **Installation Summary** page should eventually appear as shown below.



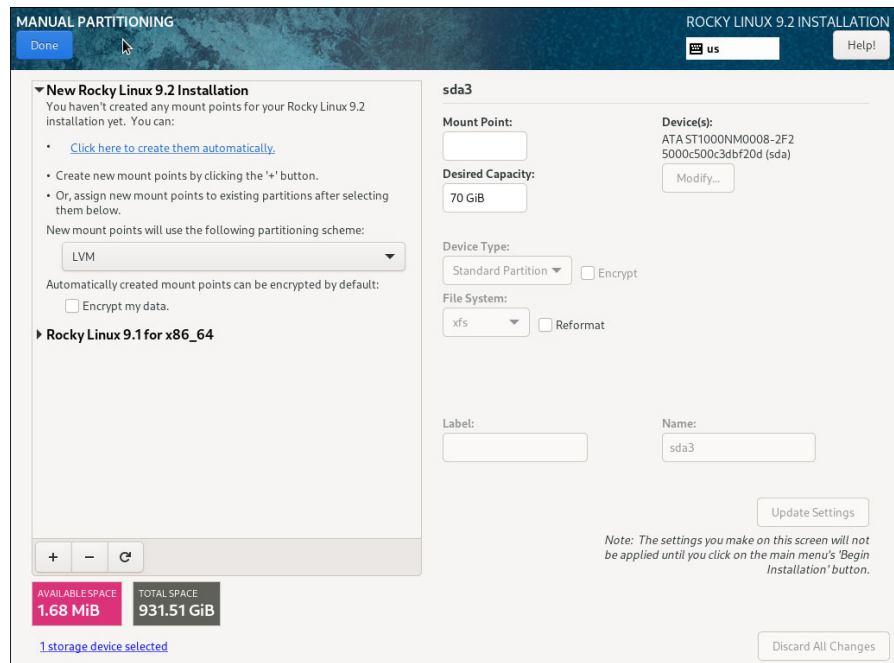
- Next, click on **Installation Destination** to manually partition the system's hard drive for the best operation with RedHawk Linux. A page similar to the following page will be displayed.



On this page, select **Custom** under **Storage Configuration** and then press **Done** in the upper left to continue.

If there is more one than disk, select the hard drive you wish to place the RedHawk installation, as well as any other drives that you wish to configure and/or format during the installation.

9. You will now be presented with the **Manual Partitioning** page, which should appear similar to the following.

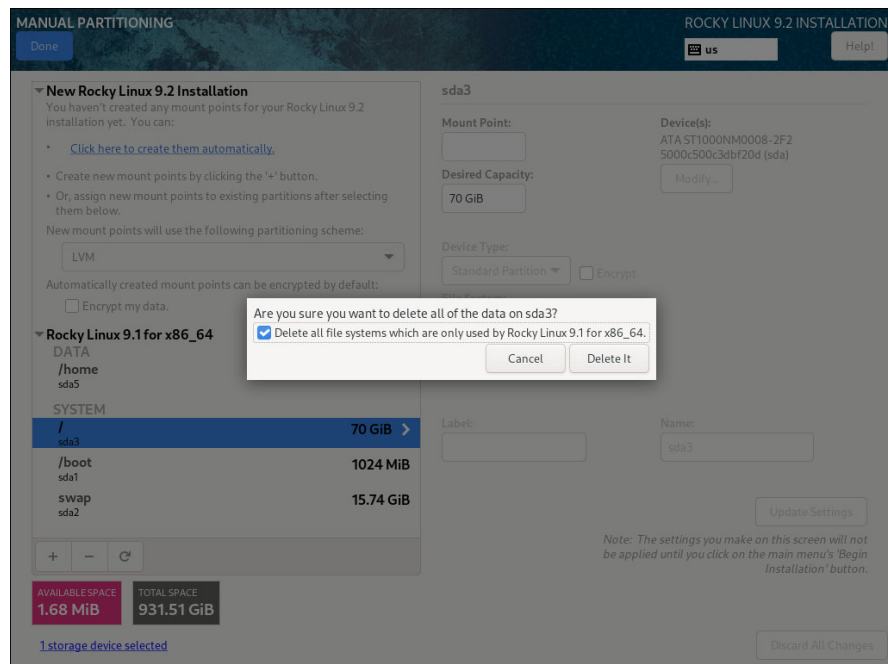


If the system's hard drive has been used previously, you should delete any existing partitions to start from a clean state.

NOTE

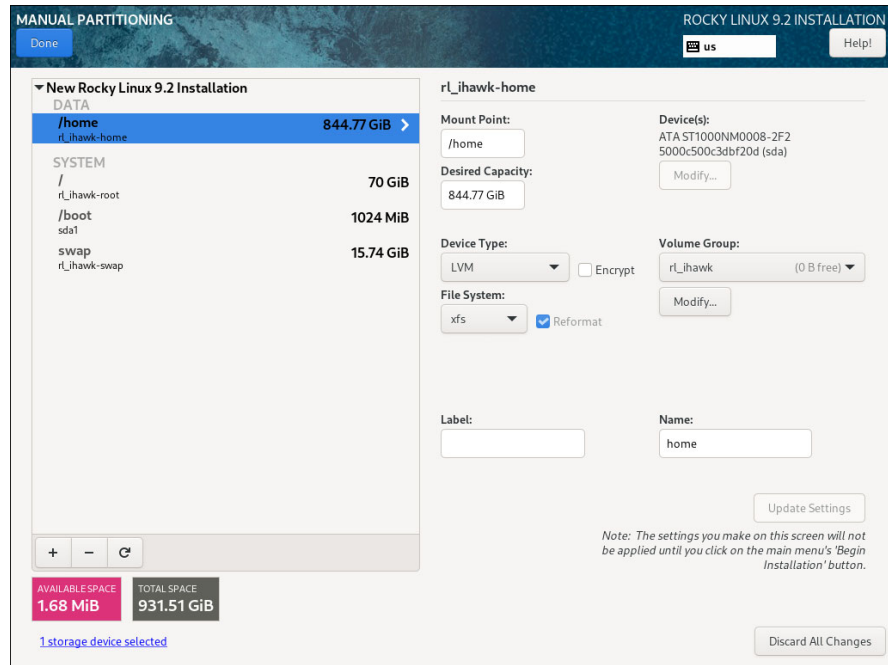
Deleting existing partitions is recommended unless you wish to create a multi-boot system. For example, one system with the ability to boot into multiple versions of RedHawk or possibly even Microsoft® Windows® operating systems. In these cases, consult with your system administrator as this document does not cover setting up a multi-boot system.

The following page illustrates selecting an existing / partition, clicking the “-” (minus) icon, checking the **Delete all other filesystems** checkbox, and finally pressing the **Delete It** button to delete an entire existing partitioning scheme, if necessary.



- On the **Manual Partitioning** page, press the **Click here to create them automatically** link to automatically create the necessary partitions required for your installation.

The following page shows an example of the automatically created partitions.



The sizes of the automatically created partitions are inadequate; the following steps will adjust the partition sizes to be optimal for a RedHawk installation.

NOTE

Be careful not to accidentally press the **Done** or the **Reset All** buttons at this point. You must only press the **Done** button at the very end of modifying the partitions.

NOTE

On systems configured to use UEFI, an additional **/boot/efi** partition will be automatically created. Do not modify this partition as it is already configured properly for a RedHawk installation.

11. On the **Manual Partitioning** page, select the **/home** partition, change the **Desired Capacity** to 10 GiB, and then press the **Update Settings** button.

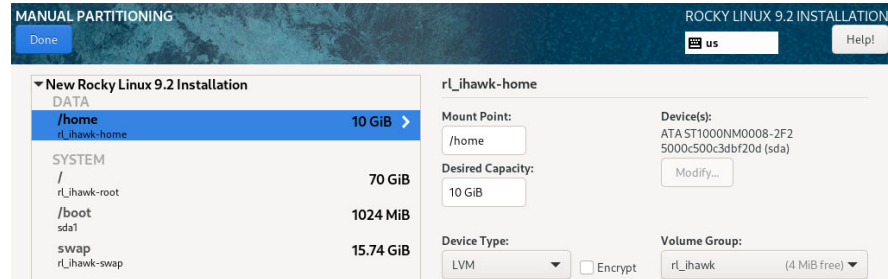
NOTE

Setting the **/home** partition to 10 GB is only a temporary change that is required in order to allow the other partitions to be resized.

NOTE

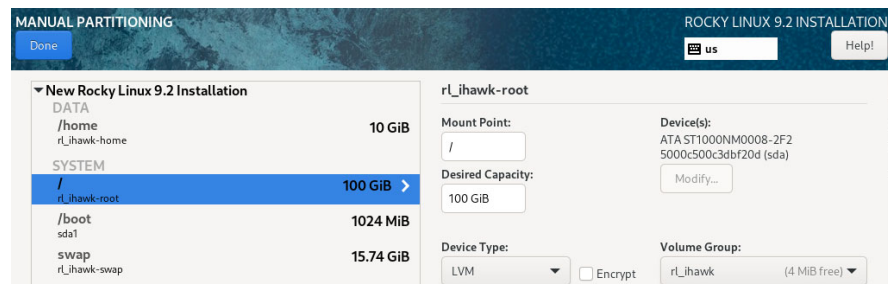
For smaller hard drives with 128 GB capacity or less, the separate **/home** partition should be eliminated by selecting it and pressing the **-** (minus) key at the bottom of the partition list. Then, skip to the next step and ignore **/home** in all of the examples.

The following snippet shows an example of what should now be displayed:



- Next, select the **/** partition, change the **Desired Capacity** to 100 GiB, and then press the **Update Settings** button.

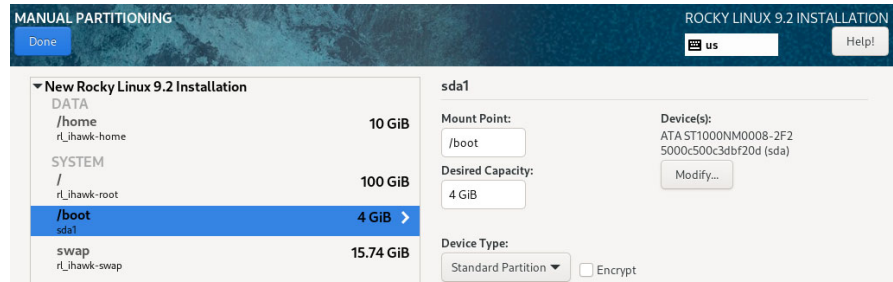
The following snippet shows an example of what should now be displayed:

**NOTE**

For smaller hard drives with 128 GB capacity or less you can leave the default for the **/** partition and skip to the next step to create the **boot** partition.

- Next, select the **/boot** partition, change the **Desired Capacity** from 1024 MiB to 4096 MiB, and then press the **Update Settings** button.

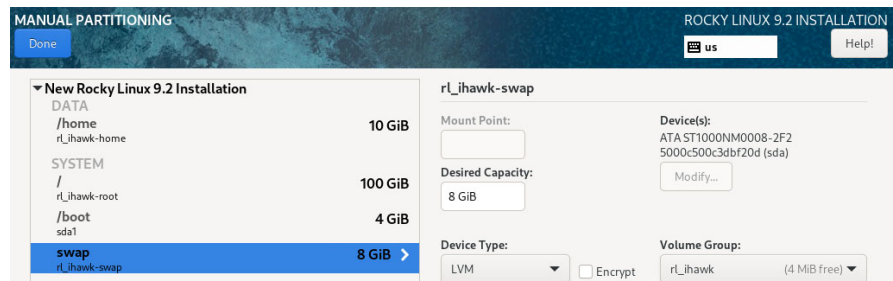
The following snippet shows an example of what should now be displayed:



- Next, select the **swap** partition, change the **Desired Capacity** to match the size recommended in the following table, and then press the **Update Settings** button.

Main Memory Size (GB)	Recommended Swap Partition Size
0 - 3	2048 MiB
4 - 15	4096 MiB
16 - 63	8192 MiB
64 - 255	16 GiB
256 - 511	32 GiB
512 - 1024	64 GiB

The following snippet shows an example of what should now be displayed:

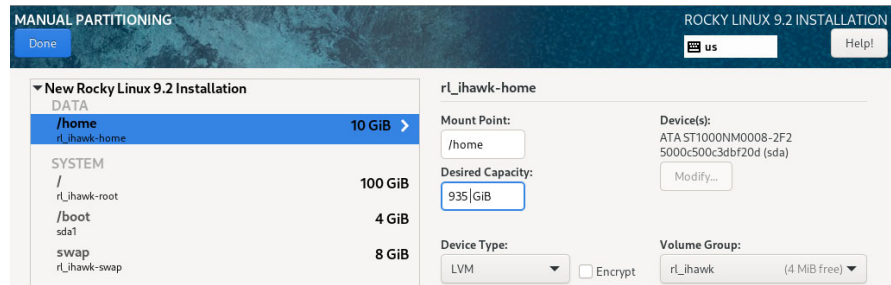


- Lastly, select the **/home** partition again, enter the complete size of the disk in the **Desired Capacity** box and then press the **Update Settings** button to set the size to the maximum size available from the disk space remaining.

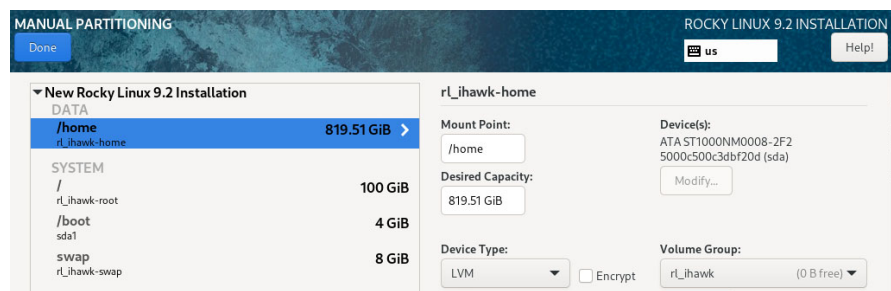
NOTE

For smaller hard drives with 128 GB capacity or less, the **/home** partition should have been deleted above, so you can perform this step with the **/** partition instead; thus, the **/** partition size will be set to the maximum size available using all remaining disk space.

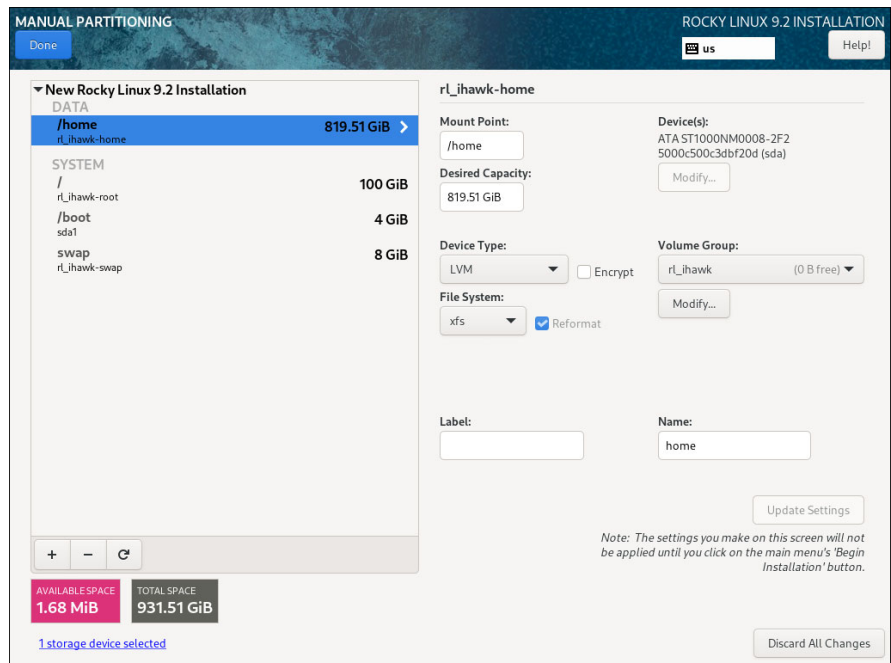
The following snippets shows **/home** size being set to the whole disk:



When you press **Update Settings**, it will set it to the maximum available size:

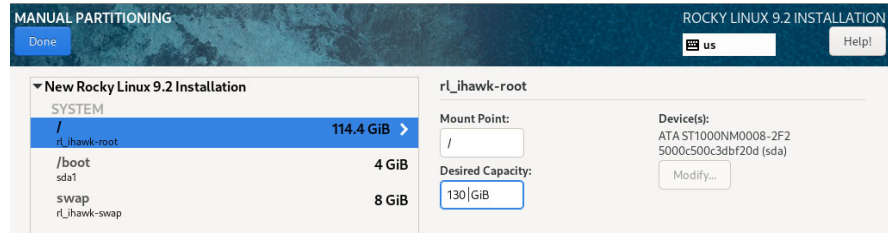


- At this point, you should now see a **Manual Partitioning** page similar to the following:

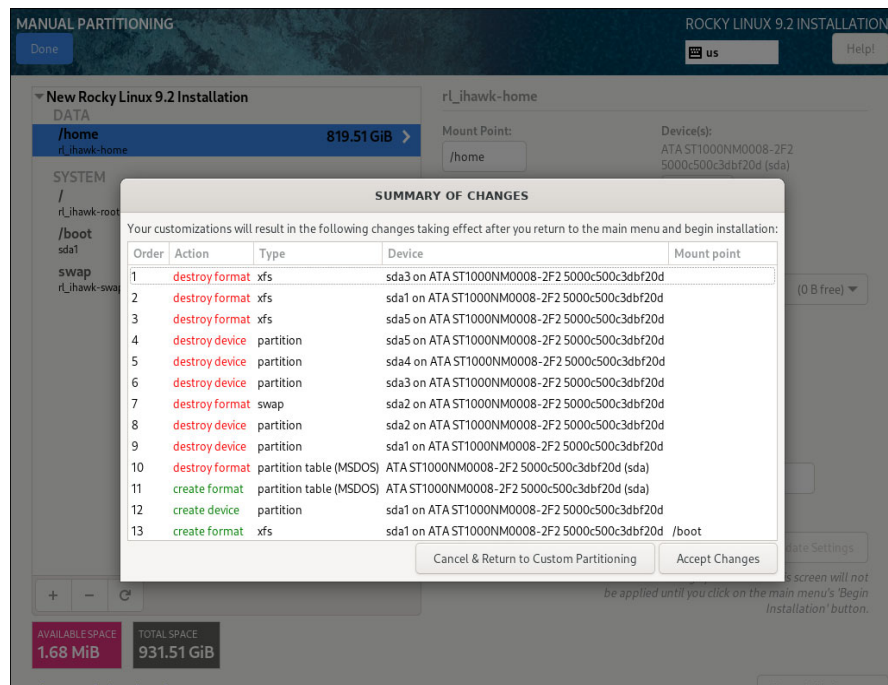


Press the **Done** button to use the layout for the system's partitioning.

Alternatively, here is an example of a system with a smaller hard drive, with 128 GB capacity or less, that should not have a **/home** partition:



17. You will now be presented with a **Summary of Changes** confirmation screen similar to the following:

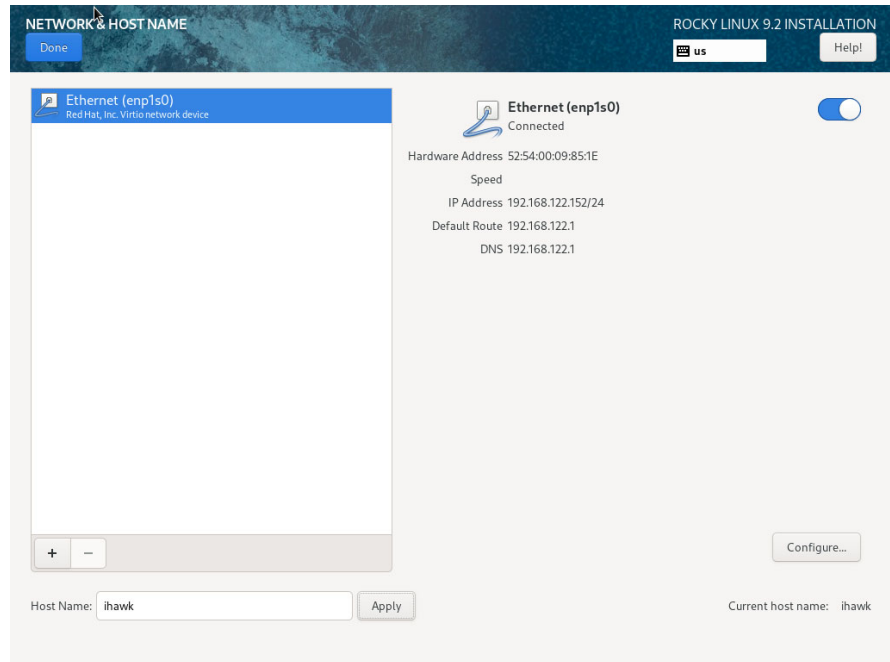


Next, press **Accept Changes** to accept the custom partitioning.

18. Back on the **Installation Summary** page, click on **Network & Hostname** to set the system’s hostname and networking configuration. Type in the hostname in the box at the bottom of the page and click on the **Apply** button next to it.

For each network connection device shown on the left, toggle the connection button to the right to the **ON** position to connect to that network automatically.

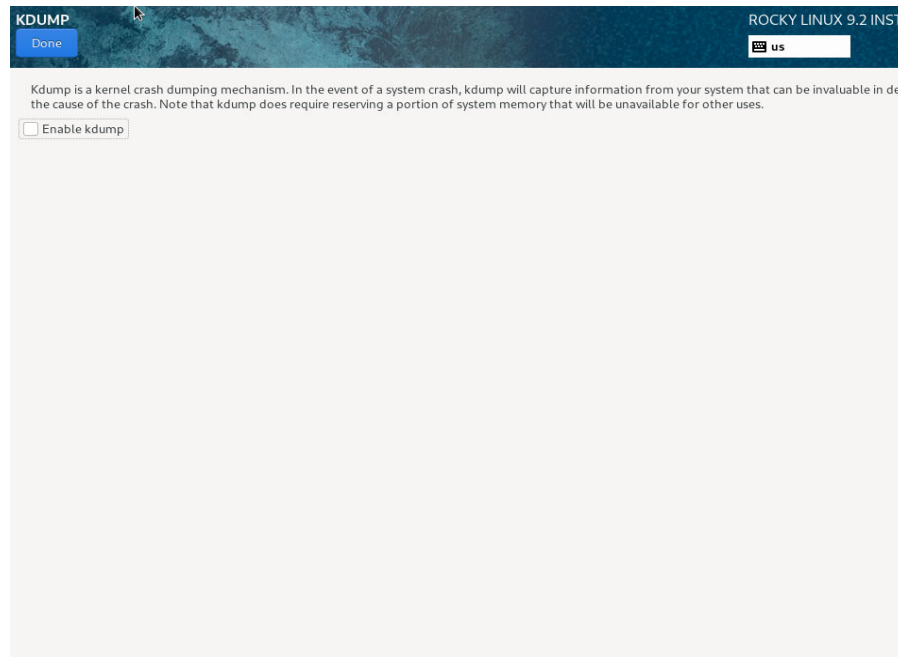
An example page with only one network connection follows:



Ensure the connected device is set to **ON** and press **Done** when you have finished configuring all of the networking details.

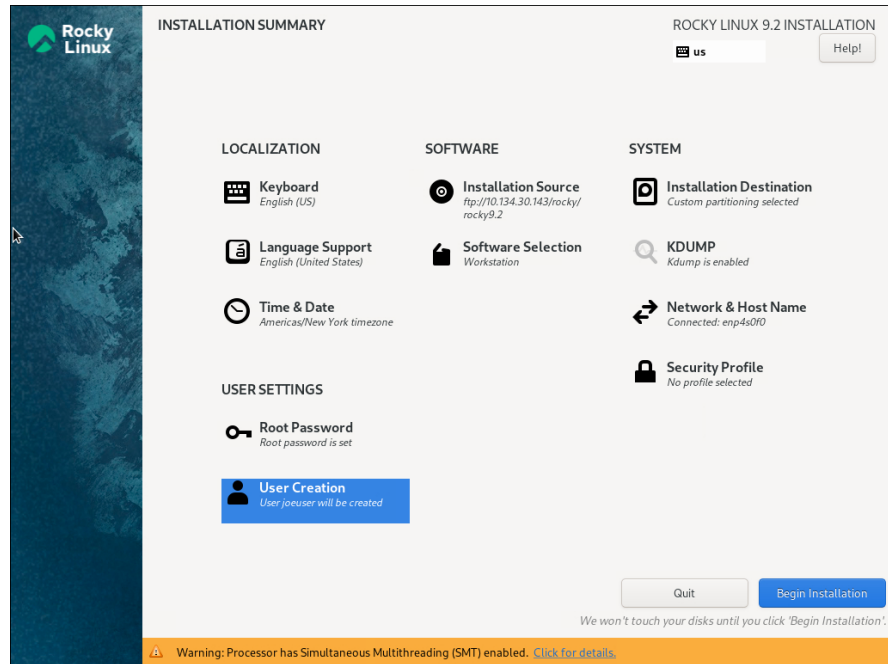
19. Back on the **Installation Summary** page, click on **Enable kdump** to deconfigure the default kernel crash dump settings.

The following screen shows the default kernel crash disabled:



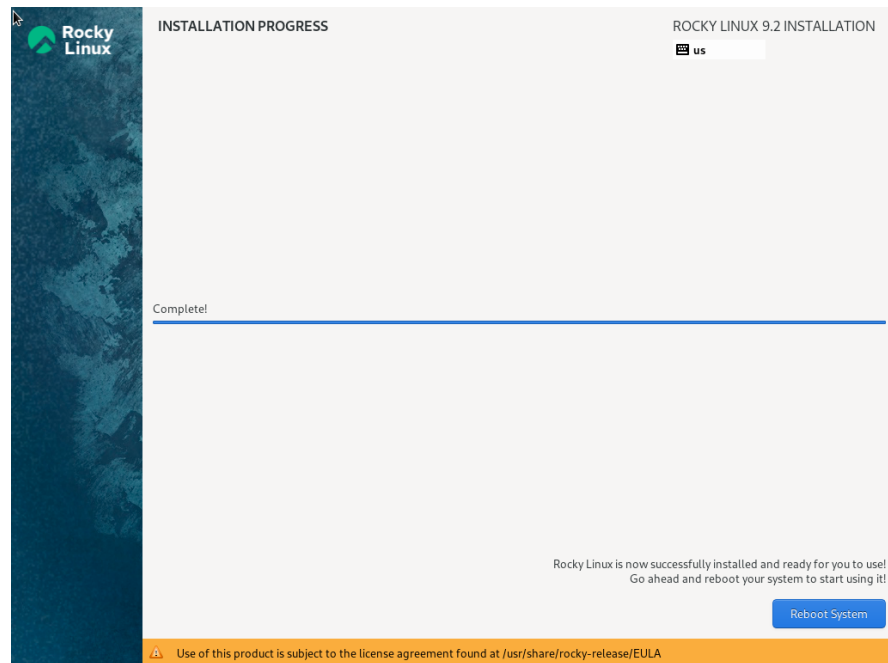
Uncheck the **Enable kdump** check box and then press **Done**.

20. Before you can begin the installation you must set the system's root password and create a non-root user. Under the **USER SETTINGS** click on **Root Password** to set the root password and **User Creation** to create the non-root user. Then the **Begin Installation** button will be visible.



Click on the **Begin Installation** button on the lower-right of the screen to start package installation.

21. After all packages have been installed you will see the following screen.



Remove the installation Blu-ray disc and press **Reboot** in the lower right to restart the system and continue.

22. You might see the following grub screen displayed after the system restart:



Press the **Enter** key or allow the grub screen to timeout to boot the newly installed system.

23. During each user's first graphical login the user may be presented with various configuration screens.

Next, to bring up a terminal window, click on the terminal icon that appears on the bottom of the screen.

The preliminary installation of Rocky is complete. Proceed to the next section to complete the Rocky installation and updates.

5.1.2 Installing Rocky Updates

The disc labeled Rocky Updates Version 9.2 provides three functions:

- Updates the system with the latest updates released by Rocky that have been validated by Concurrent Real-Time on RedHawk Linux.
- Installs packages needed by the RedHawk installation. These updates are important to the proper operation of RedHawk Linux.
- The disc may be used at any time to install additional Rocky 9.2 packages. The **dnf (8)** command may be used to access its contents, as long as the first "baseurl" in `/etc/yum.repos.d/Rocky-Updates-Media.repo` points to its mountpoint.

To install the Rocky Updates, execute the following instructions on the console or in a terminal window running as root.

1. The automounter should have mounted the disc under the directory: `/run/media/root/Rocky-9.2-Updates-x86_64`. Execute the following commands as root to install the update software:

```
cd /run/media/root/Rocky-9.2-Updates-x86_64
./install-updates
```

NOTE

If the automounter failed to automount the disc, it can be manually mounted under a subdirectory created under any system directory. For example:

```
mkdir /media/Rocky-updates
mount /dev/sr0 /media/Rocky-updates
cd /media/Rocky-updates
./install-updates
```

If you have multiple disc drives the drive may be labeled **sr1** or some other number instead of **sr0**.

NOTE

If the script **install-updates** returns an error, run the **mount (8)** command and check to see if it was mounted with the **noexec** option. If the **noexec** option is present, remount the optical media as follows:

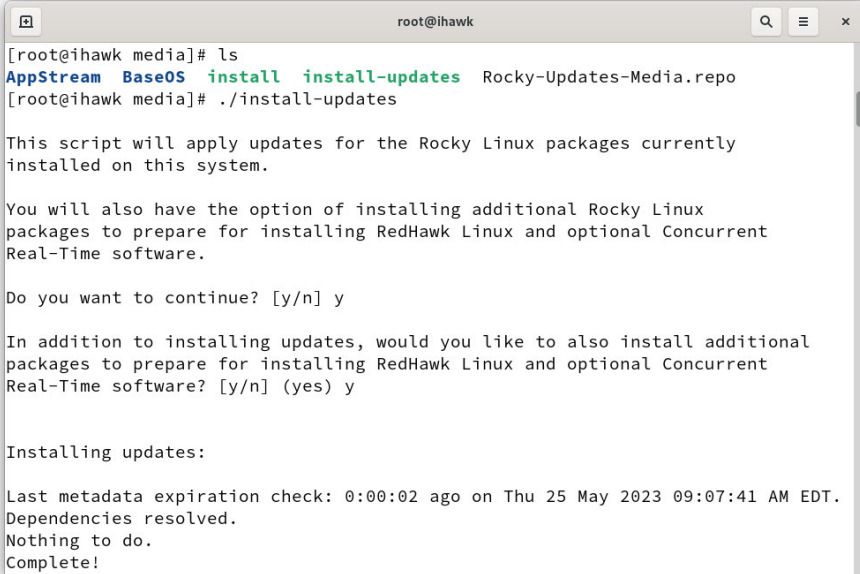
```
mount -o remount,exec <mount-point>
```

where *mount-point* is the directory name in the output of the previous mount command for that optical media.

2. The installation script will first ask you to confirm that you want to proceed with updating Rocky packages. Type **Y** and press **Enter** to continue.

The installation script will then ask if you wish to install additional Rocky packages required by RedHawk. Concurrent Real-Time recommends that you press **Enter** to install the full set of Concurrent Real-Time recommended package updates.

The Rocky operating system will be updated from packages in the disc. No action is required of you during this step.



```

root@ihawk
[root@ihawk media]# ls
AppStream BaseOS install install-updates Rocky-Updates-Media.repo
[root@ihawk media]# ./install-updates

This script will apply updates for the Rocky Linux packages currently
installed on this system.

You will also have the option of installing additional Rocky Linux
packages to prepare for installing RedHawk Linux and optional Concurrent
Real-Time software.

Do you want to continue? [y/n] y

In addition to installing updates, would you like to also install additional
packages to prepare for installing RedHawk Linux and optional Concurrent
Real-Time software? [y/n] (yes) y

Installing updates:

Last metadata expiration check: 0:00:02 ago on Thu 25 May 2023 09:07:41 AM EDT.
Dependencies resolved.
Nothing to do.
Complete!

```

NOTE

If the update appears to stall for several minutes shortly after pressing the **Enter** key, it is very likely that the Rocky package update checking service has locked the RPM package database to check for any available Rocky package updates. Simply issue a **killall packagekitd** at a bash shell prompt to safely allow the installation to continue.

Once the update of the Rocky operating system has completed, packages required by RedHawk will now be installed. No action is required of you during this step.

```

root@ihawk
Determining additional packages to install.

Installing additional packages:

Last metadata expiration check: 0:00:04 ago on Thu 25 May 2023 09:07:41 AM EDT.
Package accountsservice-0.6.55-10.el9.x86_64 is already installed.
Package alsa-lib-1.2.8-3.el9.x86_64 is already installed.
Package alternatives-1.20-2.el9.x86_64 is already installed.
Package atkmm-2.28.2-2.el9.x86_64 is already installed.
Package atk-2.36.0-5.el9.x86_64 is already installed.
Package audit-libs-3.0.7-103.el9.x86_64 is already installed.
Package bash-5.1.8-6.el9_1.x86_64 is already installed.
Package bc-1.07.1-14.el9.x86_64 is already installed.
Package binutils-2.35.2-37.el9.x86_64 is already installed.
Package bison-3.7.4-5.el9.x86_64 is already installed.
Package cairo-gobject-1.17.4-7.el9.x86_64 is already installed.
Package cairomm-1.14.2-10.el9.x86_64 is already installed.
Package cairo-1.17.4-7.el9.x86_64 is already installed.
Package coreutils-8.32-34.el9.x86_64 is already installed.
Package cpio-2.13-16.el9.x86_64 is already installed.
Package cpp-11.3.1-4.3.el9.x86_64 is already installed.
Package cryptsetup-2.6.0-2.el9.x86_64 is already installed.

```

NOTE

While the messages displayed during package updates appear to indicate that package *downloading* is occurring, no actual network access is performed when using the Updates Blu-ray disc.

3. Upon completion of the system update as shown in the image below, the system will be ready for the RedHawk Linux installation.

```

root@ihawk
qt5-qtwebsockets-5.15.3-1.el9.x86_64
rocky-logos-httpd-90.14-1.el9.noarch
sdl12-compat-1.2.60-1.el9.x86_64
systemtap-sdt-devel-4.8-2.el9.x86_64
tcsh-6.22.03-6.el9.x86_64
tftp-server-5.2-37.el9.x86_64
usermode-1.114-4.el9.x86_64
virt-viewer-11.0-1.el9.x86_64
web-assets-filesystem-5-15.el9.noarch
xorriso-1.5.4-4.el9.x86_64

Complete!

All updates have been applied.

Please contact Concurrent Real-Time technical support if you had any
problems during this installation (http://www.concurrent-rt.com/support
or 1-800-245-6453).

Note that you may rerun this script at any time. You can also mount
this DVD and use dnf(8) to access its contents. See the RedHawk Linux
Release Notes for more information.

[root@ihawk media]# █

```

4. When the update completes, execute the following commands:


```
cd ..
eject
```

NOTE: If there is more than one media device, you must specify the device to be ejected; e.g., **eject /dev/sr1**.

5. Remove the disc from the optical media drive and store.
6. Type “reboot” at the system prompt and verify that the new Rocky kernel boots.
7. Continue with the steps in the next section to install RedHawk Linux.

5.2 Installing RedHawk Linux

After completing the installation of Rocky in the previous section, perform the following steps to install RedHawk Linux:

1. Log in as root and take the system down to single-user mode:
 - a. At the system prompt, type **init 1**.
 - b. Enter the root password at the rescue prompt to access the shell.
2. Locate the disc labeled “RedHawk Linux Version 9.2” appropriate to your system’s architecture and insert it into the optical media drive.
3. If the device does not mount automatically, execute the **mount** command appropriate for your optical media device.
4. Execute the following commands to install RedHawk Linux, substituting the actual mount point used for your optical media device if necessary:

```
cd /path-to-actual-mount-point
./install-redhawk
```

```
root@ihawk:/media — /bin/bash ./install-redhawk
[root@ihawk media]# ./install-redhawk

This process will install the RedHawk Linux core files
for RedHawk Linux 9.2 (Frost) on the current system (ihawk).

Do you want to install RedHawk Linux? [y/n] y

-----
Concurrent Real-Time End-User License Agreement (the EULA).

This license should be read before acceptance of its terms. If the terms
are not acceptable then you must reject the license and terminate the
installation process.

A copy of this license may be found in /usr/share/doc/ccur/RedHawk-EULA
after installation.

-----

View, Accept, or Reject the terms of this license? [v/a/r] a

Would you like to install 32-bit compatibility packages? [y/n] (y) y

Preparing for installation...
```

The installation script will prompt you to accept or reject the End User License Agreement. You can view the agreement by entering “v” at the prompt. Then you are presented with the option to install 32-bit compatibility packages. The default action is to install.

While the messages displayed during RedHawk installation appear to indicate that package *downloading* is occurring, no actual network access is performed when using the RedHawk DVD.

NOTE

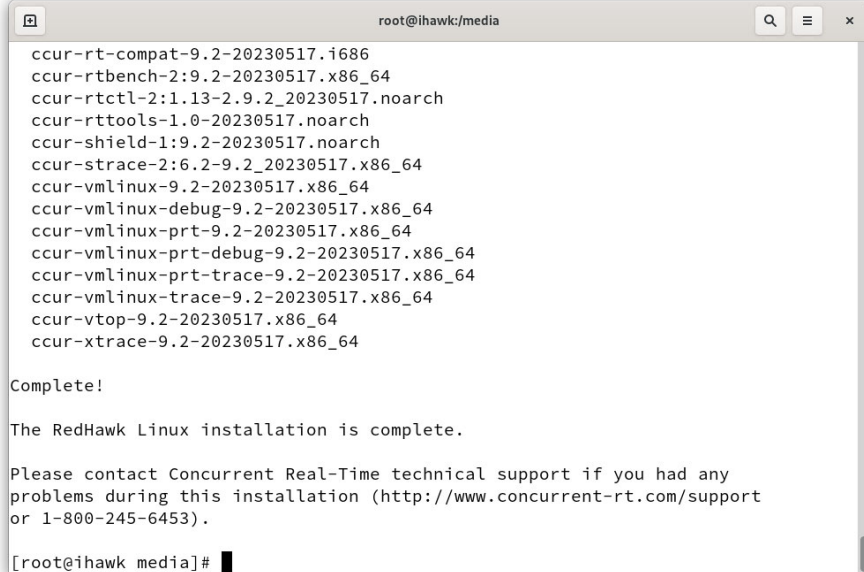
During the RedHawk installation the following message can be safely ignored:

```
Failed to stop auditd.service: Operation
refused, unit auditd.service may be requested
by dependency only (it is configured to
refuse manual start/stop.
```

NOTE

It is normal for the installation script to appear to be stalled near the end of installation. It is performing several background operations that are required and the script must not be interrupted.

- The following messages will be displayed once all RedHawk package installation has completed successfully.



```

root@ihawk/media
ccur-rt-compat-9.2-20230517.i686
ccur-rtbench-2:9.2-20230517.x86_64
ccur-rtctl-2:1.13-2.9.2_20230517.noarch
ccur-rttools-1.0-20230517.noarch
ccur-shield-1:9.2-20230517.noarch
ccur-strace-2:6.2-9.2_20230517.x86_64
ccur-vmlinux-9.2-20230517.x86_64
ccur-vmlinux-debug-9.2-20230517.x86_64
ccur-vmlinux-prt-9.2-20230517.x86_64
ccur-vmlinux-prt-debug-9.2-20230517.x86_64
ccur-vmlinux-prt-trace-9.2-20230517.x86_64
ccur-vmlinux-trace-9.2-20230517.x86_64
ccur-vtop-9.2-20230517.x86_64
ccur-xtrace-9.2-20230517.x86_64

Complete!

The RedHawk Linux installation is complete.

Please contact Concurrent Real-Time technical support if you had any
problems during this installation (http://www.concurrent-rt.com/support
or 1-800-245-6453).

[root@ihawk media]#

```

- When the installation completes, execute the following commands:

```
cd ..
eject
```

- Remove the disc from the drive and store.
- Reboot the system choosing a new RedHawk kernel and verify that the system starts booting properly.

NOTE

The default display server is Wayland. To switch to another display server, simply log off and, from the login screen and click on your username. At this point, click on the gear at the bottom right and select a different display server.

- If you are installing an RCIM on your system, please refer to the accompanying document 'Real-Time Clock and Interrupt Module (RCIM) User's Guide'. Otherwise, proceed to the following section to install Frequency-Based Scheduler (FBS).

5.3 Installing the Frequency-Based Scheduler (FBS)

FBS is an optional package to RedHawk Linux. If you will be using FBS, install it at this time by performing the following steps:

1. With RedHawk Linux Version 9.2 running, log in as root and take the system down to single-user mode.
2. Locate the disc labeled “RedHawk FBS Version 9.2” appropriate to your system’s architecture and insert it into the optical media drive.
3. If the optical media disc device does not mount automatically, execute the **mount** command, for example:

```
mount /dev/sr0 /media/dvd
```

4. To install, execute the following commands:

```
cd /path-to-actual-mount-point
./install-fbs
```

```

root@ihawk/media — /bin/bash ./install-fbs
[root@ihawk media]# ls
Documentation  install      Packages      repodata      uninstall-fbs
EULA          install-fbs  redhawk-fbs-media.repo  uninstall
[root@ihawk media]# ./install-fbs

This process will install the Frequency Based Scheduler (FBS)
for RedHawk Linux 9.2 (Frost) on the current system (ihawk).

Do you want to install RedHawk FBS? [y/n] y

-----
Concurrent Real-Time End-User License Agreement (the EULA).

This license should be read before acceptance of its terms.  If the terms
are not acceptable then you must reject the license and terminate the
installation process.

A copy of this license may be found in /usr/share/doc/ccur/RedHawk-EULA
after installation.

-----
View, Accept, or Reject the terms of this license? [v/a/r] a
Would you like to install 32-bit compatibility packages? [y/n] (y) y
    
```

Follow the on-screen instructions until the installation script completes.

```

root@ihawk/media
Installing      : ccur-fbsched-fortran-9.2-20230517.x86_64      1/3
Running scriptlet: ccur-fbsched-fortran-9.2-20230517.x86_64      1/3
Installing      : ccur-fbsched-compat-9.2-20230517.i686       2/3
Running scriptlet: ccur-fbsched-compat-9.2-20230517.i686       2/3
Installing      : ccur-fbsched-9.2-20230517.x86_64           3/3
Running scriptlet: ccur-fbsched-9.2-20230517.x86_64           3/3
Verifying       : ccur-fbsched-9.2-20230517.x86_64           1/3
Verifying       : ccur-fbsched-compat-9.2-20230517.i686       2/3
Verifying       : ccur-fbsched-fortran-9.2-20230517.x86_64     3/3

Installed:
ccur-fbsched-9.2-20230517.x86_64
ccur-fbsched-compat-9.2-20230517.i686
ccur-fbsched-fortran-9.2-20230517.x86_64

Complete!

The RedHawk FBS installation is complete.

Please contact Concurrent Real-Time technical support if you had any
problems during this installation (http://www.concurrent-rt.com/support
or 1-800-245-6453).

[root@ihawk media]#
    
```

- When the installation completes, execute the following commands:

```
cd ..
eject
```

- Remove the disc from the optical media drive and store.
- Exit single-user mode (Ctrl-D).

5.4 Installing Additional RedHawk Products

If you will be installing any additional RedHawk products, do so now. Refer to the products' documentation for installation instructions.

5.5 Installing RedHawk Updates from Disc

Discs labeled "RedHawk Update Disc" include updates to RedHawk and its products. If a RedHawk Updates disc is provided, install it now.

- Ensure that the system is in multi-user mode.
- Locate the disc labeled "RedHawk Update Disc" appropriate to your system's architecture, insert it into the drive.
- If the disc device does not mount automatically, execute the **mount** command, for example:

```
mount /dev/sr0 /media/dvd
```

- Execute the following commands to install the RedHawk updates included on the disc:

```
cd /path-to-actual-mount-point
./install-updates
```

When the installation is complete, the Main window for Concurrent Real-Time's Network Update Utility (NUU) displays, listing product updates that complete your installation of RedHawk. Depending on the installation state of your Concurrent Real-Time products, the NUU Main window may show software modules which are out of date.

Before installing any modules, check for NUU updates separately. Apply any NUU updates and then restart NUU before applying any other updates.

NOTE

You should disable the external Rocky repositories (Base, Updates and Contrib) before continuing. Select **Edit Configuration** in the **Repositories** menu to disable these repositories.

With NUU up-to-date, from the NUU Main window, click on the **Select Update of All Out-of-Date** button, then click on the **Apply Actions** button to install all listed product updates.

5. When the installation completes, execute the following commands:

```
cd ..  
eject
```

6. Remove the disc from the optical media drive and store.
7. If there are more update discs, repeat these steps to install all updates.
8. Reboot the system choosing the updated RedHawk kernel and verify that the system boots properly.
9. Check for additional RedHawk updates available through the RedHawk Updates web site as outlined in the following section.

5.6 Installing RedHawk Updates from Web Site

1. Additional updates may have been issued (that are not included on any “RedHawk Update Disc” you may have received). They should be downloaded and installed now. Refer to “Software Updates” on page 57 for details.
2. When complete, or if no updates are available, reboot the system choosing the new RedHawk kernel and verify that the system boots properly.

6.0. NVIDIA Graphics Configuration

The Unified NVIDIA Linux Display Driver (version 525.85.12) is provided as an add-on disc with the purchase of NVIDIA video cards or upon request.

See sections 6.1, "Supported NVIDIA GPUs" and 6.2, "Multiple NVIDIA Video Card Considerations" below for more information on NVIDIA driver compatibility.

6.1 Supported NVIDIA GPUs

You can examine the list of supported GPUs for driver 525.85.12 at the NVIDIA web site which is located at:

<http://www.nvidia.com>

Note that if your NVIDIA GPU is not supported by the 525.85.12 driver, you will have to do one of the following:

- replace the existing older NVIDIA card in your system with a newer NVIDIA card that is supported by the 525.85.12 driver
- go to the NVIDIA web site mentioned above and download a legacy NVIDIA driver that supports your NVIDIA card, and follow the installation instructions described on that driver's web page

NOTE

The NVIDIA driver that is provided with RedHawk installations has been modified to reduce jitter on shielded CPUs in a real-time environment. Therefore, if you choose to download and use a legacy NVIDIA driver directly from the NVIDIA web site, you may observe interference on shielded CPUs during graphics activity.

6.2 Multiple NVIDIA Video Card Considerations

Note that you may not use the unified 525.85.12 Driver and a legacy NVIDIA Linux Display Driver together at the same time.

If you have a system with a mix of legacy-only and unified-only NVIDIA video cards, you will only be able to use one set of cards (legacy or unified) at any single point in time.

It is highly recommended that you physically remove the legacy or unified video cards that you are not using so that they do not interfere with the card(s) that you are planning to use. Failure to do so may lock up your system or X11 session.

If you have a mixed video card system as described here, it is recommended that you upgrade your legacy NVIDIA video cards to unified video cards and use the unified 525.85.12 driver as your display driver.

6.3 Display Configurations

RedHawk comes with the GNOME windowing system which only supports multiple displays as a single continuous desktop spanning multiple displays with one controlling mouse and keyboard. Screens can be configured left, right, above, or below each other in any fashion.

NOTE

Earlier RedHawk releases that included GNOME 2 supported configuring each individual monitor of a multiple monitor setup as a separate desktop, however, this capability was dropped in GNOME 3. Advanced users who still wish to utilize separate desktops will need to install a different windowing system than GNOME 3, but that is beyond the scope of this documentation.

You can use the **nvidia-xconfig(1)** tool to recreate the X configuration file, **xorg.conf** and **nvidia-settings(1)** to customize the configuration. Both are briefly described below.

6.3.1 Single

Single mode is a single X Screen displayed as a single Desktop on a single monitor.

6.3.2 Multiple X Screens

The Multiple X Screens configuration consists of a single Desktop spanning multiple monitors. This mode has the following characteristics:

- A separate X Screen for each display is used.
- The mouse moves freely between displays.
- If you maximize a window, it fills a single display.
- You can drag objects from one display to another.
- This mode causes a little extra overhead for X.

6.4 Using nvidia-xconfig

The **nvidia-xconfig** utility can also be used to recreate the file. It is suggested that the following precautions be taken:

1. Read sections 6.1 - 6.3 above and complete any actions required.
2. Run `init 3` from the command line:
`init 3`
3. Save the **xorg.conf** file:
`mv -i /etc/X11/xorg.conf /etc/X11/xorg.conf.orig`
4. Run the **nvidia-xconfig** utility:
`nvidia-xconfig`

- Run `init 5` from the command line:
`init 5`

See the `nvidia-xconfig(1)` man page for details about using `nvidia-xconfig`.

You can customize the configuration further via the `nvidia-settings(1)` command. See “Using `nvidia-settings`” section below for more information on this command.

6.5 Using `nvidia-settings`

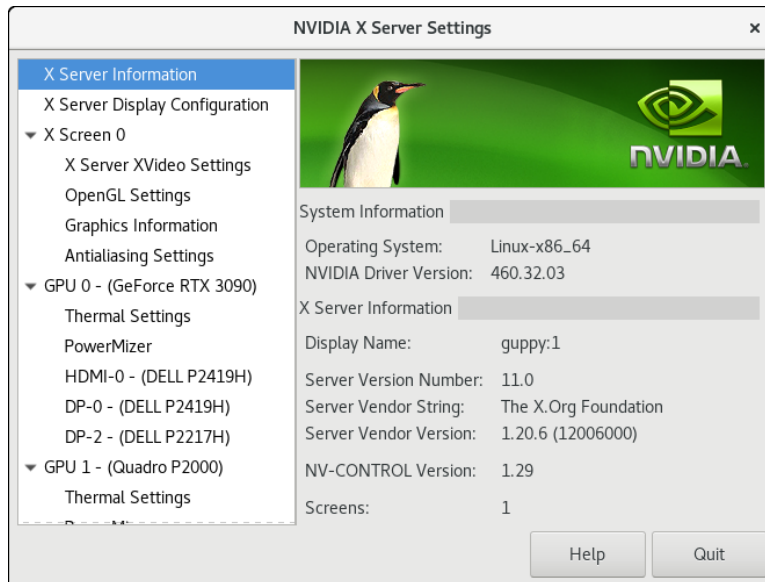
The `nvidia-settings` utility can be used to tune single display settings and also to configure a multidisplay configuration. See the `nvidia-settings(1)` man page for more details.

In the example that follows, a multidisplay configuration is modified using `nvidia-settings`.

To start the `nvidia-settings` utility, issue following the command:

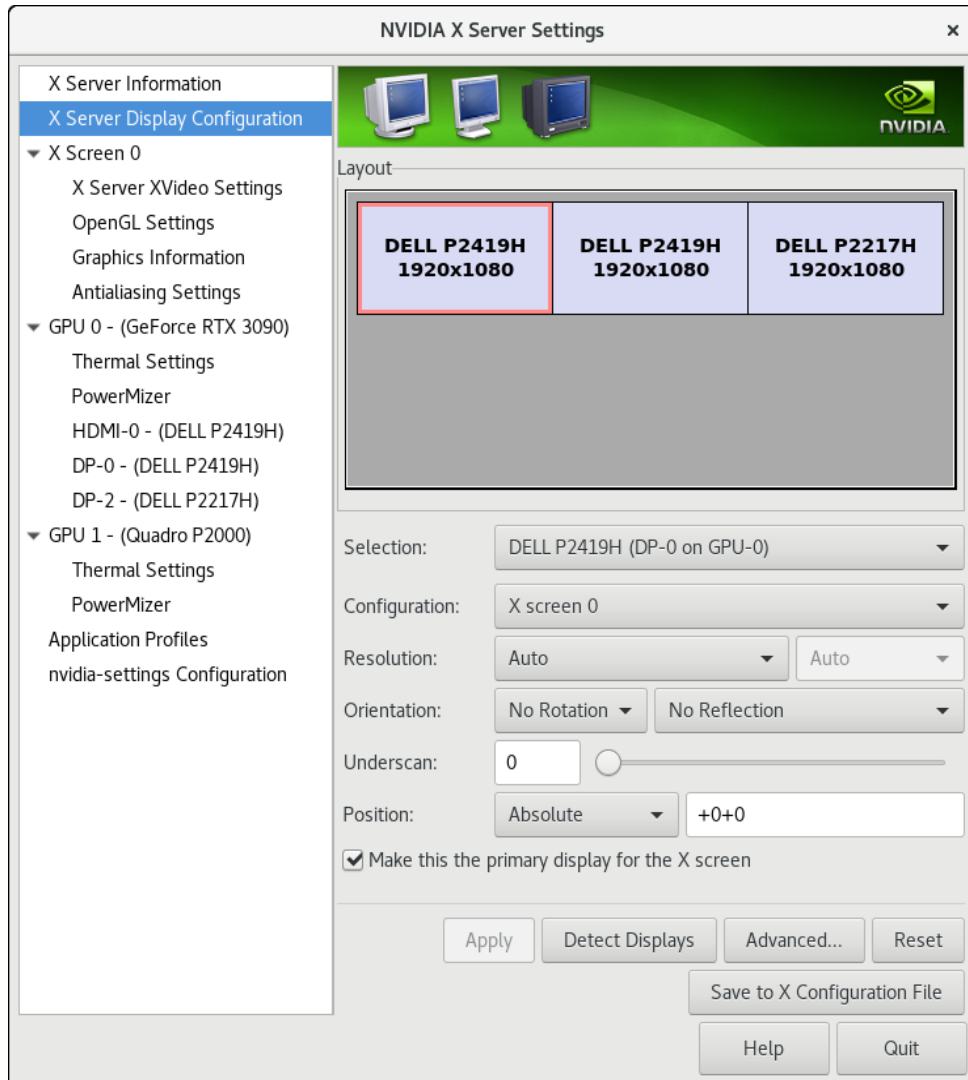
```
nvidia-settings
```

The GUI will start and you will see the “X Server Information” as indicated by the highlighted option on the left side:



On the left side of the screen, you can see that there are two NVIDIA cards on the system: GPU0, and GPU1. All three monitors are connected to the GPU0 card. On the right side, you have system information including the NVIDIA driver version.

To view the “X Server Display Configuration” select that option from the list on the left as shown highlighted below:



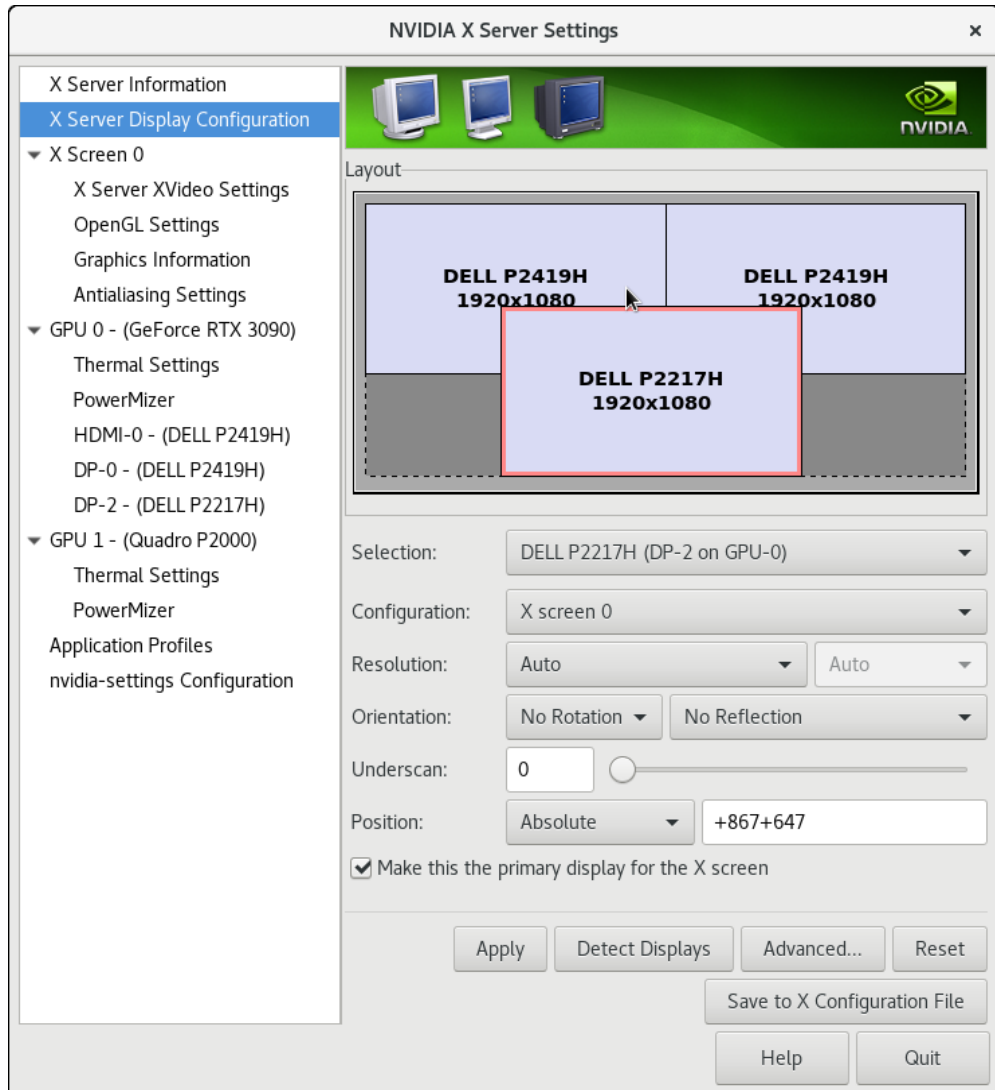
In the Layout window, we see a graphical depiction of the three displays detected. Notice that all the monitors were already configured by **nvidia-xconfig** on the first boot.

Click on the **Detect Displays** button if there are other monitors connected that are not shown in the Layout window.

While the displays were detected and configured, it is not the desired layout for this example. Currently the 2217H display is on the right and one of the 2419H displays is the primary. We want the P227H display to be in the middle position and to be the primary.

The image below shows we have selected the DELL 2217H display (as seen by the red outline around the box) and its configuration page is now displayed.

We have declared it to be the primary monitor (the screen where the desktop will be displayed) by checking the box labeled **Make this the Primary for the X Screen**. And currently we are dragging its box to the middle position for the desired layout.

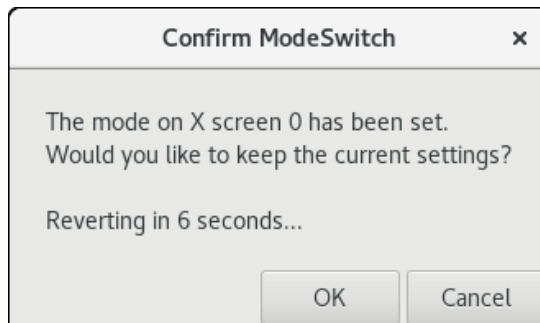


The result will look like the following image, with the displays side by side:

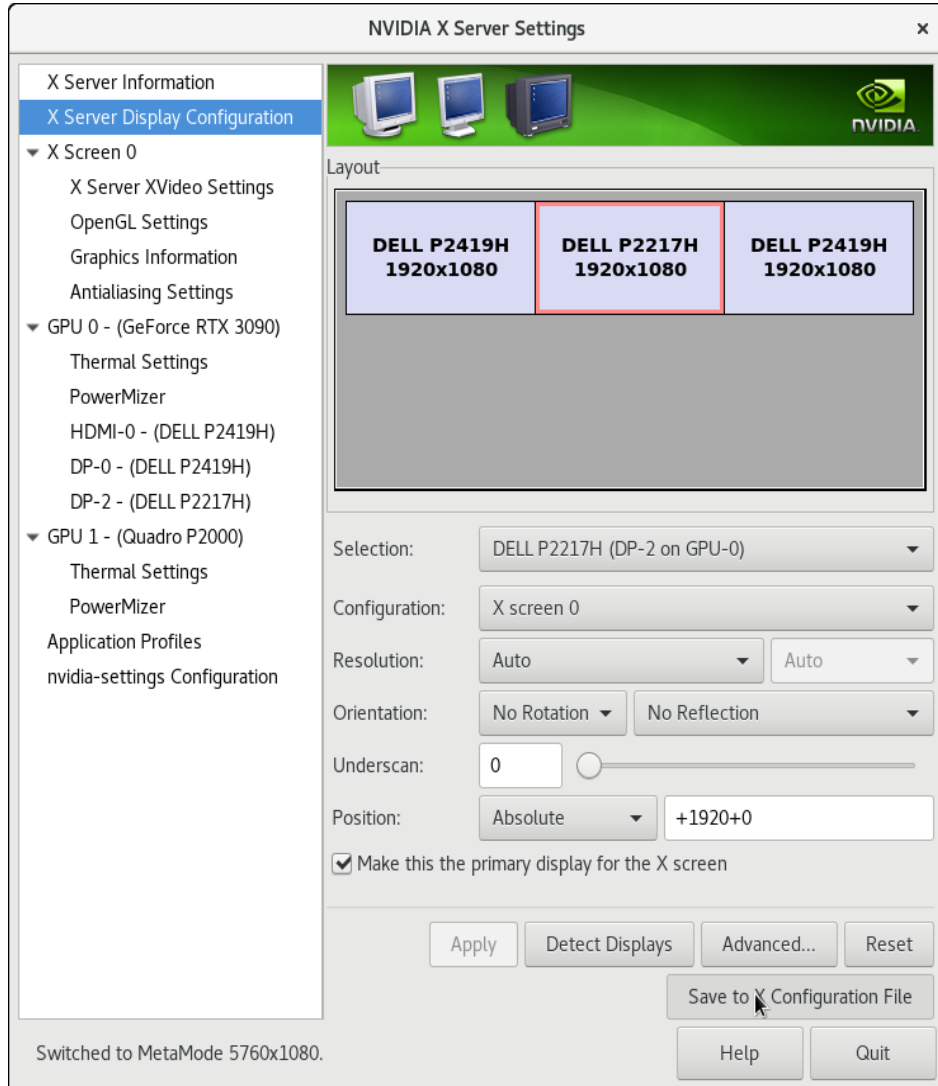


When you click on **Apply**, the changes will take effect immediately. The desktop will now appear on the display selected as primary, the DELL 2217H in this example.

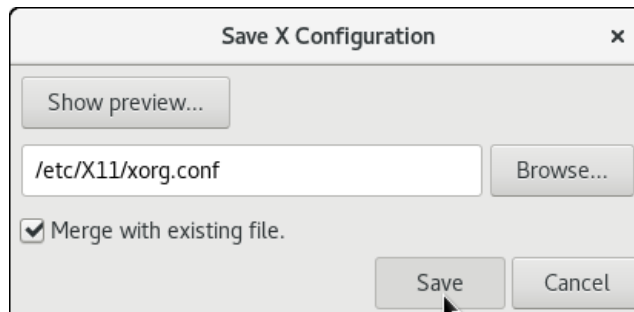
For some operations, such as changing the layout of the displays, a confirmation box will display and you will be given about 12 seconds to confirm the change or it will revert back to the previous setting. Press **OK** to accept the changes. If you were late in confirming and the changes were reverted, just click on the **Apply** button again.



Next step is to save the configuration changes to the **xorg.conf** file on the system. Click on **Save to X Configuration File** button as shown below to save the file:



A box labeled **Save X Configuration box** will then appear. Choose **Save** to save the changes to the **/etc/x11/xorg.conf** file.



Use the **Quit** button at the right hand corner of the display to exit the tool.

6.6 Troubleshooting Problems

The X server looks for a configuration in `/etc/X11/xorg.conf` each time it starts up (normally in runlevel 5). You will find that newer versions of X are getting away from depending on configuration files and require only minimum information to create even the largest multidisplay configurations. In fact, X will work in default mode with NO configuration file at all.

It is not uncommon for obsolete options or incorrect settings specified in `xorg.conf` to cause the system to fail to start X correctly. Sometimes X will get so confused it won't be able to do anything but lock up, cause the system to panic or reboot, or just come up in some invalid video state.

Simply stopping and restarting X does not always restore correct functionality. It is best to issue the command(s):

```
init 1
init 5
```

or

```
reboot
```

See the X server actions logged in `/var/log/Xorg.<number>.log` and `Xorg.<number>.log.old`. Look for the most recently updated.

Normally, X will respond to errors at start up time by telling you there is a problem and offer to show you the log, then create a fresh configuration.

A fresh configuration looks very much like the configuration created by the installer.

If you are unable to create a working `xorg.conf` using the `nvidia-xconfig` utility, it may be because the directions were not followed precisely, or problems may have been created by hand edits after the fact. Take logical steps and verify functionality at the various steps.

Try removing `/etc/X11/xorg.conf` entirely, reboot to runlevel 3, and run `nvidia-xconfig`.

NOTE

Do not run `nvidia-xconfig` in run level 1 or single user mode. This will create an invalid `xorg.conf` file.

If you have the original `xorg.conf` created by the installer, but it's not working, you probably have the wrong driver defined for the primary video display defined by the BIOS. Try the following config:

```
Section "ServerLayout"
    Identifier      "Default Layout"
    Screen          0  "Screen0" 0 0
    InputDevice     "Keyboard0" "CoreKeyboard"
EndSection

Section "InputDevice"
    Identifier      "Keyboard0"
    Driver          "kbd"
EndSection
```

```

Section "Device"
    Identifier      "Videocard0"
    Driver          "vesa"
EndSection

Section "Screen"
    Identifier      "Screen0"
    Device         "Videocard0"
    DefaultDepth   24
    SubSection "Display"
        Viewport    0 0
        Depth       24
    EndSubSection
EndSection

```

In some cases, the PCI Bus ID is not stated in the `xorg.conf` file and the X server will not start without it. If this might be the case, append the PCI Bus ID to the last line of the Device Section.

To find the PCI Bus ID on your system, use the query option of the `nvidia-xconfig` tool as follows:

```

nvidia-xconfig -query-gpu-info | head -n 24
Number of GPUs: 2

GPU #0:
Name      : Quadro P2000
UUID     : GPU-424d5960-4d24-25bc-8081-3e64829b9e63
PCI BusID : PCI:129:0:0

Number of Display Devices: 0

GPU #1:
Name      : GeForce RTX 3090
UUID     : GPU-dblbf7e8-cf92-5127-f0e1-463eb8b39744
PCI BusID : PCI:1:0:0

Number of Display Devices: 3

```

From this output we can see that GPU #1 is the one with devices attached. If a PCI Bus ID line does not exist in the Section Device entry in the `xorg.conf` file, append one with the appropriate value for your system. For example:

```

Section "Device"
    Identifier      "Device 0"
    Driver          "nvidia"
    VendorName     "NVIDIA Corporation"
    BoardName      "GeForce RTX 3090"
    BusID          "PCI:1:0:0"
EndSection

```

Typical drivers in iHawk systems include:

- `radeon` – Common in many servers with embedded graphics chips
- `nouveau` – The generic Linux NVIDIA driver
- `nvidia` – Provided by NVIDIA or Concurrent Real-Time. NVIDIA drivers are modified by Concurrent Real-Time for real-time performance. Use the correct driver from Concurrent Real-Time to ensure the best performance for your system.

- vesa – The generic fall back low performance driver which should work for all VGA adapters.

NVIDIA has a number of generations of graphics cards which cannot all use the same “nvidia” driver version. Not even the generic “nouveau” driver in the Linux kernel works on all NVIDIA cards. The “nvidia” driver will actually disable an nvidia controller or fail to load if it is the wrong version for that card. You cannot mix cards of different generations if the driver does not support all of them.

There is no need to specify resolutions, refresh rates, and color depths for modern VGA adapters and Displays. It is best to allow the hardware and software to negotiate these settings.

WARNING

Using old configuration files is risky. It is not uncommon for obsolete options and entries to cause your system to hang, reboot, or prevent normal usage. You should start with these basic configs and gradually modify them with the options you think you need in order to create customized configurations.

7.0. Additional Information

This section contains helpful information about issues that may be applicable at your site.

7.1 Installation/Configuration Issues

7.1.1 File System Backup Recommendations

All file systems should be archived or preserved prior to commencing a re-installation. This can be accomplished using normal backup methods. Concurrent Real-Time recommends obtaining a new disk while keeping the original disk to ensure minimal data loss.

Table 7-1 contains a list of configuration files that may be useful in configuring a newly installed RedHawk system to match an existing configuration.

Table 7-1 Files Recommended for Backup

NOTE: This is not an all inclusive list and not all files are meant to be copied intact to a new system.

Path	Comments
/etc/hosts	To preserve hostnames on file.
/etc/fstab	To maintain existing mounts. Will not preserve mount points.
/etc/sysconfig/network	Network information.
/etc/sysconfig/network-scripts/ifcfg-*	Network device configuration.
/etc/resolv.conf	DNS configuration info.
/etc/nsswitch.conf	NIS/DNS configuration info.
/etc/ntp.conf /etc/ntp/step-tickers	NTP configuration. See ntpd(1).
/etc/rc.local /etc/rhosts	Startup info.
/etc/X11/xorg.conf	X11 server/device/screen configuration data.
/etc/modules.conf	For reference and comparison.
/etc/security/capability.conf	PAM configuration.
/etc/ssh/*	To preserve host keys.
/etc/inittab	For reference and comparison.
/etc/xinetd.d/	For reference and comparison. Capture any file customizations.
/var/spool/cron/	To preserve user crontab entries.
/sbin/systemctl -t service -a > <i>save_file</i>	For reference to configure new system.
/etc/*.conf	Customized configuration files.
/etc/sysconfig/*	Customized configuration files.
/etc/pam.d/*	Customized PAM files.
rpm files	Those installed after previous system installation that need to be moved forward to the new system. Use <code>/bin/rpm -qa --last more</code> to view.

7.1.2 File System Swap Size Guidelines

Table 7-2 supplies the recommended swap partition sizes for various sizes of main memory. The swap space allocations listed below should be adequate for all real-time systems.

Table 7-2 Swap Partition Size Guidelines

Main Memory Size (GB)	Recommended Swap Partition Size
0 - 3	2048 MiB
4 - 15	4096 MiB
16 - 63	8192 MiB
64 - 255	16 GiB
256 - 511	32 GiB
512 - 1024	64 GiB

7.1.3 How to Use Linux Rescue

An installation or upgrade may not boot if the following conditions exist:

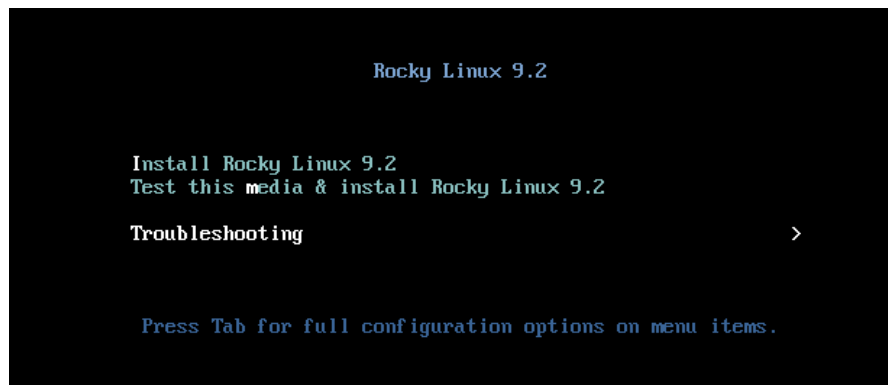
- the disk LABEL scheme is not correct
- there are mismatching LABEL or partition entries in `/etc/fstab` and/or `/etc/grub2.cfg` -> `/boot/grub2/grub.cfg`
`/etc/grub2-efi.cfg` -> `/boot/efi/EFI/rocky/grub.cfg`

This can happen when dealing with multiple disks and can be extremely confusing.

It is possible to recover from these situations by booting into a Linux rescue image via the *Rescue a Rocky Linux system* boot option on the Rocky 9.2 installation media.

If you cannot boot after the installation or upgrade, perform the following steps.

1. Boot a Rocky 9.2 installation disc.
2. Once the grub menu is displayed use the arrow keys to select **Troubleshooting** as shown in the following screen.



3. Press **Enter** and then using the arrow keys select **Rescue a Rocky Linux** system as shown in the following screen.

```

                                Troubleshooting

Install Rocky Linux 9.2 using text mode
Rescue a Rocky Linux system
Run a memory test

Boot from local drive

Return to main menu <

Press Tab for full configuration options on menu items.

If the system will not boot, this lets you access files
and edit config files to try to get it booting again.

```

4. Press **Enter** and the system will boot into rescue mode from the live Blu-ray Disc. Once fully booted the following screen will be displayed.

```

Starting installer, one moment...
anaconda 34.25.2.10-1.el9_2.rocky.0.3 for Rocky Linux 9.2 started.
 * installation log files are stored in /tmp during the installation
 * shell is available on TTY2
 * when reporting a bug add logs from /tmp as separate text/plain attachments
=====
Rescue

The rescue environment will now attempt to find your Linux installation and
mount it under the directory : /mnt/sysroot. You can then make any changes
required to your system. Choose '1' to proceed with this step.
You can choose to mount your file systems read-only instead of read-write by
choosing '2'.
If for some reason this process does not work choose '3' to skip directly to a
shell.

1) Continue
2) Read-only mount
3) Skip to shell
4) Quit (Reboot)

Please make a selection from the above: 1

```

5. Enter **1** to continue and then press **ENTER** to get the root shell as shown below.

```

=====
Rescue Shell

Your system has been mounted under /mnt/sysroot.

If you would like to make the root of your system the root of the active system,
run the command:

    chroot /mnt/sysroot

When finished, please exit from the shell and your system will reboot.

Please press ENTER to get a shell:
bash-5.1#

```

6. You can now examine the files under **/mnt/sysimage** to correct issues identified in error messages before the system failed to boot properly.

7. If you wish to transfer files or packages to the system over the network you can start networking via DHCP with the following commands.

Invoke the following command to find out if the network is enabled and the network device name.

```
ip addr show
```

If the network is down execute the following command to bring it up:

```
ip link set <network device name> up
```

8. After networking is enabled, you can also issue the following command to better simulate running commands on the actual system:

```
chroot /mnt/sysimage
```

At this point the system files on the hard drive appear in the usual locations in the file system, and you can run additional commands like **blscfg** in Rocky-based operating systems and **ccur-grub2** in Ubuntu, to change the default kernel to boot or modify kernel boot options. See the **blscfg(1)** and **ccur-grub2(1)** man page for more information.

7.1.4 Installing Remotely Over VNC

If during installation the GUI fails to start, it may be caused by graphics driver compatibility problems or with certain graphics cards and/or monitors not being probed properly. Adding the **nomodeset** boot parameter to the kernel may solve this problem. If it does not, we recommend installing remotely over VNC.

Virtual Network Computing (VNC) is a graphical desktop sharing system which uses the RFB protocol to remotely control another computer. It transmits the keyboard and mouse events from one computer to another, relaying the graphical screen updates in reverse direction, over a network.

You need to be able to establish a network connection between the system you are installing (the VNC server) and the system that will remotely display the installation GUI (the VNC client). Any linux system can be used as a VNC client. Install the *tigervnc* package if the command **vncviewer** does not exist.

You also need to modify boot parameters. The instructions for modifying the boot parameters vary depending on whether you are on a BIOS or a UEFI based system as follows:

- On BIOS-based systems, the preferred way is to press the **Tab key** and add custom boot options to the command line. Press **ENTER** to boot the modified option.
- On UEFI-based systems, press the **e** key and use the arrow keys to add custom boot options to the end of the `linuxefi` command line. When ready press **Ctrl+x** to boot the modified option.

The following example is executed on a BIOS-based system. Use the instructions above for adding boot parameters on a UEFI based system.

On the system you wish to install, start the Rocky installation. Using the arrow keys highlight the **Install Rocky Linux 9.2** menu option, then press the **Tab** key. You are then presented with the boot kernel line at the bottom of the screen. Add **inst.vnc** at the end of the line as shown below:

```

Rocky Linux 9.2

Install Rocky Linux 9.2
Test this media & install Rocky Linux 9.2

Troubleshooting >

> vmlinuz initrd=initrd.img inst.stage2=hd:LABEL=Rocky-9-2-x86_64-dvd quiet in
st.vnc_

```

NOTE

If the VNC service fails to start, it may be necessary to specify the `ip=xxx.xxx.xxx.xxx netmask=xxx.xxx.xxx.xxx` grub boot options to ensure proper NIC address configuration.

Optionally you can also add a VNC password by adding `inst.vncpassword=PASSWORD` to the boot line.

VNC is started and the connection information required by the VNC client will then be displayed as shown below:

```

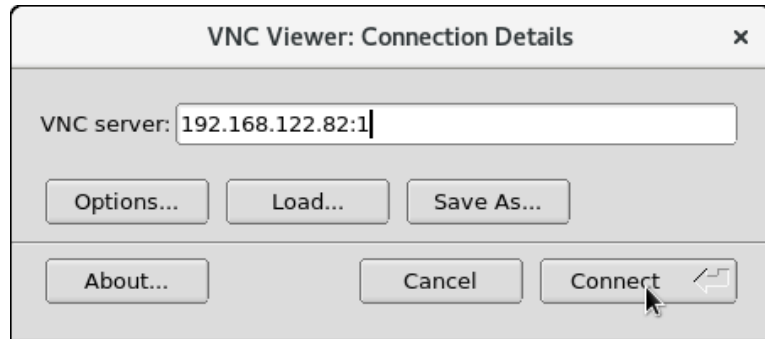
Starting installer, one moment...
anaconda 34.25.2.10-1.el9_2.rocky.0.3 for Rocky Linux 9.2 started.
* installation log files are stored in /tmp during the installation
* shell is available on TTY2
* when reporting a bug add logs from /tmp as separate text/plain attachments
15:11:35 Starting VNC...
15:11:38 The VNC server is now running.
15:11:38

WARNING!!! VNC server running with NO PASSWORD!
You can use the inst.vncpassword=PASSWORD boot option
if you would like to secure the server.

15:11:38 Please manually connect your vnc client to 192.168.122.82:1 to begin the install.
15:11:38 Attempting to start vncconfig

```

On the VNC client system run the `vncviewer` command and establish the VNC connection to your VNC server by entering the `IPaddress:screen` in the **VNC server:** box as shown below. In this example it is **192.168.122.82:1**.



Press **Connect** to connect with the VNC server and you should start to see the installation menus. Continue with the graphical installation process as described in section **5.1.1** starting with steps 5, beginning on page 13.

Once the installation is completed you can reboot the system and continue on the installed system's graphical console. If the system starts up in non-graphical mode, login and issue the command `systemctl set-default graphical.target` and reboot again to come up in graphical mode.

7.1.5 Configuring SELinux in enforcing mode

By default RedHawk is installed with SELinux disabled. To avoid problems when enabling SELinux, such as systems unable to boot, first boot in permissive mode to relabel the filesystems and then boot to enforcing mode, as follows:

1. Edit the `/etc/selinux/config` file and set:

```
SELINUX=permissive
```

2. Reboot
3. Edit the `/etc/selinux/config` file and set:

```
SELINUX=enforcing
```

4. Reboot
5. Verify that SELinux is enabled in enforcing mode by running:

```
sestatus
```

If you do not follow the instructions and find yourself unable to boot any kernel, a work-around is provided in the "Unable to Boot After Enabling SELinux" on page 56 in the Known Issues section of this document.

7.2 Considerations

7.2.1 Compiler Requirements

If you plan to build a kernel from source residing on your iHawk system on a different system, that system must be using **gcc-4.4.4** or later.

7.2.2 Hyper-thread Activation

Hyper-threading is configured by default in each of the standard RedHawk Linux kernels. It can be disabled on a per-CPU basis using the `cpu (1)` command. However, hyper-threading is also defined in the system BIOS. The setting in the BIOS will supersede any configuration of this feature in the kernel. Therefore, if hyper-threading is turned off in the BIOS, it will not be available on your system even if it is configured in the kernel.

If your system is not behaving as expected in regards to hyper-threading based on the kernel configuration, check the BIOS setting and modify it as needed. Refer to your hardware documentation to determine which BIOS setting is involved.

8.0. Known Issues

Special consideration should be given to the following areas:

Real-time Performance issues (Intel)

Starting with the 11th generation of Intel chips, Performance and Efficiency cores were introduced. If you are experiencing real-time performance issues, verify that your real-time application is running on a Performance and not on an Efficiency core.

Potential Real-Time impact of running Turbostat

Turbostat calculates average MHz on each CPU. This requires inter-processor interrupts to read two MSR registers from each CPU, even on shielded CPUs. This may have an effect on real-time performance.

Where is the debug kernel?

Pre-built debug kernel binaries are no longer provided with the releases. However, you can easily build one by using the `debug` kernel config file available in the kernel source tree (`/usr/src`). Note that debug kernels do not support NVIDIA graphics.

Extra step to enable/disable FIPS

To enable FIPS (Federal Information Processing Standards) on your system, run the following command:

```
/usr/bin/fips-mode-setup --enable
```

To disable FIPS on your system, run:

```
/usr/bin/fips-mode-setup --disable
```

Note that you have to reboot the system for the change (enable or disable) to take effect. After the reboot, you can look at the `/proc/sys/crypto/fips_enabled` file to confirm: a value of 0 means FIPS is disabled, a value of 1 means FIPS is enabled.

Package required to make a RedHawk custom kernel

Rocky 9.2 and similar distributions require the package `qt5-qtbase-devel` package in order to run Xconfig when creating a RedHawk custom kernel. This package is not included in the RedHawk installation and must be installed prior to running `ccur-config(1)`. Ubuntu has different package requirements which are listed in the section “Building and Installing Custom Kernels” in Appendix A.

Default Ubuntu 22.04 NTP server is inaccurate

The default NTP server for Ubuntu 22.04 is `systemd`'s `timesyncd`. This server is inaccurate and may cause the system time to be continuously offset by multiple milliseconds. Concurrent recommends that customers desiring more accurate system time switch to using a different NTP server like `chronyd(8)`, or purchase a Concurrent RCIM card with the GPS option.

Various warnings during crash dump creation

During the creation of crash dump files on RedHawk 9.2+ systems, various warnings may be produced that do not impact the validity of the crash dump file. The warnings vary depending on the base distribution of the RedHawk installation. For example, the following warnings may be observed:

With RedHawk on Rocky systems:

```
Missing the log_buf symbol
saving vmcore-dmesg.txt failed
```

With RedHawk on Ubuntu systems:

```
dump_dmesg: Can't find some symbols for log_buf.
The kernel version is not supported.
kdump-tools: The makedumpfile operation may be
incomplete.
kdump-tools: makedumpfile Failed.
```

While these warnings do indicate that the vmcore-dmesg.txt file has not been successfully created, the vmcore file is still saved correctly and users can view the dmesg messages within crash dumps by using the crash utility.

AMD Core Performance Boost feature not working

AMD processors do not provide a mechanism to determine if Core Performance Boost is enabled in the system's firmware settings while RedHawk is running. Due to this limitation, the **turbo** service will always appear to start successfully with AMD processors, even if the processors do not support the Core Performance Boost feature or the feature is disabled in the system's firmware settings. Verify in the firmware that the processor supports the Core Performance Boost feature and that it is enabled. See the section "Configuration" in Appendix C for more information.

EFI Runtime Services Disabled By Default

The EFI runtime services have been observed to interfere with real-time performance therefore, the services will be disabled by default. With the services disabled, the **mokutil** command cannot be used to query the secure boot state, import certificates or update the UEFI firmware.

To see that Secure Boot has been enabled, you can run **dmesg | grep -i secure**. If real-time performance is not a concern, set the kernel parameter *efi=runtime* to enable the services. Note that the EFI runtime services remain enabled in the base distribution kernels (for example, the Rocky kernel).

Problems executing programs that use RedHawk system calls

The RedHawk system call IDs have been changed to start at 1900. Verify that you are using the new system call IDs as shown in the table below.

System call	New ID	Old ID
fbsched	1900	420
sched_setscheduler_head	1901	435
resched_cntl	1902	421
postwait	1903	422
cpustat	1904	424
cpucntl	1905	444
procstat	1906	452
local_irq	1907	434
mlockall_pid	1908	437
munlockall_pid	1909	454
watchpoint_ctl	1910	510

BIOS “Console Redirection”

The “Console Redirection” BIOS feature, when enabled, has been observed to interfere with the proper operation of the integrated VGA video and the Xorg X server with some iHawk platforms, such as the Dell PowerEdge™ 6650 (iHawk Model HQ665).

NMI Button

Using the NMI button on the processor enters **kdb** on the console when configured. It cannot be used, however, to step repeatedly through an error condition.

PAM Capabilities

Using Kerberos telnet services with PAM is not recommended. If `krb5-telnet` is on and Kerberos is not properly configured, the following error will occur upon logging in via telnet:

```
login: Cannot resolve network address for KDC in requested realm
while getting initial credentials
```

The `krb5-telnet xinetd` service should be disabled:

```
systemctl disable krb5-telnet
```

sadc(8) Issue

When a system configuration change is made that affects the number of CPUs (for example when booting with a uniprocessor kernel or changing hyper-threading configuration), the **sadc (8)** (sar data collector) program cannot successfully write data in the daily data file `/var/log/sa/sa##` (## is the day of the month). This results in **crond** sending an email every ten minutes to `root@localhost` with the following message:

```
Cannot append data to that file
```

To eliminate the email, remove or move the `/var/log/sa/sa??` file for the current date.

irqbalance

The **irqbalance** feature is disabled on RedHawk Linux. This Linux feature is meant to distribute interrupts equally across CPUs. It does not honor the IRQ affinity masks set up in `/proc/irq/irq#/smp_affinity` and therefore will cause interrupts to be routed to shielded CPUs.

This feature can be enabled/disabled at boot time with:

```
systemctl {enable|disable} irqbalance
```

as well as started/stopped while the system is running with:

```
systemctl {start|stop} irqbalance
```

Boot Problems with Monitor-embedded USB Hub and Flash Memory Reader

An iHawk system with a USB hub embedded within its attached monitor that includes a flash memory reader will fail to boot if the flash media is not installed. Once the flash media is installed, the system will boot.

Compatibility Issues for Ada programs

RedHawk 9.2 is based on Rocky Enterprise Linux 9.2. Binary and source compatibility issues exist for MAXAda programs between Rocky 3.0 and Rocky 9.2.

Please see the Compatibility section in the *MAXAda for RedHawk Linux Version 3.5.1 Release Notes*, publication number 0898357-3.5.1, for details.

Inactive Virtual Terminal State After Changing Run Levels

Note that on some systems, changing from run-level 5 to run-level 3 may place the VGA console onto an inactive virtual terminal (e.g., /dev/tty8). If this happens, switching to an active virtual terminal will allow normal system operation to continue; press **Ctrl-Alt-F1** to switch to virtual terminal 1.

Excessive ksoftirqd Runs Affecting Determinism

In more recent kernel.org kernels the IP route cache table size was changed from a fixed size of 4K entries to a dynamic size based on the amount of available memory. With 4 GB of memory, this table is sized at 128K entries. Every 10 minutes, a flush of that table is initiated. The approximate time to flush 4K entries is 1.5ms every 10 minutes. If the table is sized at 128K entries, this time can be in the area of 10ms to 15ms every 10 minutes. This can be problematic if network determinism is an issue, especially in a single CPU system.

If this is an issue, the IP route cache table can be set to a fixed size using the grub command `rhash_entries=n`, where *n* is the number of table entries; e.g., `rhash_entries=4096` for 4K entries.

Pings to Multicast Addresses Disabled by Default

In more recent kernel.org kernels the default setting for the `sysctl` flag that allows ping to a multicast address has changed. Previously it was set to enable broadcast and multicast ICMP echo (pings) and timestamp requests. Now this functionality is disabled.

There are two methods in which to change this flag if you need to ping multicast addresses:

- **The `sysctl (8)` utility** changes the value in a running kernel and takes effect immediately; no rebuild or reboot is needed:

```
# sysctl -w net.ipv4.icmp_echo_ignore_broadcasts=0
```

- To initialize the parameter to the desired value on every reboot, add the following command and `sysctl` parameter to `/etc/sysctl.conf`:

```
# Controls broadcast and multicast ICMP echo and timestamp requests
net.ipv4.icmp_echo_ignore_broadcasts = 0
```

USB Ports Non-functional on Supermicro Boards

Some Supermicro boards (Model X6DA8-G2, CCUR part number 820-2010483-913) may have non-functional USB ports accompanied by the following message:

```
USB 1-1: new high speed USB device using ehci_hsd and address 2
USB 1-1: device descriptor read/64, error -110
```

This can be corrected by changing the BIOS setting for both SATA [0/1] IDE Interface and SCSI interface controllers to “ENABLED”.

Configure Quad Port Ethernet

If your system has a quad port Ethernet, you may need to edit `/etc/modprobe.conf` and configure the ports to the appropriate driver. The example below assigns the quad port to eth0 through eth3 and uses the Intel e1000 module (Gigabit Network driver). For readability, convention has these lines inserted at the top of `/etc/modprobe.conf`.

```
alias eth0 e1000
alias eth1 e1000
```

```
alias eth2 e1000
alias eth3 e1000
```

NFS v4 Intermittent Connectivity

On rare occasions, attempts to use NFS version 4 protocol to connect to an older NFS server may be denied intermittently, with the connection also subsequently failing to negotiate an NFS version 3 protocol connection. If your system experiences this behavior with any NFS servers, adding a `vers=3` mount option to the corresponding entry in `/etc/fstab` will allow the NFS filesystem to be mounted properly.

Unable to Boot After Enabling SELinux

If you experience problems logging in or booting a RedHawk system after enabling SELinux, it is most likely because some filesystem needs to be relabeled to be compatible with SELinux. To achieve this you must first boot in permissive mode before attempting to boot in enforcing mode.

If you have made the change to run in enforcing mode before running in permissive mode and none of your kernels now boot, you must stop the boot at the grub screen, choose the kernel with SELinux enabled and edit the kernel boot command, appending the following to that line:

```
enforcing=0
```

Then continue to boot the system. The system will boot in permissive mode, file systems will be relabeled as required and the system will then reboot. After the system successfully boots, you can verify that you are running in enforcing mode by executing the `sestatus` command. Instructions on how to enable SELinux in enforcing mode are in the section "Configuring SELinux in enforcing mode" on page 50.

9.0. Software Updates and Support

9.1 Direct Software Support

Software support is available from a central source. If you need assistance or information about your system, please contact the Concurrent Real-Time Software Support Center at our toll free number 1-800-245-6453. For calls outside the continental United States, the number is 1-954-283-1822. The Software Support Center operates Monday through Friday from 8 a.m. to 5 p.m., Eastern Standard Time.

Calling the Software Support Center gives you immediate access to a broad range of skilled personnel and guarantees you a prompt response from the person most qualified to assist you. If you have a question requiring on-site assistance or consultation, the Software Support Center staff will arrange for a field analyst to return your call and schedule a visit.

You may also submit a request for assistance at any time by using the Concurrent Real-Time, Inc. web site at <https://concurrent-rt.com/support>

9.2 Software Updates

Updates to Concurrent Real-Time RedHawk software can be obtained via Concurrent Real-Time's Software Portal. There are three ways of installing product updates:

- Using the Network Update Utility (NUU) installed on your RedHawk system
- Manual installation after browsing and downloading individual RPMs from Concurrent Real-Time's software repositories
- Building a customized Update disc using Concurrent Real-Time's web site for immediate download

9.2.1 Updating via NUU

NUU supports installation and updating of software products from Concurrent Real-Time software repositories over a network. NUU utilizes DNF and the RPM subsystems to install and update software.

NUU is installed automatically with RedHawk, however, you should configure it to include all of the Concurrent Real-Time software products installed on your system.

Clicking on the "Updates (NUU)" icon on your desktop launches NUU to check to see if Concurrent Real-Time updates are available for your system.

NOTE

It is recommended that all Rocky repositories should be disabled when checking for Concurrent Real-Time updates. In NUU, select the **Repositories -> Edit Configuration** menu item and ensure that the *base*, *updates* and *extras* repositories are disabled.

Instructions for configuring NUU can be found in the QuickStart.pdf document available when you click on the NUU link on the redhawk.concurrent-rt.com website or directly via this link <http://redhawk.concurrent-rt.com/network/QuickStart.pdf>

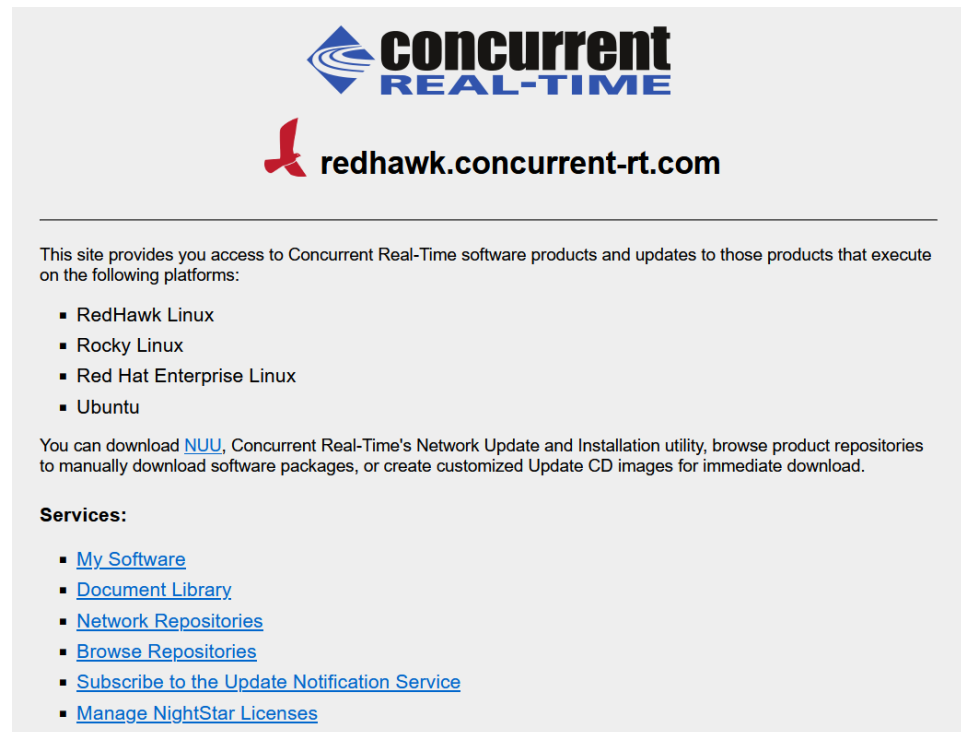
The first time you invoke NUU you will need to specify your redhawk.concurrent-rt.com Login ID and Password that were provided in the shipping documents accompanying your system. If you require assistance, refer to “Direct Software Support” on page 57.

Before using NUU to install any updated software modules, check for NUU updates separately. Apply any NUU updates and then restart NUU before applying any other updates.

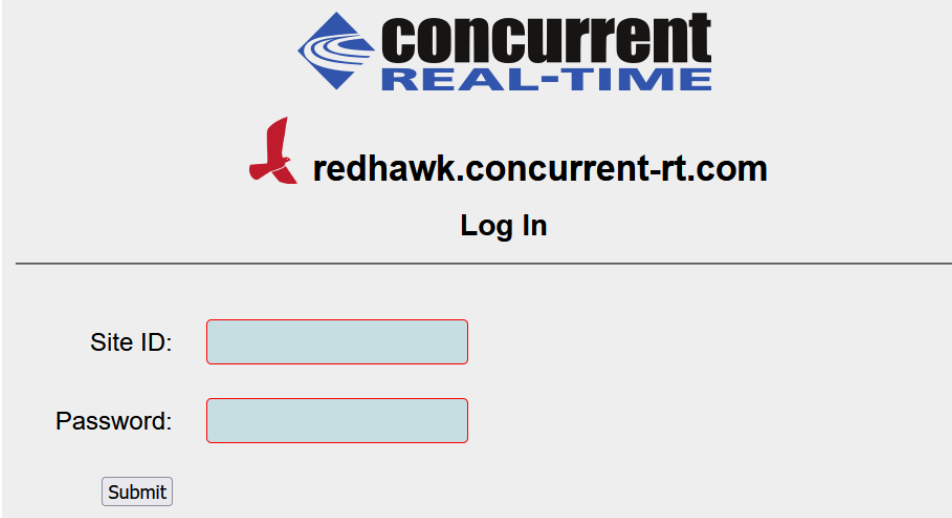
9.2.2 Installing Manually Downloaded RPMs

You can browse Concurrent Real-Time’s software repositories to locate updated RPMs and download them for manual installation.

Access the RedHawk Updates web site (<http://redhawk.concurrent-rt.com/>) by clicking on the “Concurrent Real-Time Software Portal” icon on the desktop. Below is the top half of the screen displayed when you access this web site.







Clicking on the Browse Repositories link takes you to an authentication page.



Enter your redhawk.concurrent-rt.com Login ID and Password and click the **Browse** button.

Select the products of interest and architecture from the following pages to see the list of RPMs in the product software repository.

Index of /swdist/repos/RedHawk/9.2

Name	Last modified	Size	Description
 Parent Directory/		-	
 aarch64/	19-Jun-2023 10:23	-	
 i386/	19-Jun-2023 10:23	-	
 x86_64/	19-Jun-2023 10:23	-	

To locate the latest RPMs in the repository, click on the **Last modified** column header to sort by date. You may need to click twice to set the sort order to newest-to-oldest.

After locating the RPMs of interest and downloading them to your system, you can manually install them.

To install newly downloaded packages, follow these steps:

1. Log in as root and take the system down to single-user mode:
 - a. Right click on the desktop and select **Open Terminal**.
 - b. At the system prompt, type `init 1`.
2. Change directory to the location of the updates and issue the following command:

```
rpm -Uvh * .rpm
```

The time it takes to install will vary depending on the number of updates being installed.

3. When complete, exit single-user mode (Ctrl-D).

NOTE

If you have installed an update containing new RedHawk kernels on a system that has post-installation loadable modules present, those modules must be recompiled for the new kernel; for example, an NVIDIA driver that is a later version than the one included with RedHawk or any third party package that uses loadable modules.

9.2.3 Customized Update Discs

You can use Concurrent Real-Time's Software Portal to create a customized Update Disc for your system which you can then download and burn onto physical media, or simply mount as an ISO9660 image.

Update discs have customized copies of product software repositories and a simple graphical interface for selecting packages for update and installation. These discs use NUU (described above) to talk to the disc to obtain packages -- no network access is required during installation via Update Discs.

Access the RedHawk Updates web site (<http://redhawk.concurrent-rt.com>) by clicking on the "Concurrent Real-Time Software Portal" icon on the desktop, then click on **Create Update Images**.

You will need to enter your redhawk.concurrent-rt.com Login ID and Password and then you can select the products to update. A disc image is built as part of the web session. At the end of the session, you can immediately download it for subsequent installation.

9.3 Documentation Updates

For the latest documents, including updated Release Notes and User Guides, go to Concurrent Real-Time's documentation web site at <http://redhawk.concurrent-rt.com/docs>.

A

Ubuntu Support

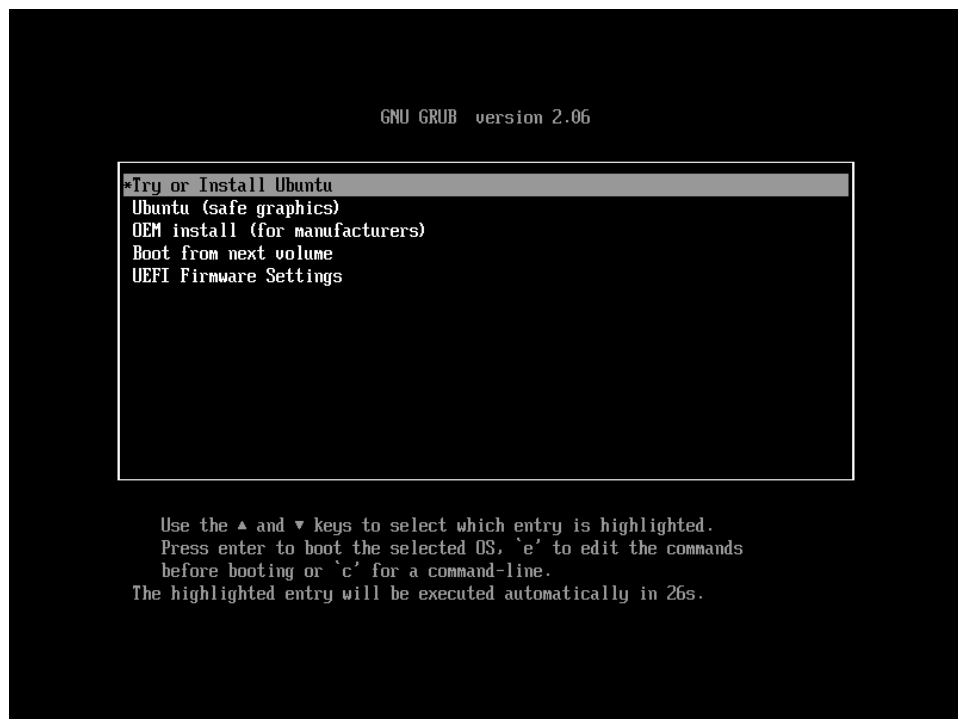
This appendix contains additional information on using the RedHawk 9.2 release with the open source Ubuntu Linux distribution.

Overview

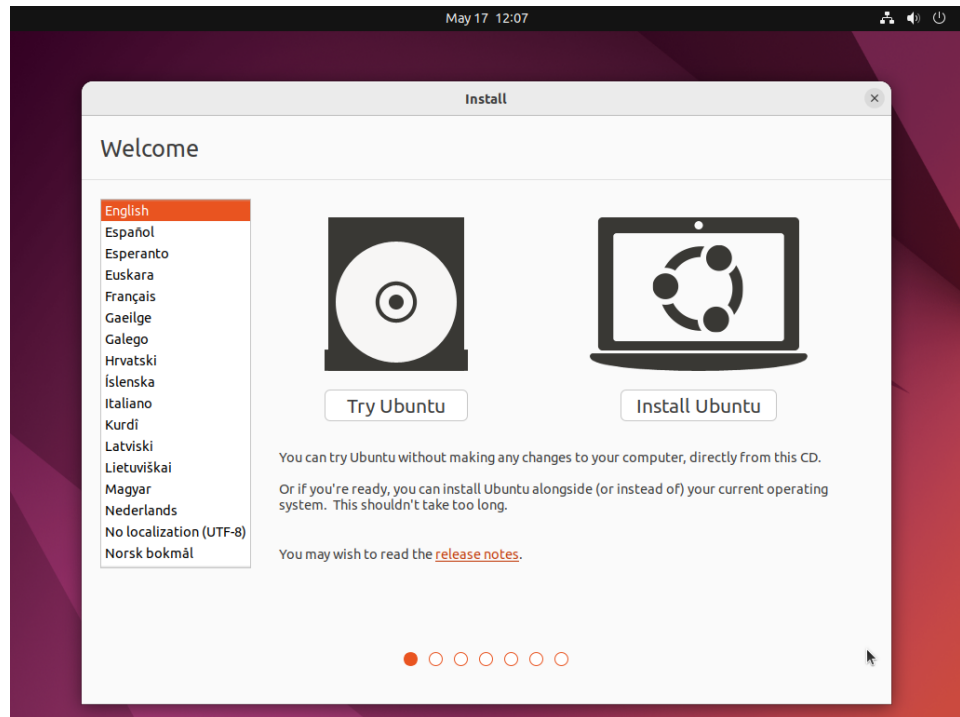
RedHawk Version 9.2 is compatible with the Ubuntu 22.04 LTS (Long Term Support) distribution. This appendix provides instructions for installing RedHawk 9.2 onto a brand new Ubuntu 22.04 installation. Installing RedHawk 9.2 onto an existing Ubuntu 22.04 system should also work correctly, however that is beyond the scope of this document.

Installing Ubuntu

First, download the latest Ubuntu 22.04 LTS Desktop ISO from the Ubuntu.com website and burn it onto a DVD and boot the DVD in your target system. The **GNU GRUB** page will be displayed as below:



Press Enter on the highlighted **Try or Install Ubuntu** to proceed. First menu is the **Welcome** menu as shown below.



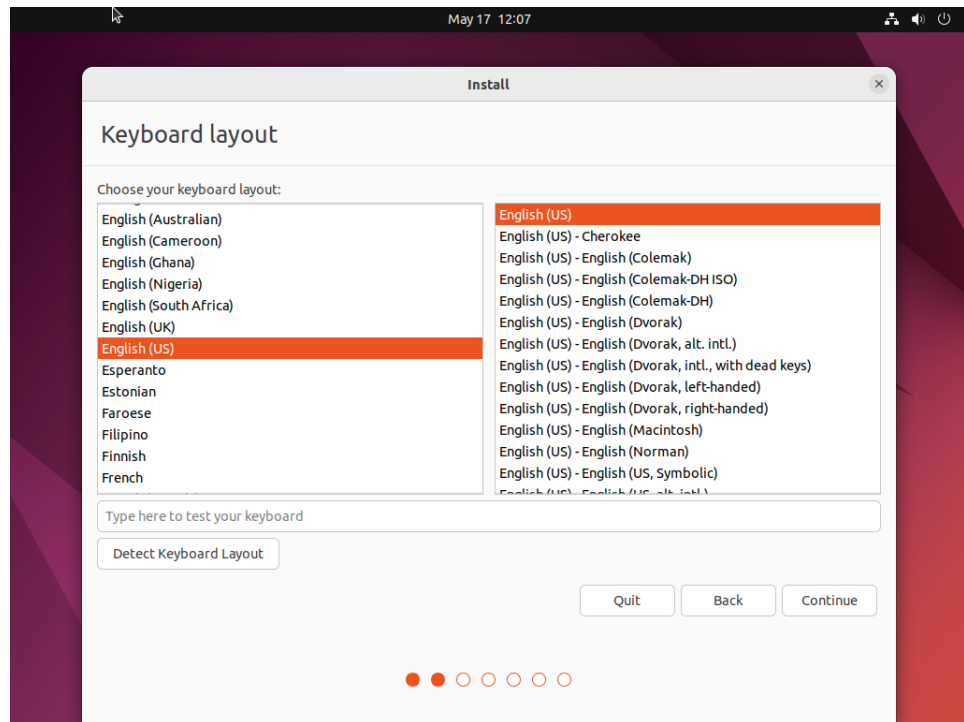
Press the **Install Ubuntu** button to proceed with the installation.

NOTE

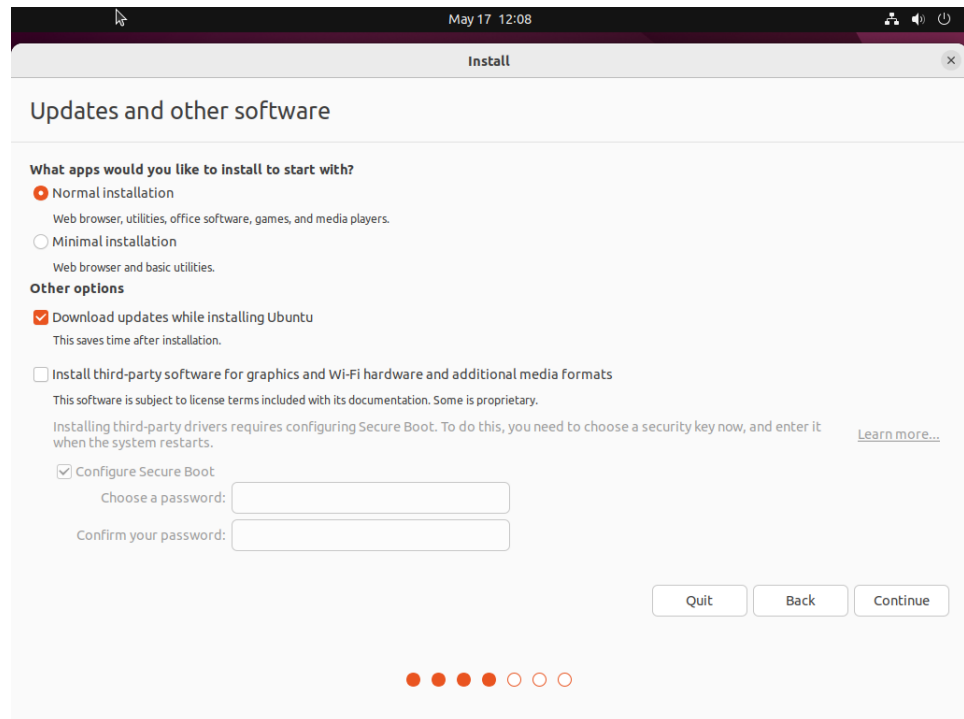
If instead of the **Welcome** page you see a persisting dark screen, it may be that the installer system is incompatible with the graphics card on the target system.

In that case, you may still be able to install in a safe graphics mode. Start over and choose the **Ubuntu (safe graphics)** menu item from the **GNU GRUB** menu and follow the installation instructions in this chapter to complete the installation.

Next, select the desired layout in the **Keyboard layout** page shown below:

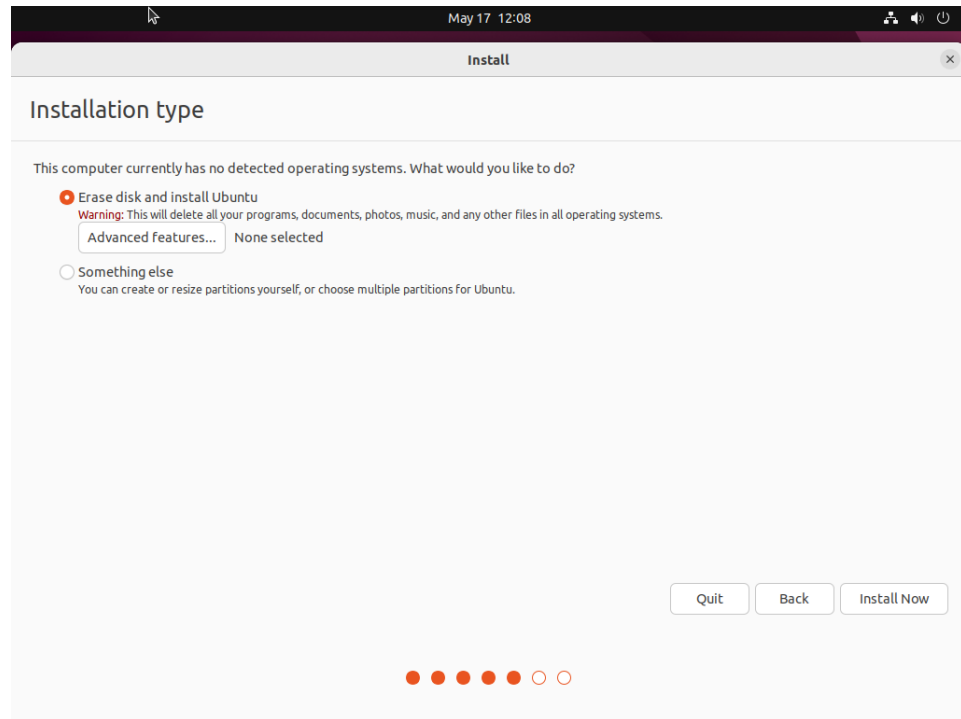


Press **Continue** and the **Updates and other software** page should be displayed as follows:



Check the boxes for **Normal installation** and **Download updates while installing Ubuntu**. The download option will download, but not install, updates.

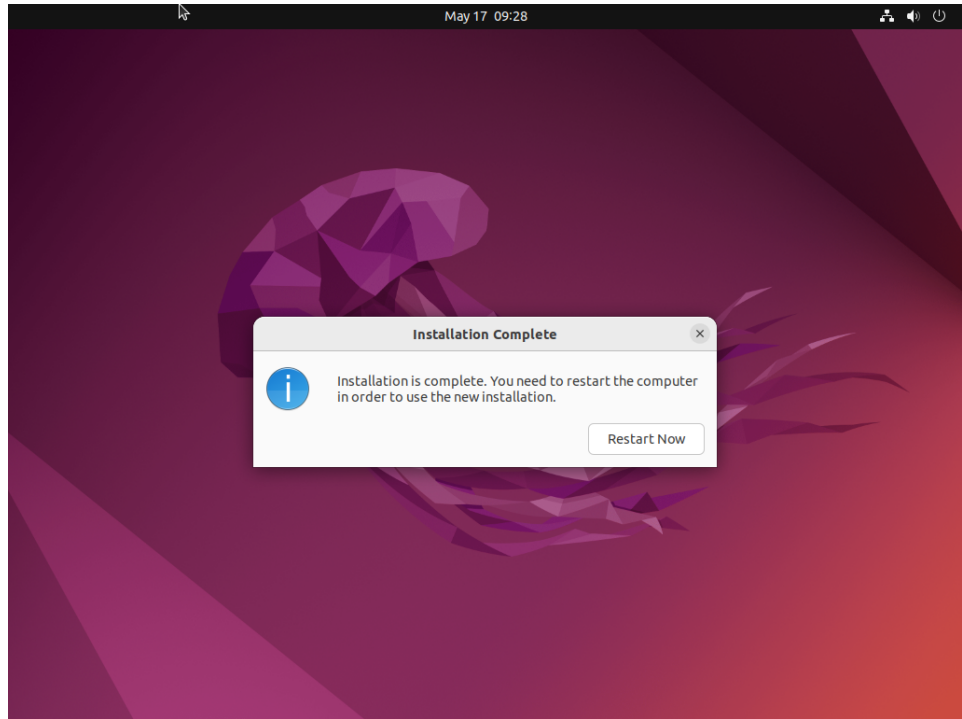
Press **Continue** and the **Installation type** screen should be displayed as follows:



Choose **Erase disk and install Ubuntu** and then press **Install Now** to continue. You will then be prompted to confirm the action. Press **Continue** to confirm and continue.

In the next few pages you will be prompted to configure various settings including **Timezone, Username, System Name and Password**. After configuring these settings, press **Continue** to continue with the installation.

Depending on system and network speed, the installation can take up to 60 minutes to complete; once the installation has finished, a similar message will be displayed.



Press **Restart Now** to reboot the newly installed system.

Updating Ubuntu Software

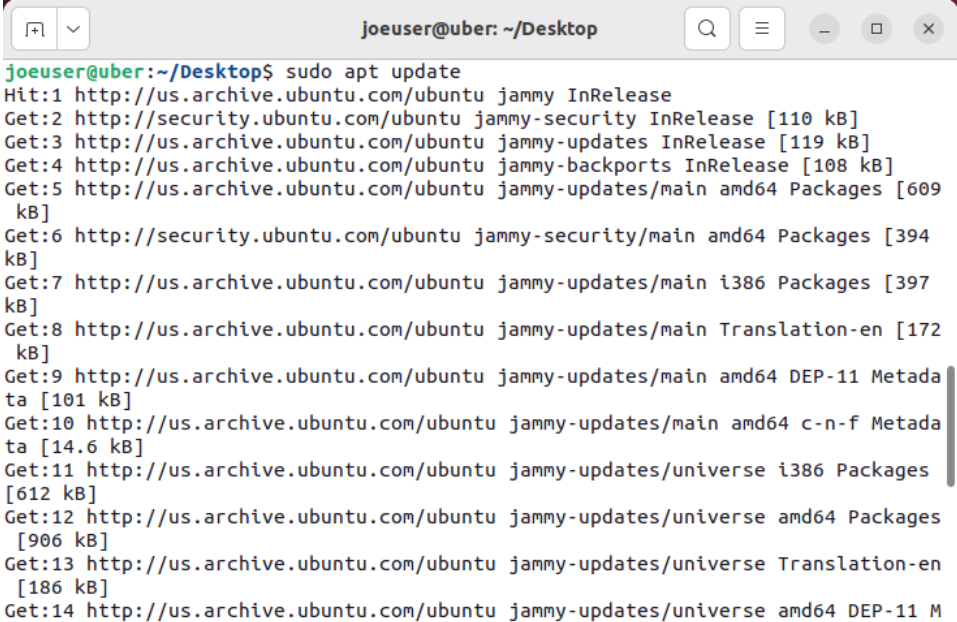
While updates were downloaded on the system during the install, the updates were not applied. Follow the instructions below to update the system now.

Once the system has booted to a graphical login screen, log into the system and bring up a terminal window.

Execute the following command to update the cached list of available packages and their versions.

```
sudo apt update
```

The screen images below shows an example output from the command.



```

joeuser@uber: ~/Desktop
joeuser@uber:~/Desktop$ sudo apt update
Hit:1 http://us.archive.ubuntu.com/ubuntu jammy InRelease
Get:2 http://security.ubuntu.com/ubuntu jammy-security InRelease [110 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu jammy-updates InRelease [119 kB]
Get:4 http://us.archive.ubuntu.com/ubuntu jammy-backports InRelease [108 kB]
Get:5 http://us.archive.ubuntu.com/ubuntu jammy-updates/main amd64 Packages [609
  kB]
Get:6 http://security.ubuntu.com/ubuntu jammy-security/main amd64 Packages [394
  kB]
Get:7 http://us.archive.ubuntu.com/ubuntu jammy-updates/main i386 Packages [397
  kB]
Get:8 http://us.archive.ubuntu.com/ubuntu jammy-updates/main Translation-en [172
  kB]
Get:9 http://us.archive.ubuntu.com/ubuntu jammy-updates/main amd64 DEP-11 Metada
  ta [101 kB]
Get:10 http://us.archive.ubuntu.com/ubuntu jammy-updates/main amd64 c-n-f Metada
  ta [14.6 kB]
Get:11 http://us.archive.ubuntu.com/ubuntu jammy-updates/universe i386 Packages
  [612 kB]
Get:12 http://us.archive.ubuntu.com/ubuntu jammy-updates/universe amd64 Packages
  [906 kB]
Get:13 http://us.archive.ubuntu.com/ubuntu jammy-updates/universe Translation-en
  [186 kB]
Get:14 http://us.archive.ubuntu.com/ubuntu jammy-updates/universe amd64 DEP-11 M

```



```

joeuser@uber: ~/Desktop
Get:15 http://security.ubuntu.com/ubuntu jammy-security/main i386 Packages [216
  kB]
Get:16 http://security.ubuntu.com/ubuntu jammy-security/main amd64 DEP-11 Metada
  ta [41.6 kB]
Get:17 http://security.ubuntu.com/ubuntu jammy-security/main amd64 c-n-f Metadat
  a [9,884 B]
Get:18 http://security.ubuntu.com/ubuntu jammy-security/universe i386 Packages [
  529 kB]
Get:19 http://us.archive.ubuntu.com/ubuntu jammy-updates/multiverse amd64 DEP-11
  Metadata [940 B]
Get:20 http://us.archive.ubuntu.com/ubuntu jammy-backports/main amd64 DEP-11 Me
  tadata [8,004 B]
Get:21 http://us.archive.ubuntu.com/ubuntu jammy-backports/universe amd64 DEP-11
  Metadata [16.9 kB]
Get:22 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 Packages
  [727 kB]
Get:23 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 DEP-11 Me
  tadata [18.5 kB]
Fetched 5,564 kB in 2s (2,817 kB/s)
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
172 packages can be upgraded. Run 'apt list --upgradable' to see them.
joeuser@uber:~/Desktop$

```

To install new packages and newer versions of packages, issue the following command:

```
sudo apt upgrade
```

```

joeuser@uber: ~/Desktop
joeuser@uber:~/Desktop$ sudo apt upgrade
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
Calculating upgrade... Done
The following packages have been kept back:
 dpkg libegl-mesa0 libgbm1 libgl1-mesa-dri libglapi-mesa libglx-mesa0
 libxatracker2 mesa-vulkan-drivers
The following packages will be upgraded:
 alsacm-conf apparmor apport apport-gtk apt apt-utils bind9-dnswriter
 bind9-host bind9-libs cpp-11 cups-browsed cups-filters
 cups-filters-core-drivers distro-info-data dnsmasq-base evince evince-common
 fonts-opensymbol gcc-11-base gdm3 ghostscript ghostscript-x gir1.2-gdm-1.0
 gir1.2-javascriptcoregtk-4.0 gir1.2-pango-1.0 gir1.2-webkit2-4.0
 gnome-settings-daemon gnome-settings-daemon-common im-config intel-microcode
 ipp-usb isc-dhcp-client isc-dhcp-common libapparmor1 libapt-pkg6.0
 libcupsfilters1 libcurl3-gnutls libcurl4 libevdocument3-4 libevview3-3
 libfontembed1 libfprint-2-2 libfreetype6 libgdm1 libgl2.0-0 libgl2.0-bin
 libgl2.0-data libgnutls30 libgs9 libgs9-common libgssapi-krb5-2
 libjavascriptcoregtk-4.0-18 libk5crypto3 libkrb5-3 libkrb5support0
 libldap-2.5-0 libldap-common libldb2 libllvm15 liblouis-data liblouis20
 libmbim-glib4 libmbim-proxy libmm-glib0 libncurses6 libncursesw6 libnetplan0
 libnss3 libpango-1.0-0 libpangocairo-1.0-0 libpangoft2-1.0-0
 libpangoxft-1.0-0 libprotobuf23 libpulse-mainloop-glib0 libpulse0

```

You will be presented with information about the pending upgrade and then be prompted to continue:

```

joeuser@uber: ~/Desktop
libreoffice-common libreoffice-core libreoffice-draw libreoffice-gnome
libreoffice-gtk3 libreoffice-impress libreoffice-math libreoffice-ogltrans
libreoffice-pdfimport libreoffice-style-breeze libreoffice-style-colibre
libreoffice-style-elementary libreoffice-style-yaru libreoffice-writer
libsasl2-2 libsasl2-modules libsasl2-modules-db libsasl2-modules-gssapi-mit
libsmclient libsnmp-base libsnmp40 libssl3 libtiff5 libtinfo6 libuno-cppu3
libuno-cppuhelpergcc3-3 libuno-purpenvhelpergcc3-3 libuno-sal3
libuno-salhelpergcc3-3 libwbclient0 libwebkit2gtk-4.0-37 libwebp7
libwebpdemux2 libwebpmux3 libxml2 linux-firmware modemmanager ncurses-base
ncurses-bin netplan.io openssl printer-driver-foo2zjs
printer-driver-foo2zjs-common printer-driver-splix pulseaudio
pulseaudio-module-bluetooth pulseaudio-utils python3-apport python3-ldb
python3-louis python3-macaroonbakery python3-problem-report python3-protobuf
python3-software-properties python3-tz python3-uno python3.10
python3.10-minimal rsync samba-libs software-properties-common
software-properties-gtk sudo systemd-hwe-hwdb tar tcpdump thermald tzdata
ubuntu-advantage-tools uno-libs-private update-notifier
update-notifier-common ure vim-common vim-tiny xserver-common xserver-xephyr
xserver-xorg-core xserver-xorg-legacy xwayland xxd
164 upgraded, 0 newly installed, 0 to remove and 8 not upgraded.
60 standard LTS security updates
Need to get 252 MB/482 MB of archives.
After this operation, 34.8 MB of additional disk space will be used.
Do you want to continue? [Y/n] y

```

When the upgrade completes, issue the reboot command to reboot the system:

```
sudo reboot
```

Installing RedHawk Linux

Once the system has booted to a graphical login screen, log into the system. Insert the RedHawk OS Installation DVD into the system's optical media drive and close any file-browser window that opens when the DVD is inserted. Then open a terminal window, and cd to the mounted directory of the DVD.

NOTE

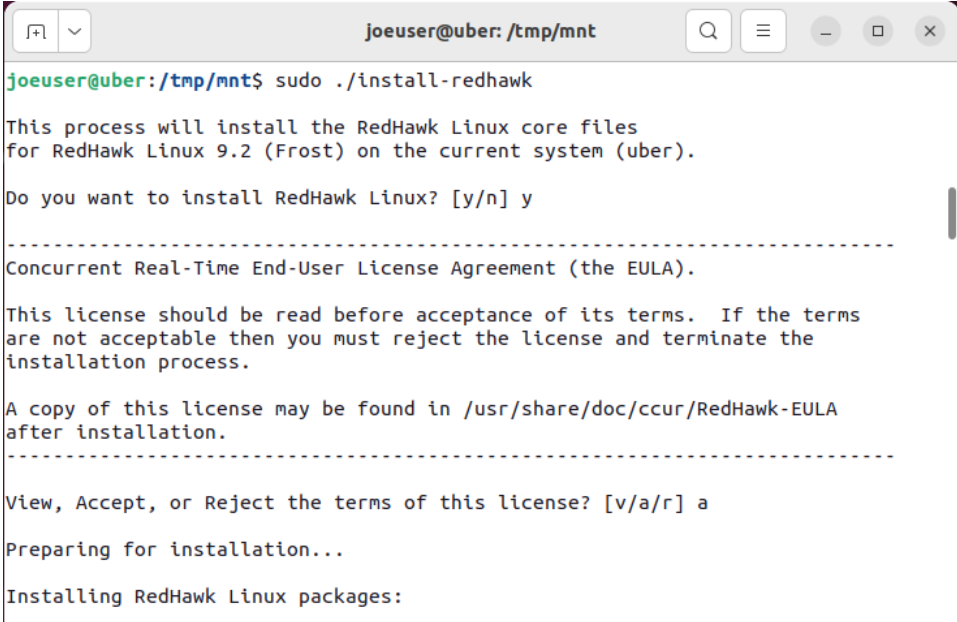
If an issue is encountered when installing from DVD, execute the following command after inserting the DVD.

```
sudo setfacl -m g::5,o::5 /media/*
```

Execute the following commands to install RedHawk Linux, substituting the actual mount point used for your optical media device.

```
cd /path-to-actual-mount-point
sudo ./install-redhawk
```

The installation script will prompt you to accept or reject the End User License Agreement. You can view the agreement by entering “v” at the prompt.



```
joedriver@uber: /tmp/mnt
joedriver@uber: /tmp/mnt$ sudo ./install-redhawk
This process will install the RedHawk Linux core files
for RedHawk Linux 9.2 (Frost) on the current system (uber).
Do you want to install RedHawk Linux? [y/n] y
-----
Concurrent Real-Time End-User License Agreement (the EULA).
This license should be read before acceptance of its terms. If the terms
are not acceptable then you must reject the license and terminate the
installation process.
A copy of this license may be found in /usr/share/doc/ccur/RedHawk-EULA
after installation.
-----
View, Accept, or Reject the terms of this license? [v/a/r] a
Preparing for installation...
Installing RedHawk Linux packages:
```

While the messages displayed during RedHawk installation appear to indicate that package *downloading* is occurring, no actual network access is performed when using the RedHawk DVD.

NOTE

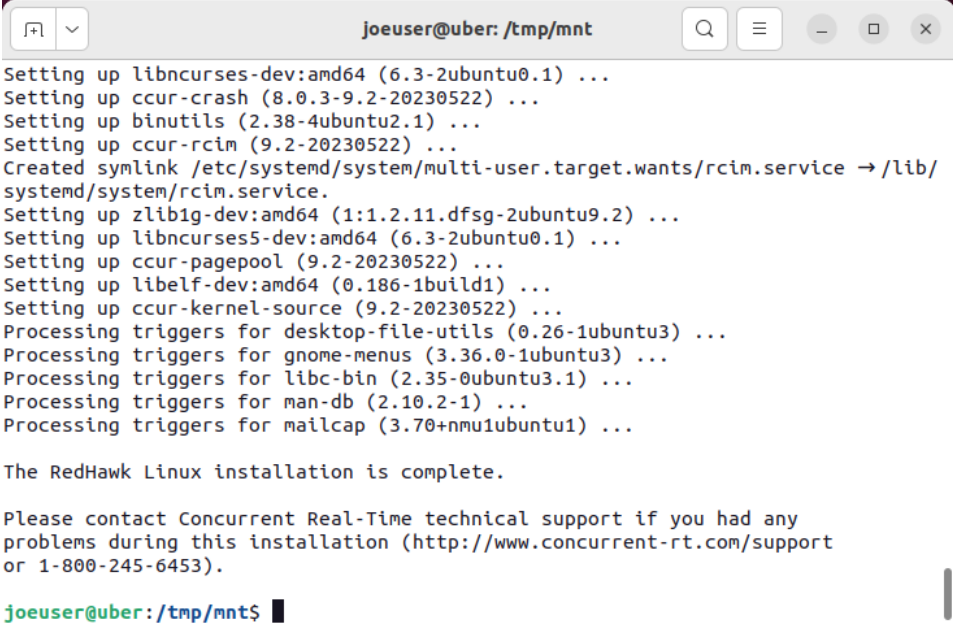
For each RedHawk kernel that is installed, the following warning is printed. The warning can be safely ignored:

```
Warning: os-prober will not be executed to
detect other bootable partitions. Systems on
them will not be added to the GRUB boot
configuration. Check GRUB_DISABLE_OS_PROBER
documentation entry.
```

NOTE

It is normal for the installation script to appear to be stalled near the end of installation. It is performing several background operations that are required and the script must not be interrupted.

Messages similar to the ones below will be displayed once all RedHawk package installation has completed successfully.



```

Setting up libncurses-dev:amd64 (6.3-2ubuntu0.1) ...
Setting up ccur-crash (8.0.3-9.2-20230522) ...
Setting up binutils (2.38-4ubuntu2.1) ...
Setting up ccur-rcim (9.2-20230522) ...
Created symlink /etc/systemd/system/multi-user.target.wants/rcim.service → /lib/
systemd/system/rcim.service.
Setting up zlibc-dev:amd64 (1:1.2.11.dfsg-2ubuntu9.2) ...
Setting up libncurses5-dev:amd64 (6.3-2ubuntu0.1) ...
Setting up ccur-pagepool (9.2-20230522) ...
Setting up libelf-dev:amd64 (0.186-1build1) ...
Setting up ccur-kernel-source (9.2-20230522) ...
Processing triggers for desktop-file-utils (0.26-1ubuntu3) ...
Processing triggers for gnome-menus (3.36.0-1ubuntu3) ...
Processing triggers for libc-bin (2.35-0ubuntu3.1) ...
Processing triggers for man-db (2.10.2-1) ...
Processing triggers for mailcap (3.70+nmu1ubuntu1) ...

The RedHawk Linux installation is complete.

Please contact Concurrent Real-Time technical support if you had any
problems during this installation (http://www.concurrent-rt.com/support
or 1-800-245-6453).

joeuser@uber: /tmp/mnt$ █

```

Eject and remove the disc from the drive and reboot the system choosing a newly installed RedHawk kernel and verify that the system boots up to the graphical login.

At this point you have completed the basic RedHawk Linux installation. If you wish to install additional RedHawk software, refer to the following sections in the main chapter of the Release Notes:

“Installing the Frequency-Based Scheduler (FBS)” on page 31

“Installing Additional RedHawk Products” on page 33

Updating RedHawk Software

NOTE

The latest and most up-to-date instructions for installing software via Concurrent's network package repositories can always be found on the <http://redhawk.concurrent-rt.com/network> web page.

Perform the following steps to allow the Ubuntu package management software to access Concurrent Real-Time's Debian repositories.

1. Obtain Concurrent Real-Time's public key by issuing the following command:

```
sudo wget http://redhawk.concurrent-rt.com/ \
network/ccur-public-key
```

Add this key to the package management database by issuing the following command:

```
sudo apt-key add ccur-public-key
```

2. Create a new file named `redhawk.list` in the `/etc/apt/sources.list.d` directory with the line below, replacing *Login* and *Pass* with the appropriate values.

```
deb http://redhawk.concurrent-rt.com/ubuntu/ \
Login/Pass/redhawk/generic 9.2.n core
```

Note that the Login ID (also referred to as your Site ID) and password are assigned to you from Concurrent Real-Time and are included in a cover letter that is delivered with your system or with your software.

Also note that in addition to the core channel shown in the example above you can add `fbs` to the end of the line if you have purchased those optional products.

3. Issue the following command to update the currently cached package repository information:

```
sudo apt-get update
```

This command will *not* change any software on your system; it merely updates all of the package repository definitions from the `/etc/apt/sources.list` and the files under `/etc/apt/sources.list.d`.

4. Use the following command to bring your system up-to-date with the latest software packages from Concurrent Real-Time:

```
sudo apt-get install 'ccur-*
```

It is important that you use single quotes around the `ccur-*` text so that the command will correctly match all available packages.

Alternatively, you can install or update individual specific Concurrent Real-Time packages using a command similar to the following example:

```
sudo apt-get install ccur-kernel-trace ccur-vmlinux-trace
```

Ubuntu-Specific Notes

This section captures various Ubuntu-specific procedures that differ from Rocky procedures that existing RedHawk customers may be familiar with.

Default NTP Server Inaccurate

The default NTP server for Ubuntu 22.04 is `systemd's timesyncd`. This server is inaccurate and may cause the system time to be continuously offset by multiple milliseconds.

Concurrent recommends that customers desiring more accurate system time switch to using a different NTP server like `chronyd(8)`, or purchase a Concurrent RCIM card with the GPS option.

Building and Installing Custom Kernels

To install a newly built RedHawk custom kernel you should follow the usual steps that are described in the `ccur-config(1)` man page. However, you will also need to issue some additional commands to complete the kernel installation. See example below.

NOTE

The following additional packages are not in the default installation and must be installed on the system in order to build a RedHawk custom kernel: `make`, `gcc`, `flex`, `bison`, `qtbase5-dev`, `g++` and `gawk`.

The following example shows the commands to configure, build and fully install a custom kernel based on the RedHawk trace configuration. Note that warnings can be safely ignored if the subsequent commands successfully complete.

```
cd /usr/src/linux-6.1.19RedHawk9.2
sudo ./ccur-config trace
sudo make -j 10 bzImage modules
sudo make -j 10 modules_install
sudo make -j 10 install
```

```
sudo update-initramfs -c -k \  
6.1.19-rt8-RedHawk-9.2-custom  
sudo update-grub
```

To boot from the custom kernel run **ccur-grub2(1)** without arguments to obtain the grub *index number* of the custom kernel. Then execute the command a second time to make the custom kernel the default kernel as follows:

```
sudo ccur-grub2 -d <index number>
```

Kernel Crash Dumps

Kdump is a kernel crash dumping mechanism that allows you to save the contents of the system's memory to be analyzed later. Kexec is used to boot a Linux kernel from the context of another kernel and save the contents of the first kernel's memory.

The following instructions provide the basics of installing the software, reserving memory, configuring kdump, forcing a crash dump, and using the crash tool to analyze the dump.

1. Install the crash dump package.

The **linux-crashdump** package installs all the tools required to get crash dumps working.

```
sudo apt install linux-crashdump
```

During the installation, the following questions may be asked. If so reply as shown below.

```
Should kexec-tools handle reboots (sysvinit only)? NO  
Should kdump-tools be enabled by default? YES
```

2. Reserve Kernel Memory for the capture kernel.

A part of the system memory has to be reserved for the capture kernel. This part of the system memory will no longer be available to the main kernel.

A default memory reservation should be automatically configured for you when you install the tools. If it is not there or you need to alter the memory reservation, edit the configuration file.

```
sudo vi /etc/default/grub.d/kdump-tools.cfg
```

You should see a line defining the crash kernel memory reservation as:

```
crashkernel=512-:192M
```

Next, update the grub files by issuing the command:

```
sudo update-grub
```

3. Configure your kdump kernel as the default kernel and reboot the system.

Note that any of the RedHawk kernels (standard or trace) can be used as the kdump kernel. Invoke **ccur-grub2** without any options to get the kernel index number of the desired kernel.

```
sudo ccur-grub2 -d <dump kernel index no.>
sudo reboot
```

Once the system is up, verify the crashkernel memory has been reserved:

```
dmesg | grep crashkernel | grep -i reserving
```

The output will look similar to this:

```
[0.000000] kexec: Reserving the low 1M of memory for crashkernel
[0.000000] Reserving 192MB of memory at 2912MB for crashkernel
```

4. Next modify the kdump configuration.

First remove some links in the **/boot** directory that are problematic for kdump:

```
rm /boot/vmlinuz-*RedHawk*
```

Next, if not already there, generate links for kdump in the **/var/lib/kdump** directory:

```
KRELEASE='uname -r'
cd /var/lib/kdump
ln -s /boot/vmlinuz-{$KRELEASE} ./vmlinuz
ln -s /boot/initrd.img-{$KRELEASE} ./initrd.img
```

Verify that the following parameter is set to 1 in the file **/etc/default/kdump-tools**:

```
USE_KDUMP=1
```

Reload the new kdump configuration with the modifications just made.

```
sudo kdump-config reload
```

5. Verify the configuration, making sure the current state in the output says 'ready to kdump'.

```
sudo kdump-config show
```

The output will look similar to this, with the current RedHawk release versions:

```
DUMP_MODE:          kdump
USE_KDUMP:          1
KDUMP_SYSCTL:       kernel.panic_on_oops=1
KDUMP_COREDIR:      /var/crash
crashkernel addr:   0xb6000000
                    /var/lib/kdump/vmlinuz: symbolic link to /boot/vmlinuz-6.1.19-
                    rt8-RedHawk-9.2-trace
kdump initrd:
                    /var/lib/kdump/initrd.img: symbolic link to /var/lib/kdump/
                    initrd.img-6.1.19-rt8-RedHawk-9.2-trace
current state:      ready to kdump

kexec command:
```

```
/sbin/kexec -p --command-line="BOOT_IMAGE=/boot/vmlinuz-6.1.19-rt8-RedHawk-9.2-trace root=UUID=eab38b4f-5643-4071-baff-5f25990e2c7d ro quiet splash vt.handoff=7 console=ttyS0,115200 reset_devices systemd.unit=kdump-tools-dump.service nr_cpus=1 irqpoll nousb ata_piix.prefer_ms_hyperv=0" --initrd=/var/lib/kdump/initrd.img /var/lib/kdump/vmlinuz
```

6. To test the kdump configuration, a crash can be forced.

Note that the following command has to be run as the root user; **sudo** will not work in this case. Be aware that the command will crash the system and reboot it, so take necessary precautions.

```
echo c > /proc/sysrq-trigger
```

Many of the errors during the crash recovery can be ignored, including the following errors from **kdump-tools**. See "Various warnings during crash dump creation" in the Known Issues section on page-52 for more information.

```
Starting Kernel crash dump capture service...
[ 39.694990] kdump-tools[7832]: Starting kdump-tools:
[ 39.695247] kdump-tools[7850]: * running makedumpfile -c -d 31 /
proc/vmcore/var/crash/202110271350/dump-incomplete
Copying data: [100.0%] | eta: 0
s
[ 60.243791] kdump-tools[7874]: The kernel version is not
supported.
[ 60.243837] kdump-tools[7874]: The makedumpfile operation may be
incomplete.
[ 60.243872] kdump-tools[7874]: The dumpfile is saved to /var/
crash/202110271350/dump-incomplete.
[ 60.245277] kdump-tools[7874]: makedumpfile Completed.
[ 60.424189] kdump-tools[7850]: * kdump-tools: saved vmcore in /
var/crash/202110271350
[ 60.696787] kdump-tools[7850]: * running makedumpfile --dump-
dmesg /proc/vmcore /var/crash/202110271350/dmesg.202110271350
[ 60.770728] kdump-tools[7883]: dump_dmesg: Can't find some
symbols for log_bu f.
[ 60.771109] kdump-tools[7883]: The kernel version is not
supported.
[ 60.771155] kdump-tools[7883]: The makedumpfile operation may be
incomplete.
[ 60.771186] kdump-tools[7883]: makedumpfile Failed.
[ 60.771398] kdump-tools[7850]: * kdump-tools: makedumpfile --
dump-dmesg fail
ed. dmesg content will be unavailable
[ 60.773691] kdump-tools[7850]: * kdump-tools: failed to save
dmesg content in /var/crash/202110271350
[ 60.796721] kdump-tools[7886]: Wed, 27 Oct 2021 13:50:37 -0400
[ 61.076207] kdump-tools[7887]: Rebooting.
```

7. Examine the crash after the system reboots.

The **KRELEASE** variable, as set below, assumes you are currently booted off the same kernel version you were running when the system crashed. If not, replace **KRELEASE** with the kernel release name of the kernel used in the crash.

If you get an error from the **crash** command, verify you are using **/usr/ccur/bin/crash**:

```
which crash
KRELEASE=`uname -r`
cd /var/crash
ls -ltr
cd <crash-dir>
```

```
crash /usr/lib/debug/boot/vmlinux-{$KRELEASE} \  
./dump.*
```


B

UEFI Secure Boot

This appendix contains instructions to configure a RedHawk Linux system to boot in UEFI Secure Boot mode.

NOTE

Secure Boot, at this time, is supported on Rocky and Rocky-compatible distributions. It is not supported on the Ubuntu release.

NOTE

The EFI runtime services are disabled by default in the RedHawk 9.2, therefore, you cannot use the `mokutil` command once running on a RedHawk kernel. Running the `mokutil` command to query the state will return "EFI variables are not supported on this system". The EFI runtime services remain enabled by default in the base kernels (Rocky or RedHat). See "EFI Runtime Services Now Disabled By Default" in the Known Issues section on page-52 for more information.

Overview

UEFI Secure boot is a verification mechanism ensuring that code launched by firmware is trusted. UEFI Secure Boot requires that each binary loaded at boot is validated against known keys, located in firmware. A chain of trust is then established from the firmware to the signed drivers and kernel modules.

Configuration

Booting a RedHawk Linux system in UEFI Secure Boot mode requires that the BIOS is modified to enable Secure Boot and that the RedHawk machine owner key (MOK) is added to the system's MOK list.

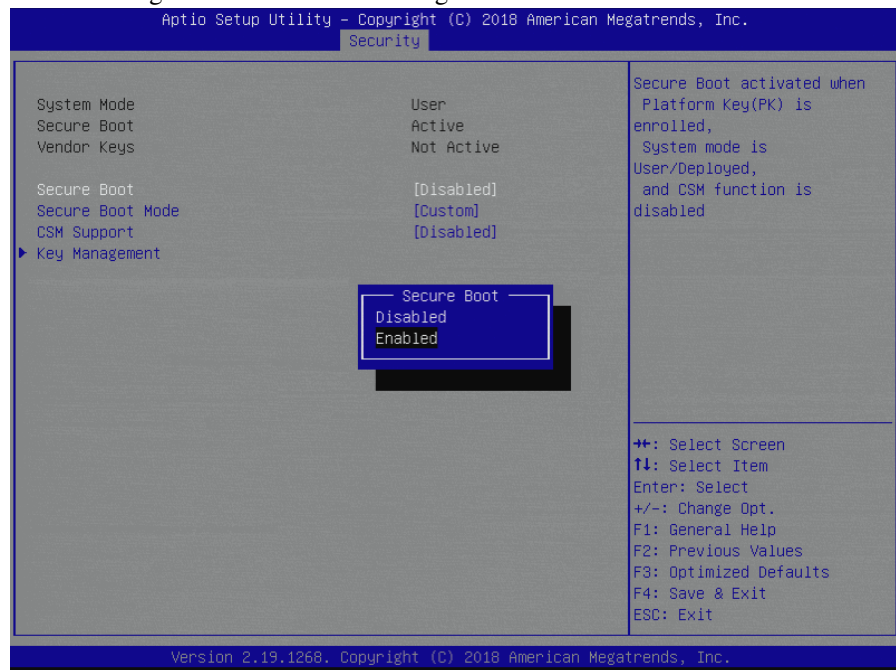
The following instructions will configure a RedHawk Linux system to boot in UEFI Secure Boot mode.

1. If you have not yet installed the RedHawk Linux system, install it now. Note that the system must be installed UEFI-enabled and running a Red-

Hawk Linux version 9.2 or later. See “Installation Procedures” on page 11 of this document for help.

2. Reboot the system and enter the BIOS Setup. Verify that the system is in UEFI Boot mode and then enable Secure Boot. Save the BIOS change and reset the system. When the kernel boot menu appears, use the up and down arrow keys to choose a base (Rocky or Red Hat) kernel from the kernel boot menu.

The following screen shows the enabling of Secure Boot in the BIOS.



3. Once booted, open a terminal window and execute the following **mokutil (1)** command to verify that the system is booted with Secure Boot enabled.

```
# mokutil --sb-state
SecureBoot enable
```

NOTE

On some newer hardware, the above command will not show that SecureBoot is enabled until you enroll the keys. If that is the case, ignore the state and continue. If problems persist, disabling Compatibility Support Mode (CSM) and/or updating the motherboard firmware to the latest version may resolve the issue.

4. Next, issue the following **mokutil (1)** command to request for the enrollment of the RedHawk machine owner key (MOK). The command will prompt to create and confirm a password for this request.

```
# cd /boot/efi
# mokutil --import ./redhawk-ca.cer
input password:
input password again:
```

5. Now configure the RedHawk trace kernel as the default boot kernel. Use **blscfg** to find the index of the RedHawk trace kernel. If it is not set as the default boot kernel, then use the **-d** option to set it as the default.
6. Reboot the system. Just before loading GRUB, on the system console, the MOK Management menus will prompt you to complete the enrollment request. The screens that follow show an example MokManager key enrollment.

NOTE

The MokManager window displayed on the console must be accessed within 10 seconds or it will time out and resume booting without enrolling the MOK.

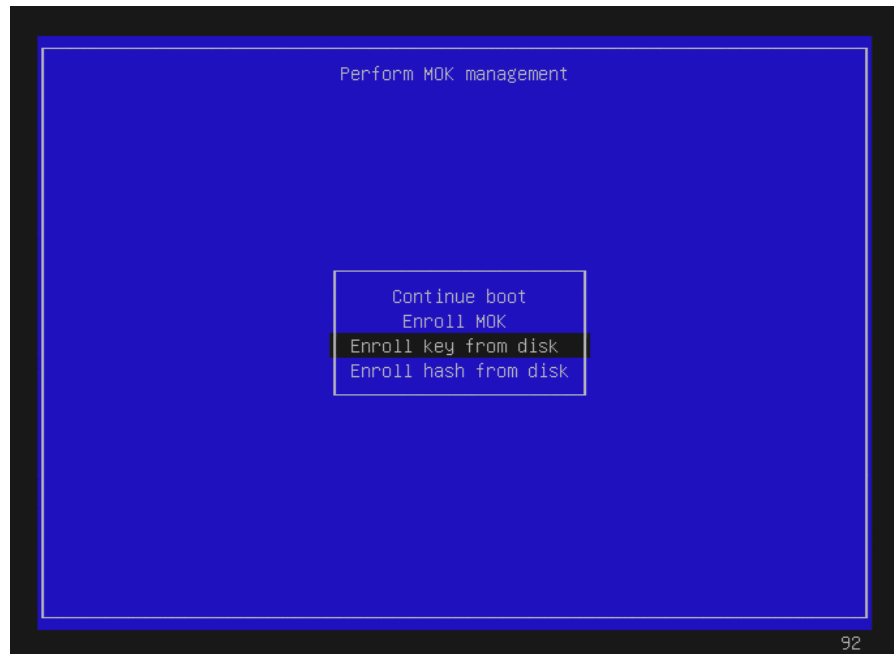
NOTE

The enrollment request is remembered only on the boot following when the request is issued. If the MokManager window times out or there is an issue during the enrollment, you must reboot a base system kernel (Rocky or Red Hat) and reissue the request, starting again with step 4 above.

Press any key, within 10 seconds, to start MOK management.



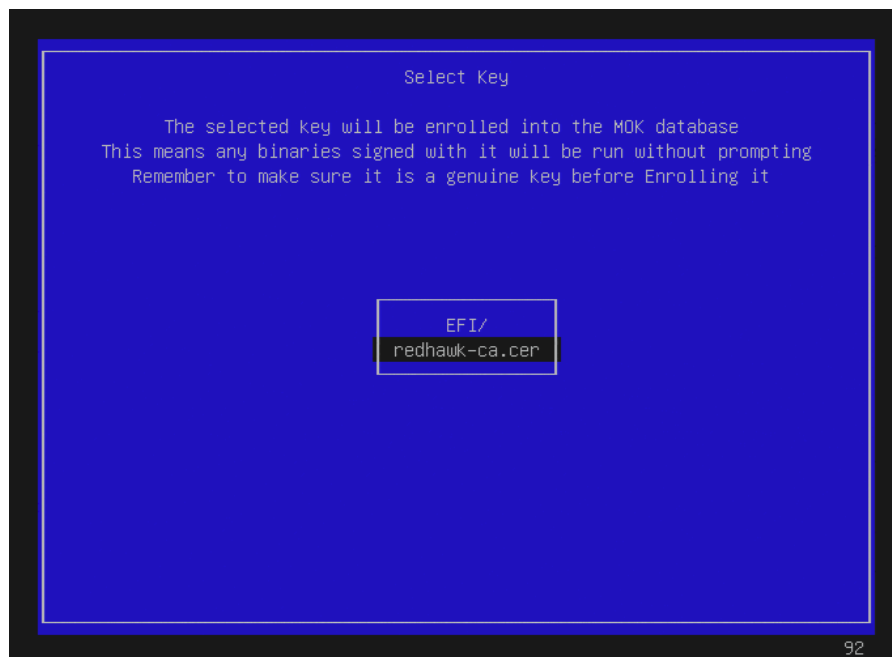
Select **'Enroll Key from disk'** and press ENTER.



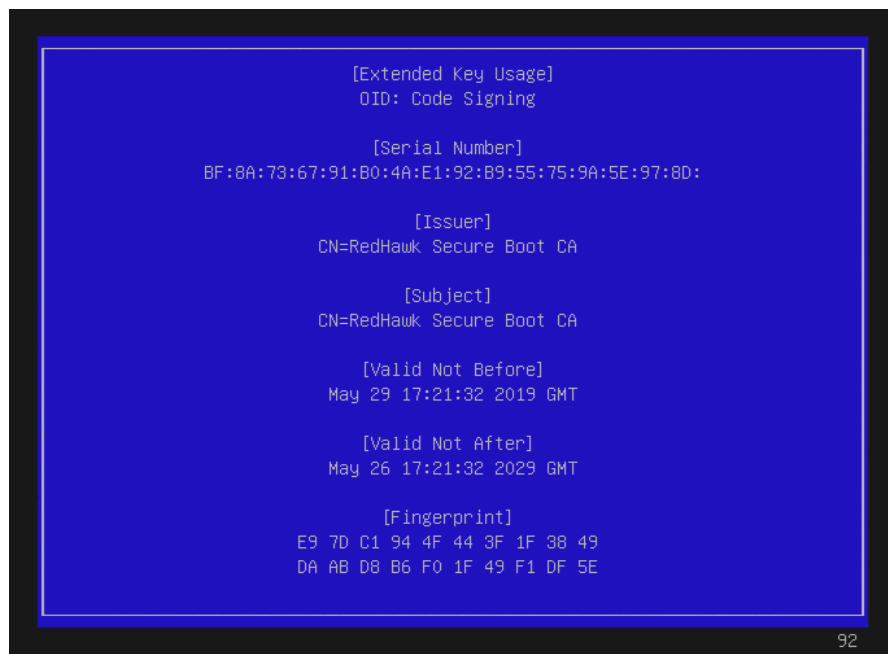
Press ENTER on the selected key to continue:.



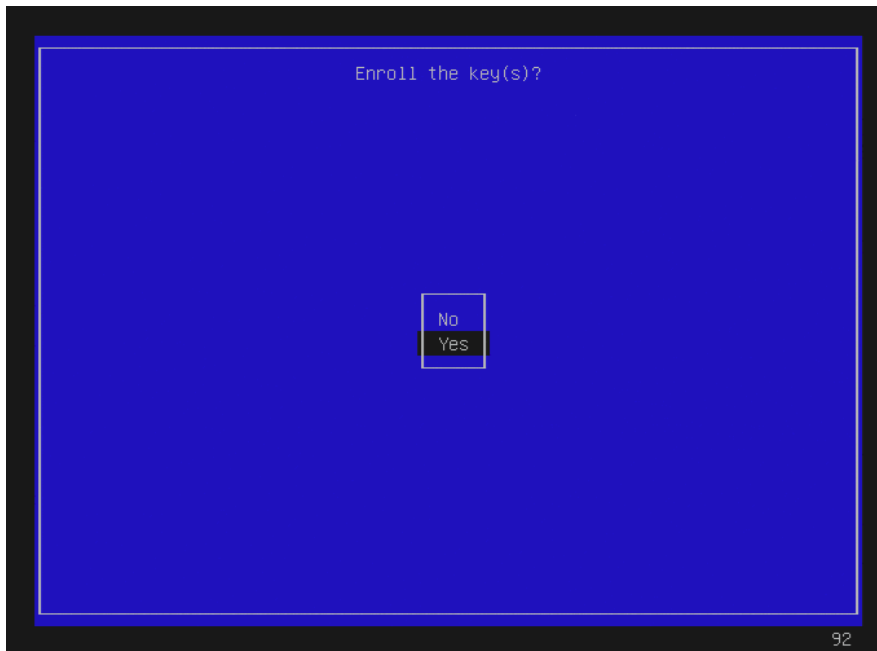
Select the key file, **redhawk-ca.cer**, and press ENTER:



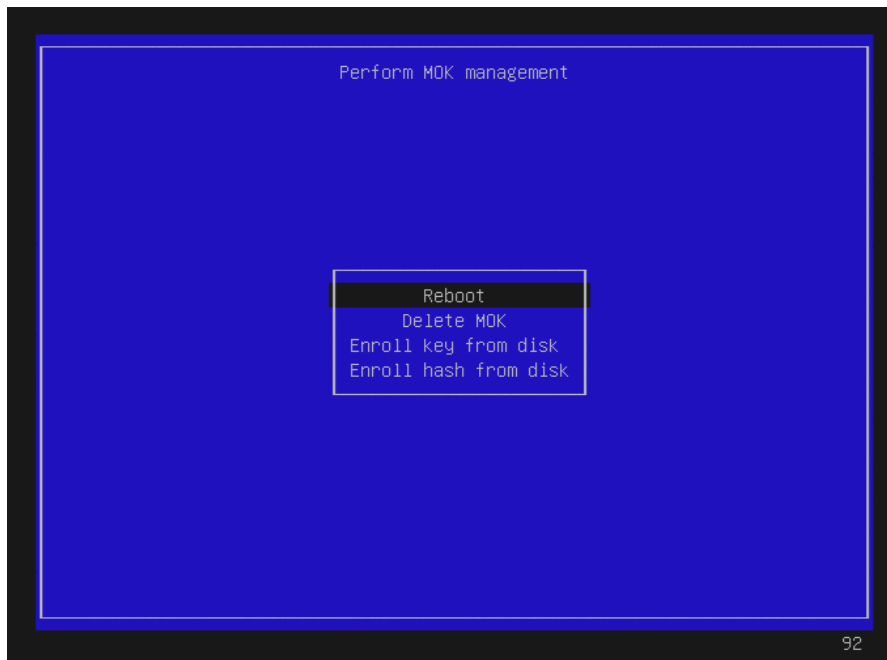
Next, a screen (not shown here) will give the option to verify the key or/and continue. Select view key to view the key and then press ENTER to go back. Select continue and press ENTER to continue. Below is an example of the key verification screen.



Select **Yes** to enroll the key and then press ENTER.



Select **Reboot** and press ENTER.



Note that on some systems, after successfully completing the enrollment, the reboot will take you back into the MokManager menu. If this happens, allow it to time out and continue booting.

7. Once booted, verify that you are booted on the RedHawk Linux trace kernel (**uname (1)**). Also verify that Secure Boot is enabled as follows:

```
dmesg | grep -i secure  
[ 0.017972] Secure Boot enabled
```


Overview

Turbo Boost is an Intel feature that enables Intel processors to run significantly faster than the processors' rated base frequencies when power usage and temperatures are within certain limits. Not all Intel processors provide the Turbo Boost feature, but for processors that do, the feature must be enabled in the system's firmware settings to be utilized.

Core Performance Boost (also known as Turbo Core) is an AMD feature that implements a similar processor speed boosting behavior for AMD processors when power usage and temperatures are within certain limits. Not all AMD processors provide the Core Performance Boost feature, but for processors that do, the feature must also be enabled in the system's firmware settings to be utilized.

The most recent versions of RedHawk Linux now include a system service called **turbo** that can enable and disable processor speed boosting at run-time through the operating system. This appendix explains how to use this service, and also provides information to help customers decide whether or not to enable processor speed boosting when running their real-time applications.

Configuration

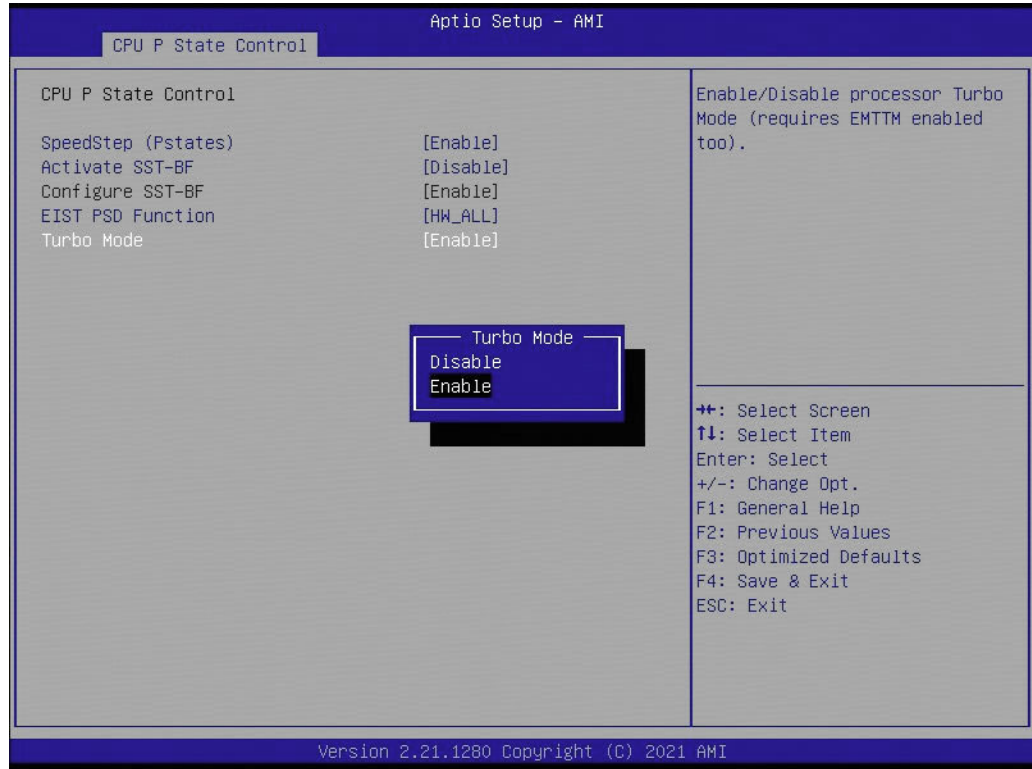
The **turbo** service is added to the system during RedHawk installation, but the service is initially installed in a default disabled state. After installation, users are free to override the default and change the state of the **turbo** service as they see fit.

See "Real-Time Implications" on page C-5 for information on how processor speed boosting can impact real-time performance.

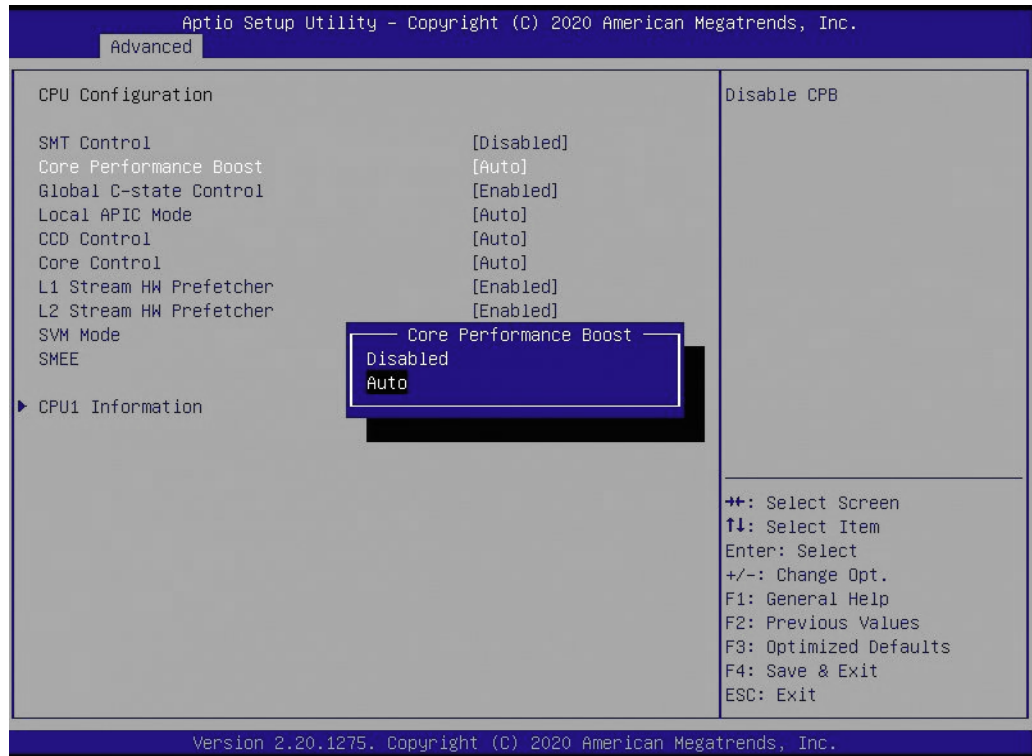
Firmware Settings

Processor speed boosting must first be enabled in the system's firmware settings before it can be utilized. For most systems, the setting will be located in the firmware settings under the **Advanced** ⇒ **CPU Configuration** page.

For systems using Intel processors, the Turbo Boost setting can usually be found under **Advanced** ⇒ **CPU Configuration** ⇒ **Advanced Power Management Configuration** ⇒ **CPU P State Control** and resembles the following display:



For systems using AMD processors, the Core Performance Boost setting can usually be found under **Advanced** ⇒ **CPU Configuration** and resembles the following display:



Service Enabling

To enable the **turbo** service and allow processor speed boosting, issue the following commands as the root user:

```
systemctl enable turbo
systemctl start turbo
```

Once enabled and started, processor speed boosting will be allowed whenever possible, and this behavior will be preserved across reboots.

To verify the **turbo** status is enabled, issue the following commands as the root user:

```
systemctl status turbo
```

Output like the following should be displayed:

```
• turbo.service - Enable or Disable Turbo Boost
  Loaded: loaded (/usr/lib/systemd/system/turbo.service; enabled; vendor preset
  Active: active (exited) since Tue 2021-11-16 14:36:48 EST; 14min ago
  Main PID: 3925678 (code=exited, status=0/SUCCESS)
  Tasks: 0 (limit: 1648261)
  CGroup: /system.slice/turbo.service

Nov 16 14:36:48 ihawk systemd[1]: Starting Enable or Disable Turbo Boost...
Nov 16 14:36:48 ihawk turbo.init[3925678]: Enabling Turbo Boost...
Nov 16 14:36:48 ihawk turbo.init[3925678]: CPU Vendor:           GenuineIntel
Nov 16 14:36:48 ihawk turbo.init[3925678]: CPU Scaling Driver:  acpi-cpufreq
Nov 16 14:36:48 ihawk turbo.init[3925678]: Turbo Boost Enabled
Nov 16 14:36:48 ihawk systemd[1]: Started Enable or Disable Turbo Boost.
```

The above output confirms that the **turbo** service is enabled and was started, and that the Turbo Boost feature has been enabled by the operating system.

Service Disabling

To disable the **turbo** service and prevent processor speed boosting, issue the following commands as the root user:

```
systemctl stop turbo
systemctl disable turbo
```

Once disabled, processor speed boosting will be prevented, and this prevention will be preserved across reboots.

To verify the **turbo** status is disabled, issue the following commands as the root user:

```
systemctl status turbo
```

Output like the following should be displayed:

```
• turbo.service - Enable or Disable Turbo Boost
  Loaded: loaded (/usr/lib/systemd/system/turbo.service; disabled; vendor prese
  Active: inactive (dead)
```

```
Nov 16 15:17:10 ihawk systemd[1]: Stopping Enable or Disable Turbo Boost...
Nov 16 15:17:10 ihawk turbo.init[3926503]: Disabling Turbo Boost...
Nov 16 15:17:10 ihawk turbo.init[3926503]: CPU Vendor:           GenuineIntel
Nov 16 15:17:10 ihawk turbo.init[3926503]: CPU Scaling Driver:  acpi-cpufreq
Nov 16 15:17:10 ihawk turbo.init[3926503]: Turbo Boost Disabled
Nov 16 15:17:10 ihawk systemd[1]: turbo.service: Succeeded.
Nov 16 15:17:10 ihawk systemd[1]: Stopped Enable or Disable Turbo Boost.
```

The above output confirms that the **turbo** service is disabled and was stopped, and that the Turbo Boost feature has been disabled by the operating system.

Service Errors

Note that starting the **turbo** service on a system may result in an error being displayed, as shown below:

```
# systemctl start turbo
Job for turbo.service failed because the control process exited with error code.
See "systemctl status turbo.service" and "journalctl -xe" for details.
```

If this occurs, check the status of the **turbo** service as indicated in the error output, as shown below:

```
# systemctl status turbo
● turbo.service - Enable or Disable Turbo Boost
   Loaded: loaded (/usr/lib/systemd/system/turbo.service; disabled; vendor prese
   Active: failed (Result: exit-code) since Tue 2021-11-16 16:06:03 EST; 34s ago
   Process: 3052534 ExecStart=/usr/lib/ccur/turbo.init start (code=exited, status
   Main PID: 3052534 (code=exited, status=1/FAILURE)

Nov 16 16:06:02 ihawk systemd[1]: Starting Enable or Disable Turbo Boost...
Nov 16 16:06:03 ihawk turbo.init[30]: Error: Intel Turbo Boost disabled in BIOS.
Nov 16 16:06:03 ihawk systemd[1]: turbo.service: Main process exited, code=exite
Nov 16 16:06:03 ihawk systemd[1]: turbo.service: Failed with result 'exit-code'.
Nov 16 16:06:03 ihawk systemd[1]: Failed to start Enable or Disable Turbo Boost.
```

The above output indicates that an error occurred because Turbo Boost has not been enabled in the system's firmware settings, however, the same error can also occur if the system's processors do not support the Turbo Boost feature.

To correct this situation, check the processor vendor's data sheet for the system's specific processors to determine whether the Turbo Boost feature is present. If the Turbo Boost feature is present, reboot the system and modify the firmware settings to enable Turbo Boost, restart the system, and then enable the **turbo** service again.

AMD Caveats

Note that AMD processors do not provide a mechanism to determine if Core Performance Boost is enabled in the system's firmware settings while RedHawk is running. Due to this limitation, the **turbo** service will always appear to start successfully with AMD processors, even if the processors do not support the Core Performance Boost feature or the feature is disabled in the system's firmware settings.

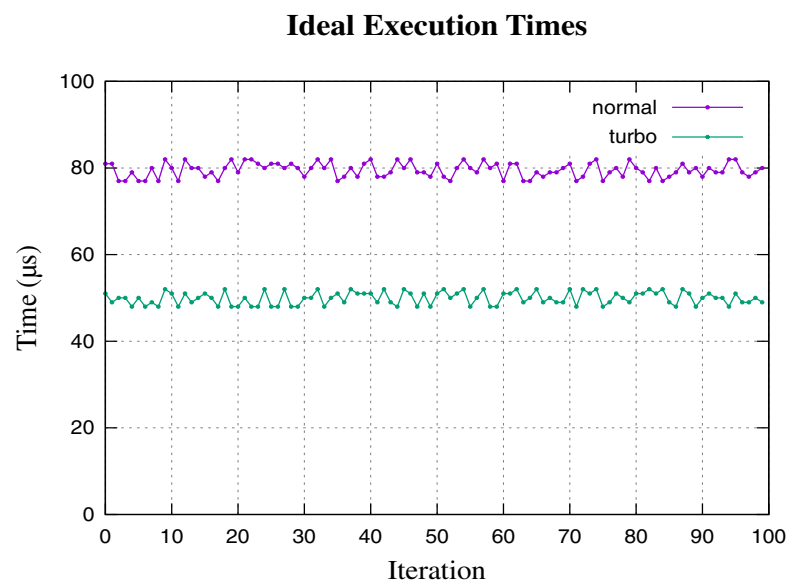
For this reason, customers with systems that utilize AMD processors must ensure that the Core Performance Boost feature is present and enabled in their system's firmware before they can expect any processor speed boosting to occur on their systems.

Real-Time Implications

The **turbo** service is disabled on RedHawk Linux by default because it can potentially confuse users and cause them to draw misleading conclusions about their system's true real-time performance capabilities. This section discusses why this confusion can occur and recommends steps that users can take to more accurately determine their system's capabilities.

Ideal Case

Ideally, enabling processor speed boosting would guarantee that real-time execution times are always uniformly faster, and ensure that power usage and temperature limits are never exceeded. If this was possible, you would expect the real-time performance for boosted execution times to always be faster than the normal, non-boosted execution times, and the following example graph illustrates this ideal case:



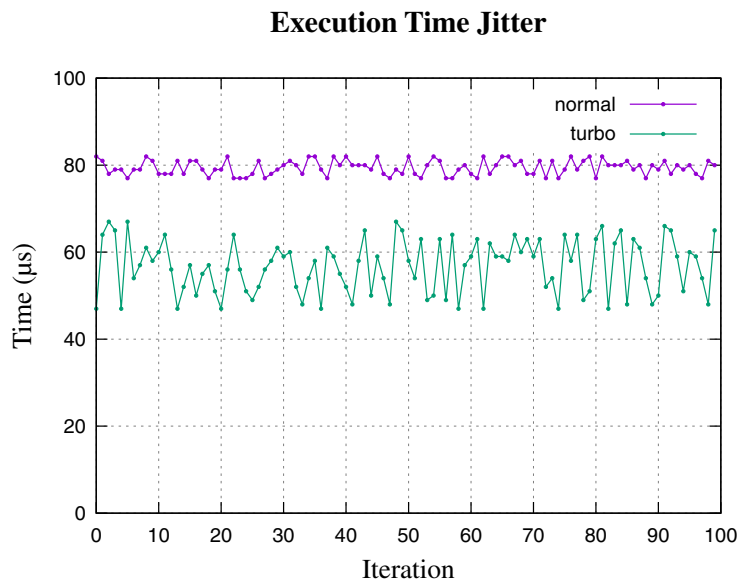
Unfortunately, while this graph may sometimes accurately represent the best and average case execution times, actual power usage and temperature limitations make this ideal case unattainable, especially for worst case execution times.

The next sections illustrate the more realistic cases that users are likely to see.

Increased Jitter

Processor speed boosting will generally always improve average and best case execution times, however, fluctuations of power usage and temperatures over time can negatively impact real-time determinism resulting in significantly increased jitter.

For example, a real-time task that has a normal, non-boosted average execution time of 80 μs , with a variance of $\pm 5 \mu\text{s}$, might be improved by processor boosting to have an average execution time of 57 μs , but with an increased variance of $\pm 10 \mu\text{s}$, as illustrated in the following graph:



For some real-time applications, an increase of execution time jitter is less important than the benefit of decreased average and best case execution times, however, for other real-time applications this increase in non-determinism is unacceptable. Users must determine which behavior is appropriate for their specific real-time applications.

The improvements to best and average case execution times may appear to suggest that enabling processor speed boosting always results in faster execution times than normal, non-boosted execution times. However, execution times are not always faster, and the next section explains why processor speed boosting can mislead users into miscalculating their true worst case execution times.

Worst Case

While processor speed boosting almost always improves best and average case execution times, increased power usage and temperatures occurring under excessive system loads can cause speed boosting to be suspended, temporarily returning execution times to their normal, non-boosted levels, as illustrated in the following graph:



The temporary suspension of processor speed boosting under these conditions should make it clear that, while processor speed boosting may improve best and average case execution times, true worst case execution times will remain unchanged regardless of whether processor speed boosting is enabled or disabled.

For this reason, it is always recommended that users measure the true worst case execution times for their real-time applications with processor speed boosting disabled.

Summary

Users must decide whether to enable or disable the **turbo** service based on the specific requirements of their real-time applications. Concurrent recommends considering the following guidelines when deciding:

1. Enabling the **turbo** service will almost always result in faster best case and average case execution times for real-time applications.
2. Enabling the **turbo** service will almost always increase the amount of execution time jitter for real-time applications.
3. Enabling the **turbo** service will not improve true worst case execution times for real-time applications.

