GNU Boot manual (version 0.1-rc5)

GNU Boot Contributors (gnuboot@gnu.org)

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1 Overview

This chapter will explain what is GNU Boot, and how it compares with somewhat similar projects.

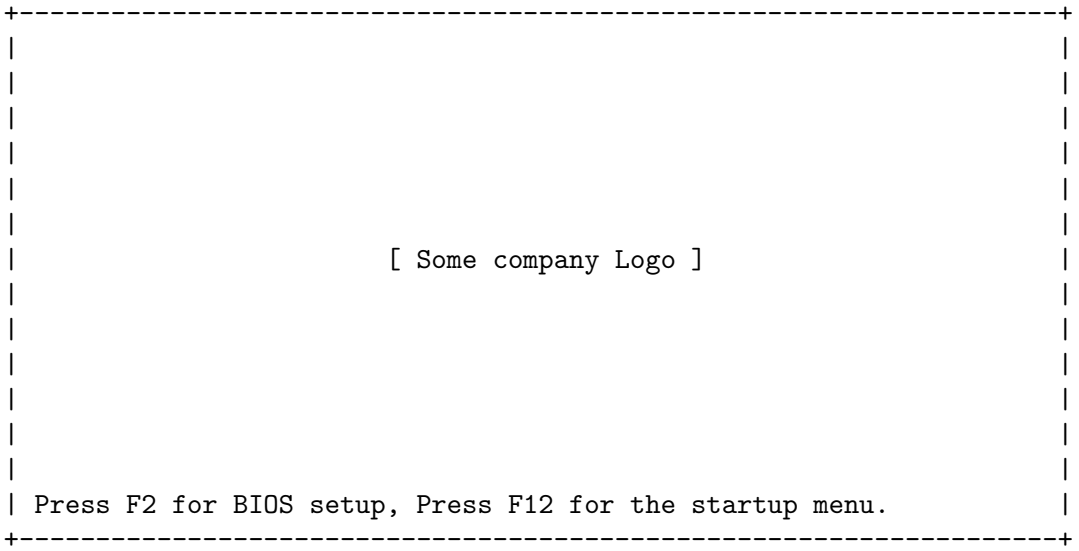
1.1 What is GNU Boot

GNU Boot is a boot software distribution. What this means will be explained below.

1.1.1 boot software

If you take a modern laptop computer, and remove the storage devices (like SSD (Solid State Drive), hard disks, etc) and then power on the computer, it will typically show something on the screen.

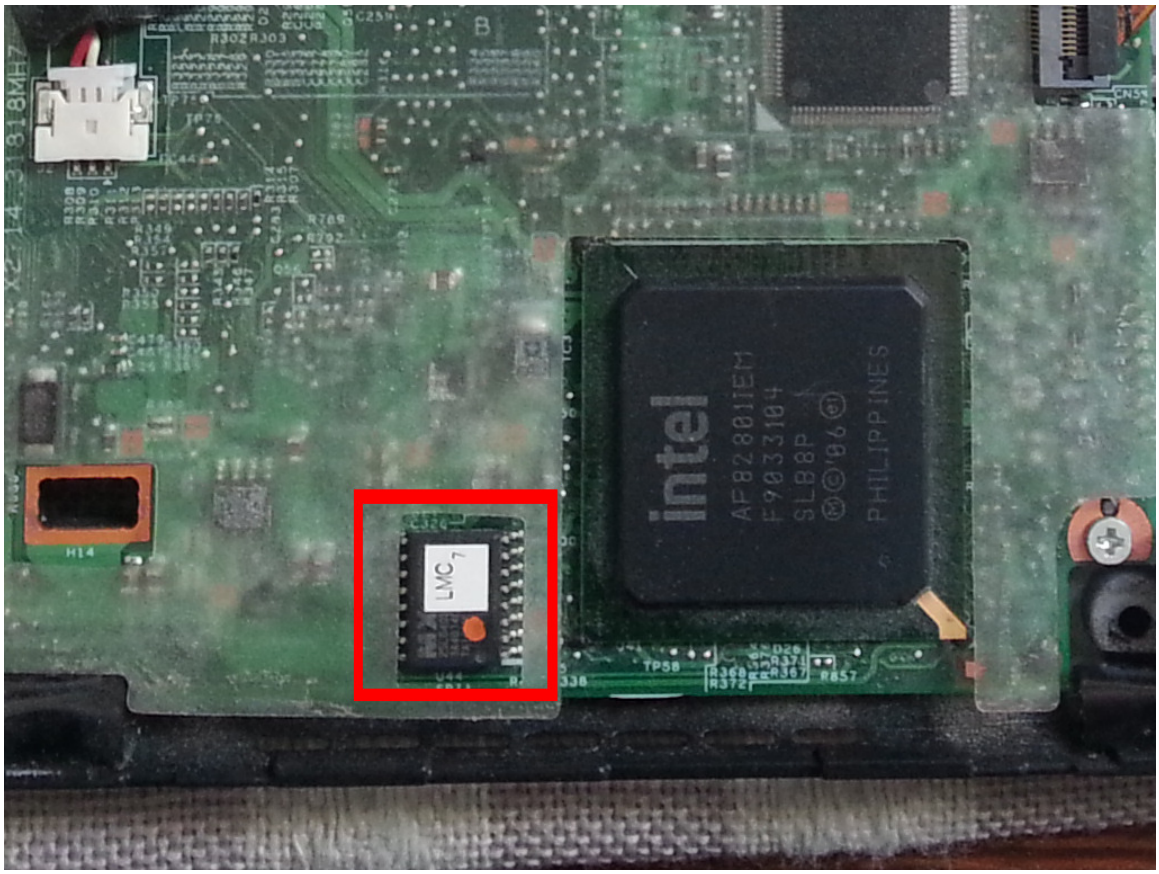
It often looks a bit like that:



What is being displayed on the screen is produced by software which is often nonfree.

It is often called BIOS (Basic Input/Output System) or UEFI (Unified Extensible Firmware Interface) on computers people are most familiar with. This software is typically stored inside a memory chip inside the computer mainboard. In some computers, this software can be replaced by free software.

Depending on how you read the manual, right below you may or may not see a picture of this memory chip on the mainboard of a ThinkPad X200.



The goal of this boot software is to initialize the hardware and load an operating system (like GNU/Linux).

This kind of "boot software" exists for a variety of reasons:

- The operating systems require certain hardware components like the RAM (Random Access Memory) to already work when they are started.
- The operating system is stored on a storage device(s) (like SSD (Solid State Drive), hard disks, etc) and part of it needs to be loaded inside the RAM (Random Access Memory) to work. Something has to do the loading, and this is done in software for flexibility and/or efficiency reasons.
- Finally, certain hardware components cannot be auto-detected and something needs to tell the operating system what drivers to load, which which settings.

GNU Boot provides such software. It enables to replace nonfree boot software (typically nonfree BIOS (Basic Input/Output System) or UEFI (Unified Extensible Firmware Interface)) on some computers.

1.1.2 distribution

GNU Boot is only a distribution because it reuses various software to produce something that can be installed.

So it is similar to GNU/Linux distributions like Trisquel 11 (aramo) that also reuse various software to produce something that can be installed.

1.2 Why free boot software is important

Freedom is important in general, and running nonfree software has negative consequences regardless of the type of software (game, boot software, operating system, driver, etc).

Here are some examples of common issues for nonfree boot software:

- Since the boot software loads the operating system, it can potentially modify it in a malicious way. In most cases part of the boot software also continues to run once the operating system is started. Because of that and, and because of the way the hardware and boot software run, the boot software can also do such modification at any time. If the boot software is nonfree, it is way harder to find and remove malicious code (it's even impossible to remove in some cases), and there is no way to make sure that there is none left. For instance many nonfree boot software where shipped with the CompuTrace malware (which was advertised as an anti-theft security feature).
- Vendors of various hardware components have to collaborate together to provide updates for nonfree Boot software, so in practice they decide when updates are done. So if a computer is not sold anymore, it is unlikely to get update for its Boot software unless the Boot software uses some free software that can be updated. Also note that applying nonfree updates comes with huge risk as we don't know what's inside the updates. Hardware vendors who provide the updates also have an incentive to make things worse for the users, so they would be pushed to buy new devices.
- Some nonfree Boot software restrict what you can do with your computer. For instance they refuse to boot if you changed or removed some hardware components.

1.3 Why use GNU Boot

As explained before GNU boot is just a distribution. So it is also possible to take the same software that GNU Boot reuses, and to build, assemble and install it yourself.

However doing that is risky because if something goes wrong, your computer won't boot anymore.

So the goals of GNU Boot are to:

- Collaborate together to test if GNU Boot releases works fine.
- Provide documentation to enable easy installation and usage.
- Limit the amount of work done by GNU Boot and contribute directly to the software we reuse whenever possible.

GNU Boot also has a long term focus, so it tries not to break users use cases, and tries as much as possible to fix issues in the projects it reuses instead of doing workarounds that impact users.

1.4 Other free boot software distributions

The following GNU/Linux distributions should also provide 100% free boot software but they usually only provide them for computers using the ARM architecture (which GNU Boot doesn't support yet):

- Parabola
- PureOS
- Trisquel

The GNU Guix package manager (which GNU Boot also reuses) also provide 100% free boot software for some ARM computers. However the Guix packages are updated all the time and the Guix project doesn't provide any way for users to report that specific ARM computers work fine with the boot software they provide.

There is also Canoeboot which is a 100% free software boot distribution similar to GNU Boot. Its goal is to remove nonfree software from Libreboot. It focuses more on having the latest software and many features, including some that are not available in the projects it reuses. Because of that it can be harder for users to use.

1.5 How much free software is GNU Boot?

Being a GNU package, GNU Boot itself is 100% free software. If you find nonfree software in GNU Boot and/or any source code or binaries released by GNU Boot, please contact its maintainers by opening a bug report on its bug tracker at `https://savannah.gnu.org/bugs/?group=gnuboot`.

But that doesn't mean that GNU Boot magically makes everything not provided by GNU Boot free software.

In some cases GNU Boot even runs nonfree software not provided by GNU Boot like nonfree GPUs drivers provided by the removable GPU card. See Section 2.2 [Supported computer parts and peripherals], page 7, for more details about this issue and how to avoid running such nonfree software.

To address problems like that the Free Software Foundation (`https://www.fsf.org/`) has created the Respect Your Freedom hardware certification (`https://ryf.fsf.org/`) to list hardware that works with only free software (with some very small exceptions for some components, see its criteria (`https://ryf.fsf.org/about/criteria`) for more details).

In addition there is also The Blob Fallacy article (`https://www.fsfla.org/ikiwiki/blogs/lxo/draft/blob-fallacy`) or a video of a presentation about the same issue at LibrePlanet 2024 (`https://media.libreplanet.org/u/libreplanet/m/software-enshittification-or-freedom-it-s-not-a-hard-choice`) by Alexandre Oliva that explains the related freedom issues with nonfree software provided by the hardware and how they compare with other kind of freedom issues (nonfree driver, nonfree firmware loaded automatically by Linux, etc).

1.6 Limitations

GNU Boot is fairly recent and doesn't have an official release yet.

For the release we plan to have at least some install and upgrade instructions for some computers and an easy way for users to use GNU Boot.

Also the latest GNU Boot release candidate was not tested yet with all the computers it's supposed to support (we badly need help for that).

2 Supported hardware and configurations

2.1 Supported computers

For now, GNU Boot only provides images that can be installed on the following computers:

- Acer G43T-AM3
- Apple MacBook 1.1
- Apple MacBook 2.1
- Apple iMac 5,2
- Asus KCMA-D8
- Asus KFSN4-DRE
- Asus KGPE-D16
- Gigabyte D945GCLF2D
- Gigabyte GA-G41M-ES2L
- Intel D410PT
- Intel D510MO
- Intel D945GCLF
- Lenovo ThinkPad R400
- Lenovo ThinkPad R500
- Lenovo ThinkPad T400
- Lenovo ThinkPad T400S
- Lenovo ThinkPad T500
- Lenovo ThinkPad T60 with intel GPU
- Lenovo ThinkPad W500
- Lenovo ThinkPad X200
- Lenovo ThinkPad X200S
- Lenovo ThinkPad X200T
- Lenovo ThinkPad X301
- Lenovo ThinkPad X60
- Lenovo ThinkPad X60T
- Lenovo ThinkPad X60s
- Libiquity Taurinus X200
- Qemu PC (i440FX)
- Technoethical D16
- Technoethical T400
- Technoethical T400s
- Technoethical T500
- Technoethical X200
- Technoethical X200s

- Technoethical X200 Tablet (X200T)
- Vikings ASUS KCMA D8 mainboard and workstation
- Vikings ASUS KGPE D16 mainboard
- Vikings X200

However as GNU Boot is still relatively new, we lack installation and upgrade instructions for most of these computers.

Also not all are well tested, so it's a good idea to look on the GNU Boot website, on the status page (`https://www.gnu.org/software/gnuboot/web/status.html`) for up to date result of tests by GNU Boot users and contributors.

2.2 Supported computer parts and peripherals

Most computer parts and peripherals don't have any compatibility issue with GNU Boot because:

- they either use some standard that is most often already implemented in the software GNU Boot reuses (storage devices like SATA drives, USB keyboards, etc),
- they are not relevant or supported for booting (for instance 3D printers, cellular network cards, etc, unless people add support for them in GNU Boot in the future). Until then they are only handled in the operating system instead (with drivers),

however there is some exceptions as some hardware is non-standard and still required for booting, these are documented in the subsections below.

2.2.1 Supported GPUs and graphics

GNU Boot supports the GPUs that are present in the various laptops it supports with 100% free software. Some consideration apply while booting (see Section 2.3 [GNU Boot images], page 9, for more details), but so far once booted these GPU are known to works well on tested computers.

In addition for the non-laptop computers, it also supports the builtin AST graphics in the KGPE-D16 and KCMA-D8 with 100% free software, but this also comes with some limitations: in GNU/Linux it's only possible to display text but not images, so it's limited to console applications.

In the case of PCIe GPU / graphics cards, we don't know yet if it is possible to use them without running nonfree software.

If AMD, ATI, and Nvidia cards work under GNU Boot, it's because GNU Boot loaded and run the nonfree video BIOS that is present on the card.

It's possible to prevent the nonfree video BIOS from running and you can easily confirm that as the display will not work until the Linux driver is loaded.

The Free Software Foundation tech team has a wiki. In the disable option roms with cbfstool article (`https://savannah.gnu.org/maintenance/fsf/hardware/disable-option-roms-with-cbfstool/`), they explains how to do that.

And in the graphics cards article (`https://savannah.gnu.org/maintenance/fsf/hardware/graphics-cards/`) they also explain which GPU they tested.

However the Linux driver can also run nonfree software: All the current AMD, ATI, and Nvidia drivers have code to load and run (a different) initialization code provided on the card. For ATI and AMD cards the code that Linux runs is called AtomBIOS.

We don't know yet if there are cases where this code is not run (this would need to be tested by doing very simple modifications to the drivers, and the GNU Boot project also welcome help in this area).

2.2.2 Supported card readers

GNU Boot supports the builtin card reader of the following computers:

- Lenovo ThinkPad X200
- Lenovo ThinkPad X200S
- Lenovo ThinkPad X200T
- Libiquity Taurinus X200
- Technoethical X200
- Technoethical X200s
- Technoethical X200 Tablet (X200T)
- Vikings X200

It also supports some USB card readers that are viewed as mass-storage. With all that you can boot on an SD card a microSD card and it will be viewed like a mass storage USB key.

2.2.3 Unsupported hardware supported by projects reused by GNU Boot

The following hardware components are supported by software reused by GNU Boot, but support for them hasn't been enabled yet in GNU Boot:

- Serial ports.
- Software RAID cards: Some Silicon Image SIL3114 software RAID cards are supported by Coreboot but not enabled in GNU Boot.
- Network interfaces. Projects like iPXE has drivers for many network cards and even some Wifi cards typically used with the computers supported by GNU Boot and free distributions.
- Some printers that use serial ports could probably easily be supported once serial ports are working.

The GNU Boot project needs help to evaluate the impact of enabling these and welcome contributions in this area.

2.2.4 Supported operating systems

While GNU Boot should be able to boot almost any GNU/Linux distribution, but in some cases some configuration might be needed by the GNU Boot user. The cases that do and don't require configuration from the user will be documented in Section 2.3 [GNU Boot images], page 9, below.

Even if some cases require some configuration, GNU Boot makes sure to provide at least one way to boot free GNU/Linux distributions (see `https://www.gnu.org/distros/` for

more information on these distributions) without the need to configure anything in order to make it possible for less technical users to use computers with GNU Boot, and even reinstall the GNU/Linux distribution without needing to do anything too complicated.

To make that possible, the GNU Boot contributors that proposes improvements to the project typically test GNU Boot with free distributions, and the GNU Boot project even runs automatic tests with Trisquel 11 (aramo), one of the free distributions to make sure that it can boot fine without needing any special configuration from the user.

However sometimes fully free distributions also propose experimental or non-standard configurations for very specific use cases. For instance Guix has experimental support for GNU Hurd, an experimental kernel from the GNU project, and Trisquel supports the Xen kernel, which is a virtualization solution that not supported by all GNU/Linux distributions. These configurations are not supported in the official installers of these distribution and so users are usually aware thaty they use Xen or GNU Hurd. Using GNU Boot with these configurations might require some configuration from the user. Also we would need help from users to report what works and doesn't work or what workarounds are needed to make them work with GNU Boot.

The cases that are known not to require any configuration might also work with any GNU/Linux distributions (even the nonfree ones), however the GNU Boot project doesn't want to force contributors to download or run nonfree software to test changes, so it relies on voulounteers already running such distributions to report bugs in case something doesn't work as it should.

As for other operating systems, there is some documentation on how to boot some of them (like some BSD operating systems) on the GNU Boot website, but again we need help from voulonteers already running such systems to keep the documentation up to date and inform us of what works and doesn't work.

Also if you want to do such tests, you can open a bug report on the GNU Boot bug tracker at `https://savannah.gnu.org/bugs/?group=gnuboot`.

2.3 GNU Boot images

In computers people are most familar with, like laptops, the boot software resides in a memory chip inside the mainboard (see Section 1.1.1 [boot software], page 1, for more details).

GNU Boot provide *image files* which are files that replace the content of these memory chip.

These files are similar to disk images (`https://en.wikipedia.org/wiki/Disk_image`), ISO images (`https://en.wikipedia.org/wiki/ISO_image`), or ROM images (`https://en.wikipedia.org/wiki/ROM_image`).

We also sometime refer to the flash image files as *flash images*.

2.3.1 GNU Boot images types

For a given computer, GNU Boot provides several images with different software in it. This enable the users to choose between:

- Two boot software: GRUB or SeaBIOS (BIOS (Basic Input/Output System) implementation)

- Various keyboard layouts (colemak, deqwertz, esqwerty, frazerty, frdvbepo, itqwerty, svenska, trqwerty, ukdvorak, ukqwerty, usdvorak, usqwerty).
- Low resolution or high resolution graphics.

If you are a less technical user or helping one, or don't have much time to configure things, it is a good idea to choose an image with GRUB, and a keyboard layout of your choice (the resolution is not very important, but using high resolution looks nicer) as the image with GRUB doesn't require to do any configuration in the distributions you want to boot.

Otherwise here are the advantages/disadvantages of each combinaison:

- GRUB with high resolution graphics: Images with GRUB usually don't require the user to do any configuration of the distribution. More technical users can also use that to customize the way the system boots for more security or to support unsual boot configurations (that are not typically supported by graphical installers of GNU/Linux distributions), however these more advanced configurations also come with their set of limitations.
- SeaBIOS with text-only low resolution: It implements BIOS (Basic Input/Output System) compatibility, so it is very similar to a nonfree BIOS (Basic Input/Output System) but it require users to modify some settings inside the distribution they use, otherwise the distribution still boots but usually has a black screen during the boot (which can be problematic to diagnose a non-booting distribution). The low resolution increase compatibility with various software that are typically run at boot like memtest86+ (a software that detects broken RAM chips).
- GRUB with text-only low resolution: Since these images boot with GRUB, they also don't require any configuration of the distribution and more technical users can also use them to customize the way the system boots. Compared to GRUB images with high resolution graphics:
  - the text is bigger and that there is no background picture
  - since on most supported computers, GRUB images can also load and run SeaBIOS (there is a menu entry for it), having a text-only low resolution increase the compatibility with various boot software.
- SeaBIOS with high resolution graphics:

  Since these images boot with SeaBIOS they also implement some BIOS (Basic Input/Output System) compatibility, but they also require users to modify some settings inside the distribution they use. Compared with SeaBIOS images with text-only low resolution:
  - they are less compatible with various boot software. This can be useful for testing if you contribute to some boot software.
  - since on most supported computers, SeaBIOS images can also load and run GRUB (there is a menu entry for it when pressing the 'ESC' key at boot), having high resolution graphics can make GRUB look nicer.

2.3.2 GNU Boot images naming

Images for specific computers can be found on the GNU Boot download area (`https://ftp.gnu.org/gnu/gnuboot/`) or in the release/roms directory if you built GNU Boot from source yourself.

For a given release (or release candidate) like GNU Boot 0.1-rc3, you can find such files inside the 'roms' directory like `https://ftp.gnu.org/gnu/gnuboot/gnuboot-0.1-rc3/roms/` for GNU Boot 0.1-rc3.

Inside you have archive files like `gnuboot-0.1-rc3_x200_8mb.tar.xz` that are specific to a specific computer (here the ThinkPad X200 with 8MiB flash chip).

see Chapter 3 [Installing or upgrading GNU Boot images], page 12, to understand how to identify which archive file correspond to which computer.

Inside each archive files, there are many smaller files that are flash images. See Section 1.1.1 [boot software], page 1, to understand what a flash image is.

The flash image files correspond to the configurations described in the Section 2.3.1 [GNU Boot images types], page 9.

So for instance if we have an image named `grub_x200_8mb_corebootfb_usqwerty.rom`, it is meant for a ThinkPad X200 with 8MiB flash chip, and it uses the GRUB software to boot, and it is configured to use a QWERTY keyboard layout.

If the image contains `seabios` in its file name instead of `grub`, it uses the SeaBIOS software to boot.

The `corebootfb` in the file name correspond to the high resolution graphics described in the previous subsection (Section 2.3.1 [GNU Boot images types], page 9).

If instead the file has `txtmode` in its name, this corresponds to the text-only low resolution that was also described in the previous subsection (Section 2.3.1 [GNU Boot images types], page 9).

3 Installing or upgrading GNU Boot images

GNU Boot provides flash images for specific computers that can be found on the GNU Boot download area (https:// ftp.gnu.org/gnu/gnuboot/).

But depending on your threat model, it could be a good idea to build GNU Boot from source yourself instead, to avoid certain security attacks. See Section 4.2 [Security features], page 13, section for more context with security and threat models and Chapter 5 [Building GNU Boot from source], page 15, for more details about the security attacks mentioned above.

Once GNU Boot is downloaded or built, you will need to understand which files you need to install or upgrade. See Chapter 2 [Supported hardware and configurations], page 6, chapter for more details on how to do that.

3.1 Installation and upgrade instructions

The GNU Boot manual doesn't have well integrated installation or upgrade instructions yet but some generic installation and upgrade instructions can be found in the GNU Boot website. We need help to migrate these instructions in the manual and make them easier to understand.

4 Using GNU Boot

4.1 Using GNU Boot with QEMU

The GNU Boot project also release images for QEMU.

If you just want to try an image to see how it looks like you can use the following command:

```
qemu-system-x86_64 -M pc \
-bios grub_qemu-pc_2mb_corebootfb_usqwerty.rom
```

Here you need to replace *grub_qemu-pc_2mb_corebootfb_usqwerty.rom* by the path to the image you want to try.

For a more complete example, you can look in the GNU Boot source code as GNU Boot uses QEMU to run some automatic tests that boots Trisquel 11 (aramo).

Also note that the GNU Boot images for QEMU can be useful in some situations, but it doesn't fully replace tests run on real computers.

For instance a distribution or operating system might work on QEMU but not work on real hardware due to an incomplete graphic driver for the real hardware GPU.

4.2 Security features

Note that security is a process. To really make it work you need to understand various threats and how to respond to them (this is called *threat modelling*), so what security feature to use or not to use depends on your life, use cases, etc.

Also note that in general some security features also have downsides, such as making it harder to use the computer, making it harder to fix issues, etc, so not everybody might want these security features.

As for security features typically found in other boot software, some computers vendor sell computers with what they call *secure boot*. When it cannot be turned off, it becomes an anti-feature and the Free Software Foundation (`https://www.fsf.org/`) calls it *restricted boot*.

In 2012, the Free Software Foundation (`https://www.fsf.org/`) wrote a whitepaper (`https://www.fsf.org/campaigns/secure-boot-vs-restricted-boot/campaigns/secure-boot-vs-restricted-boot/whitepaper.pdf`), on the topic and advised that:

```
The best solution currently available for operating system distributions
includes:
1. fully supporting user-generated keys, including providing tools and full
documentation for booting and installing both modified and official
versions of the distribution using this method;
2. using a GPLv3-covered bootloader to help protect users against the
dangers of Restricted Boot;
3. avoiding requiring or encouraging users to trust Microsoft or any com-
pany which makes proprietary software; and
4. joining the FSF and the broader free software movement in pressuring
computer distributors to facilitate easy and independent installation of
```

`free software operating systems on any computer.`

GNU Boot supports various security mechanism: GRUB is a GPLv3-covered bootloader that GNU Boot reuses, and it supports user-generated keys or other security mechanism that that don't require any signing keys.

GNU Boot also obviously doesn't Trust keys from companies that make proprietary software.

At the end when used correctly, the security features provided by GNU Boot thanks to the software it reuses (like GRUB) can provide similar or stronger security guarantees than the UEFI secure boot with different security features that you may or may not want want to use depending on your threat model.

The GNU Boot Website contains various information on how to use such security features, but they are also documented in the *GNU GRUB manual* as well in more details. Since the GRUB version GNU Boot uses might be older than the online GRUB manual, you can use Guix to install the manual of older GRUB versions (see *GNU Guix reference manual* for more details).

All the security mechanism described in the GRUB manual or GNU Boot website are compatible with users freedom.

5 Building GNU Boot from source

Currently building GNU Boot flash images on two different computers will produce slightly different images.

This is a problem as it prevents people from easily verifying that the official flash images really correspond to the source code published by GNU Boot, and having the ability for anyone to verify that increases the security guarantees.

The Reproducible builds (`https://reproducible-builds.org`) project helps publicizing this problem and helps distributions and software to fix it.

So while GNU Boot also started working to fix this problem the work just stated and isn't complete yet, so in the meantime if you care about this type of risks, it might be a good idea to build GNU Boot from source yourself.

The GNU Boot website has instructions for building GNU Boot at the following URL: `https://www.gnu.org/software/gnuboot/web/docs/build/`.

See Section 5.1 [Authenticating the GNU Boot source code], page 15, as GNU Boot has ways to prevent network attacks from tempering with the souce code you are downloading.

Note that at the moment, building GNU Boot from tarballs is unsupported, so you will have to download GNU Boot from git and build from git.

5.1 Authenticating the GNU Boot source code

As explained on the GNU Boot build instructions (`https://www.gnu.org/software/gnuboot/web/docs/build/`) on the GNU Boot website, to build GNU Boot you will need to install Guix first (it can be installed on top of another GNU/Linux distribution).

You can consult either the GNU Boot build instructions (`https://www.gnu.org/software/gnuboot/web/docs/build/`) or the Section "Installation" in *GNU Guix reference manual* for how to do that.

Once this is done you can download the GNU Boot source code with the following command and go into it:

```
$ git clone https://git.savannah.gnu.org/git/gnuboot.git
$ cd gnuboot
```

And you can then authenticate the source code with the following guix command:

```
$ guix git authenticate \
dde4223088cbfe8a347626638d32902ba2323b25 \
"E23C 26A5 DEEE C5FA 9CDD  D57A 57BC 26A3 6871 16F6" \
-k origin/keyring
```

It should then print the following text:

```
guix git: successfully authenticated commit dde4223088cbfe8a347626638d32902ba2323b25
```

See Section "Invoking guix git authenticate" in *GNU Guix manual* or the Authenticate your Git checkouts! Guix blog post (`https://guix.gnu.org/en/blog/2024/authenticate-your-git-checkouts/`) for more details.

The question that remains is then how to make sure that "E23C 26A5 DEEE C5FA 9CDD D57A 57BC 26A3 6871 16F6" is the right key.

To do that the GnuPG software can help (see *its manual* for now to use it if you are interested) but the solution to this problem is not technical but social and could require significant time and effort.

To solve this problem you will need to build some sort of chain of trust between you and the person who controls the "E23C 26A5 DEEE C5FA 9CDD D57A 57BC 26A3 6871 16F6" key (here Adrien 'neox' Bourmault) with or without the help of the GnuPG software.

Wikipedia has a bit more information on the problem in its Web of trust (`https://en.wikipedia.org/wiki/Web_of_trust`) article, and the The GNU Privacy Handbook (`https://www.gnupg.org/gph`) has a section about Building your web of trust (`https://www.gnupg.org/gph/en/manual/x547.html`), that contains advises on how to do that, especially in the part about "Key validation".

6 Helping GNU Boot

The GNU Boot project needs help with this manual, specifically on moving information from the GNU Boot website to this manual.

In general there is also a lot of ways to help the GNU Boot project (from reviewing website pages for very simple mistakes or outdated information, testing GNU Boot images, etc).

See the Helping GNU Boot (`https://www.gnu.org/software/gnuboot/web/git.html`) page on the GNU Boot website for the areas where we need help and on how to help practically speaking (how to contact the project, where to send bug reports, etc).

Appendix A GNU Free Documentation License

Version 1.3, 3 November 2008

0. PREAMBLE

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