VERACRYPT

FREE OPEN-SOURCE ON-THE-FLY ENCRYPTION

USER'S GUIDE

veracrypt.codeplex.com

Version Information

VeraCrypt User's Guide, version 1.19-BETA3
Released by IDRIX on October 8th, 2016

Legal Notices

CONTENTS

PREFACE

Please note that although most chapters of this documentation apply generally to all versions of VeraCrypt, some sections are primarily aimed at users of the Windows versions of VeraCrypt. Hence, such sections may contain information that is inappropriate in regards to the Mac OS X and Linux versions of VeraCrypt.

Introduction

VeraCrypt is a software system for establishing and maintaining an on-the-fly-encrypted volume (data storage device). On-the-fly encryption means that data is automatically encrypted right before it is saved and decrypted right after it is loaded, without any user intervention. No data stored on an encrypted volume can be read (decrypted) without using the correct password/keyfile(s) or correct encryption keys. Entire file system is encrypted (e.g., file names, folder names, contents of every file, free space, metadata, etc).

Files can be copied to and from a mounted VeraCrypt volume just like they are copied to/from any normal disk (for example, by simple drag-and-drop operations). Files are automatically being decrypted on the fly (in memory/RAM) while they are being read or copied from an encrypted VeraCrypt volume. Similarly, files that are being written or copied to the VeraCrypt volume are automatically being encrypted on the fly (right before they are written to the disk) in RAM. Note that this does *not* mean that the *whole* file that is to be encrypted/decrypted must be stored in RAM before it can be encrypted/decrypted. There are no extra memory (RAM) requirements for VeraCrypt. For an illustration of how this is accomplished, see the following paragraph.

Let's suppose that there is an .avi video file stored on a VeraCrypt volume (therefore, the video file is entirely encrypted). The user provides the correct password (and/or keyfile) and mounts (opens) the VeraCrypt volume. When the user double clicks the icon of the video file, the operating system launches the application associated with the file type – typically a media player. The media player then begins loading a small initial portion of the video file from the VeraCrypt-encrypted volume to RAM (memory) in order to play it. While the portion is being loaded, VeraCrypt is automatically decrypting it (in RAM). The decrypted portion of the video (stored in RAM) is then played by the media player. While this portion is being played, the media player begins loading another small portion of the video file from the VeraCrypt-encrypted volume to RAM (memory) and the process repeats. This process is called on-the-fly encryption/decryption and it works for all file types (not only for video files).

Note that VeraCrypt never saves any decrypted data to a disk – it only stores them temporarily in RAM (memory). Even when the volume is mounted, data stored in the volume is still encrypted. When you restart Windows or turn off your computer, the volume will be dismounted and files stored in it will be inaccessible (and encrypted). Even when power supply is suddenly interrupted (without proper system shut down), files stored in the volume are inaccessible (and encrypted). To make them accessible again, you have to mount the volume (and provide the correct password and/or keyfile). For a quick start guide, please see the chapter [Beginner's Tutorial](#).

Beginner's Tutorial

How to Create and Use a VeraCrypt Container

This chapter contains step-by-step instructions on how to create, mount, and use a VeraCrypt volume. We strongly recommend that you also read the other sections of this manual, as they contain important information.

STEP 1:

If you have not done so, download and install VeraCrypt. Then launch VeraCrypt by double-clicking the file VeraCrypt.exe or by clicking the VeraCrypt shortcut in your Windows Start menu.

STEP 2:
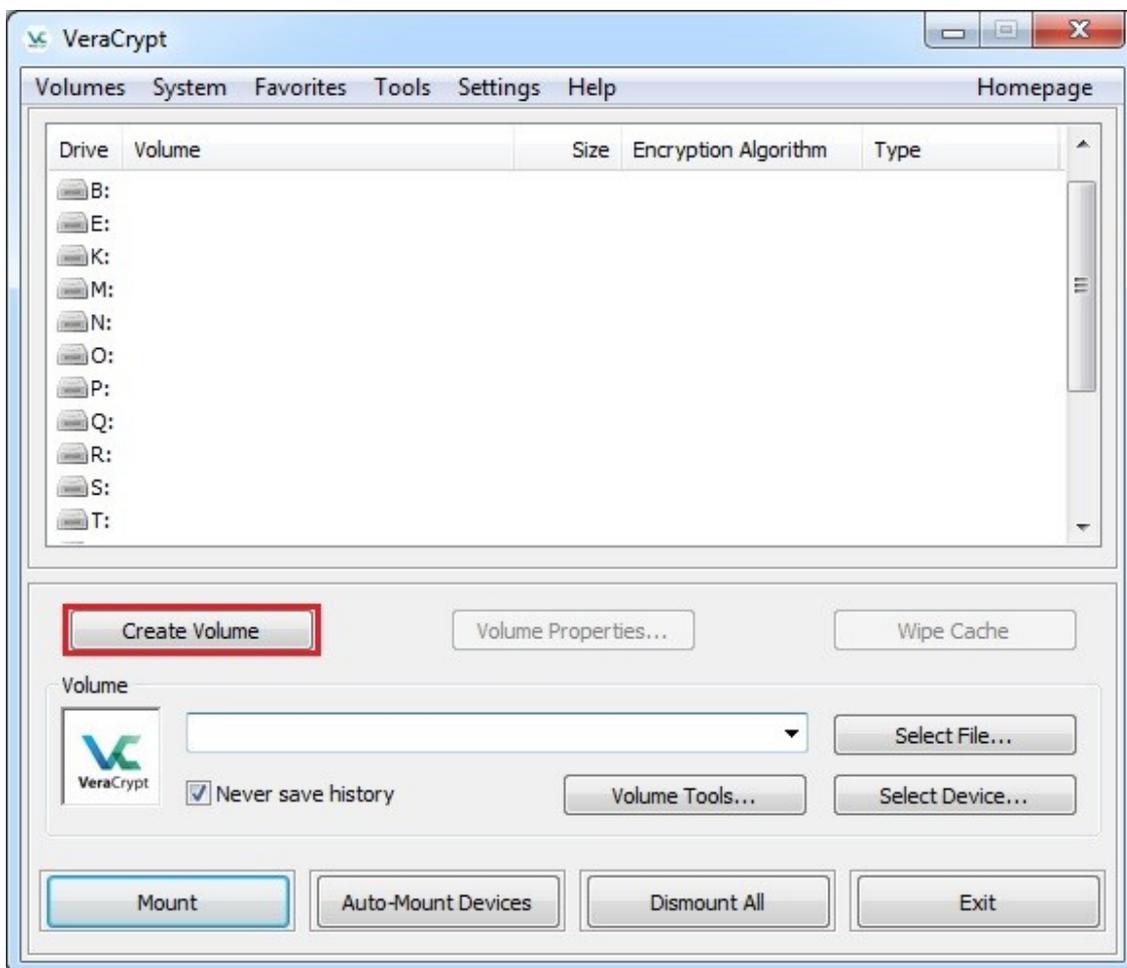
The main VeraCrypt window should appear. Click **Create Volume** (marked with a red rectangle for clarity).

STEP 3:
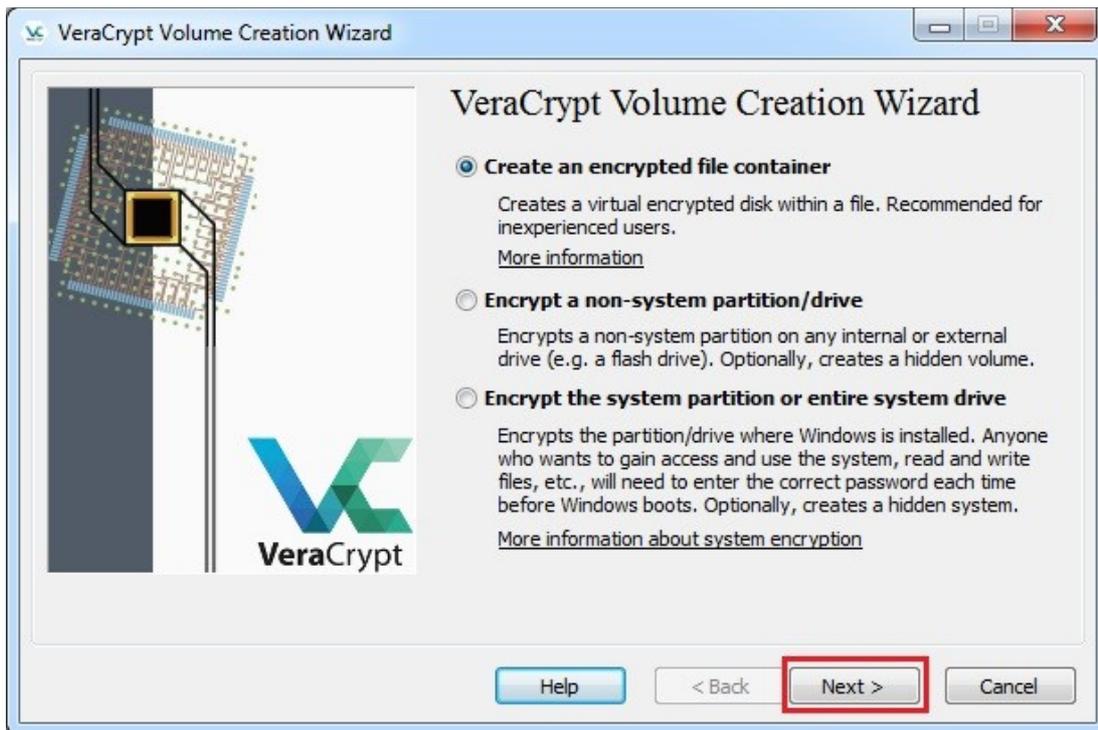
The VeraCrypt Volume Creation Wizard window should appear.

In this step you need to choose where you wish the VeraCrypt volume to be created. A VeraCrypt volume can reside in a file, which is also called container, in a partition or drive. In this tutorial, we will choose the first option and create a VeraCrypt volume within a file.

As the option is selected by default, you can just click **Next**.

Note: In the following steps, the screenshots will show only the right-hand part of the Wizard window.

In this step you need to choose whether to create a standard or hidden VeraCrypt volume. In this tutorial, we will choose the former option and create a standard VeraCrypt volume.

As the option is selected by default, you can just click **Next**.

STEP 5:

In this step you have to specify where you wish the VeraCrypt volume (file container) to be created. Note that a VeraCrypt container is just like any normal file. It can be, for example, moved or deleted as any normal file. It also needs a filename, which you will choose in the next step.

Click **Select File**.

The standard Windows file selector should appear (while the window of the VeraCrypt Volume Creation Wizard remains open in the background).

STEP 6:
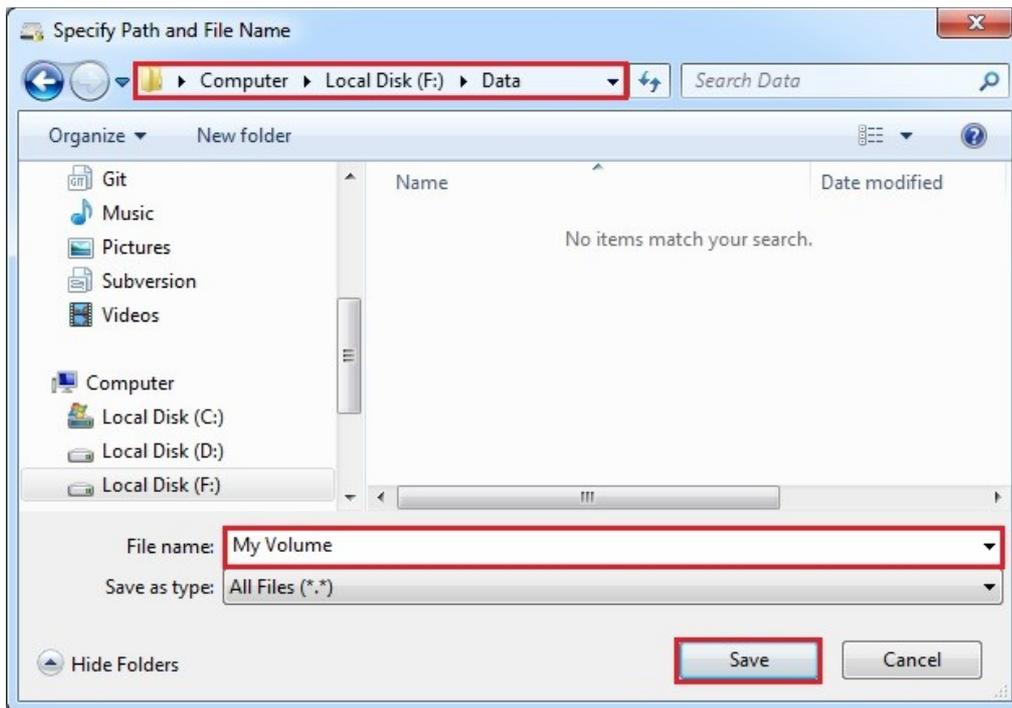
In this tutorial, we will create our VeraCrypt volume in the folder *F:\Data* and the filename of the volume (container) will be *My Volume* (as can be seen in the screenshot above). You may, of course, choose any other filename and location you like (for example, on a USB memory stick). Note that the file *My Volume* does not exist yet – VeraCrypt will create it.

IMPORTANT: Note that VeraCrypt will *not* encrypt any existing files (when creating a VeraCrypt file container). If you select an existing file in this step, it will be overwritten and replaced by the newly created volume (so the overwritten file will be *lost, not* encrypted). You will be able to encrypt existing files (later on) by moving them to the VeraCrypt volume that we are creating now. *

Select the desired path (where you wish the container to be created) in the file selector.

Type the desired container filename in the **File name** box.

Click **Save**.

The file selector window should disappear.

In the following steps, we will return to the VeraCrypt Volume Creation Wizard.

---

* Note that after you copy existing unencrypted files to a VeraCrypt volume, you should securely erase (wipe) the original unencrypted files. There are software tools that can be used for the purpose of secure erasure (many of them are free).

STEP 7:

Volume Location

F:\Data\My Volume   ▼   Select File...

☑ Never save history

A VeraCrypt volume can reside in a file (called VeraCrypt container), which can reside on a hard disk, on a USB flash drive, etc. A VeraCrypt container is just like any normal file (it can be, for example, moved or deleted as any normal file). Click 'Select File' to choose a filename for the container and to select the location where you wish the container to be created.

WARNING: If you select an existing file, VeraCrypt will NOT encrypt it; the file will be deleted and replaced with the newly created VeraCrypt container. You will be able to encrypt existing files (later on) by moving them to the VeraCrypt container that you are about to create now.

| Help | < Back | Next > | Cancel |

In the Volume Creation Wizard window, click **Next**.

STEP 8:

Encryption Options

Encryption Algorithm

AES   ▼   Test

FIPS-approved cipher (Rijndael, published in 1998) that may be used by U.S. government departments and agencies to protect classified information up to the Top Secret level. 256-bit key, 128-bit block, 14 rounds (AES-256). Mode of operation is XTS.

More information on AES   Benchmark

Hash Algorithm

SHA-512   ▼   Information on hash algorithms

| Help | < Back | Next > | Cancel |

Here you can choose an encryption algorithm and a hash algorithm for the volume. If you are not sure what to select here, you can use the default settings and click **Next** (for more information, see chapters *Encryption Algorithms* and *Hash Algorithms*).

STEP 9:

Volume Size 12

250 ○ KB ● MB ○ GB

Free space on drive F:\ is 27.87 GB

Please specify the size of the container you want to create.

If you create a dynamic (sparse-file) container, this parameter will specify its maximum possible size.

Note that the minimum possible size of a FAT volume is 292 KB.
The minimum possible size of an NTFS volume is 3792 KB.

| Help | < Back | Next > | Cancel |

Here we specify that we wish the size of our VeraCrypt container to be 250 megabyte. You may, of course, specify a different size. After you type the desired size in the input field (marked with a red rectangle), click **Next**.

STEP 10:

Volume Password

Password: ••••••••••••••••••••••••••
Confirm: ••••••••••••••••••••••••••

☐ Use keyfiles   Keyfiles...
☐ Display password
☐ Use PIM

It is very important that you choose a good password. You should avoid choosing one that contains only a single word that can be found in a dictionary (or a combination of 2, 3, or 4 such words). It should not contain any names or dates of birth. It should not be easy to guess. A good password is a random combination of upper and lower case letters, numbers, and special characters, such as @ ^ = $ * + etc. We recommend choosing a password consisting of 20 or more characters (the longer, the better). The maximum possible length is 64 characters.

Help   < Back   Next >   Cancel

This is one of the most important steps. Here you have to choose a good volume password.

Read carefully the information displayed in the Wizard window about what is considered a good password.

After you choose a good password, type it in the first input field. Then re-type it in the input field below the first one and click **Next**.

Note: The button **Next** will be disabled until passwords in both input fields are the same.

STEP 11:
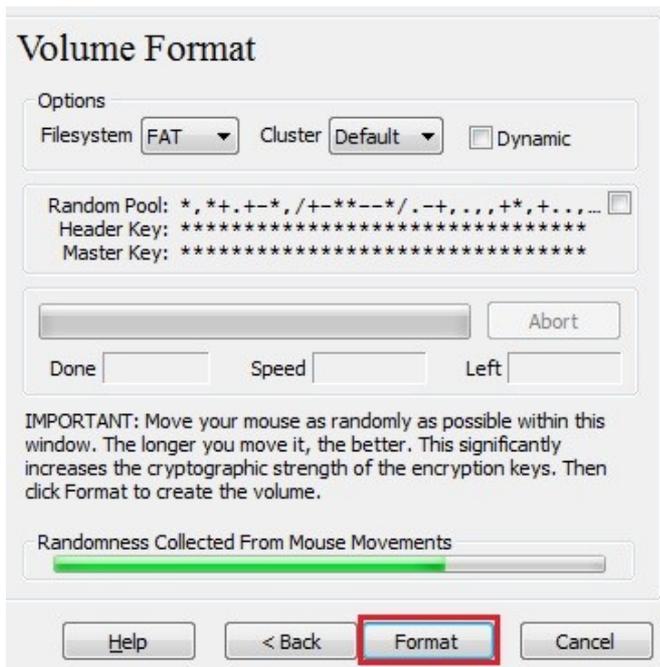
Move your mouse as randomly as possible within the Volume Creation Wizard window at least until the randomness indicator becomes green. The longer you move the mouse, the better (moving the mouse for at least 30 seconds is recommended). This significantly increases the cryptographic strength of the encryption keys (which increases security).

Click **Format**.

Volume creation should begin. VeraCrypt will now create a file called *My Volume* in the folder *F:\Data* (as we specified in Step 6). This file will be a VeraCrypt container (it will contain the encrypted VeraCrypt volume). Depending on the size of the volume, the volume creation may take a long time. After it finishes, the following dialog box will appear:
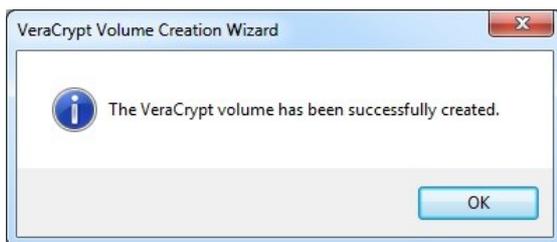
Click **OK** to close the dialog box.

STEP 12:

Volume Created

The VeraCrypt volume has been created and is ready for use. If you wish to create another VeraCrypt volume, click Next. Otherwise, click Exit.

| Help | < Back | Next > | **Exit** |
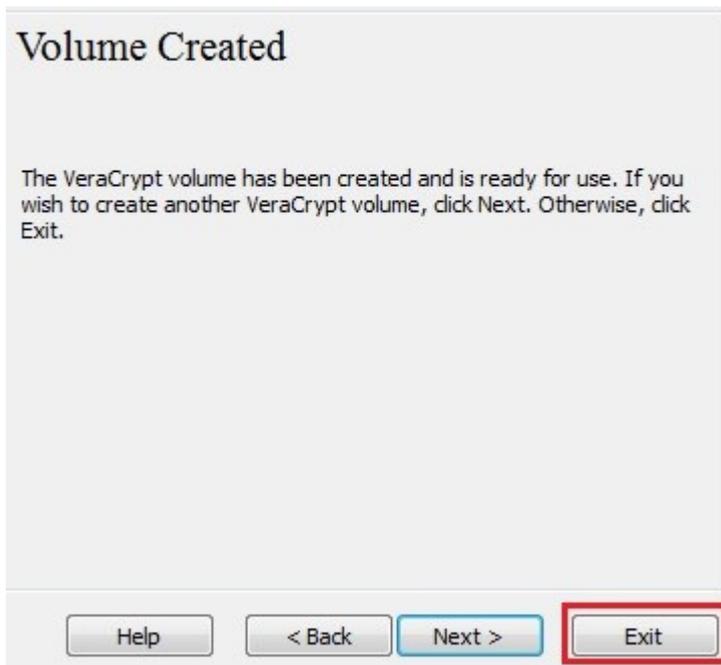
We have just successfully created a VeraCrypt volume (file container).

In the VeraCrypt Volume Creation Wizard window, click **Exit**.

The Wizard window should disappear.

In the remaining steps, we will mount the volume we just created. We will return to the main VeraCrypt window (which should still be open, but if it is not, repeat Step 1 to launch VeraCrypt and then continue from Step 13.)

STEP 13:
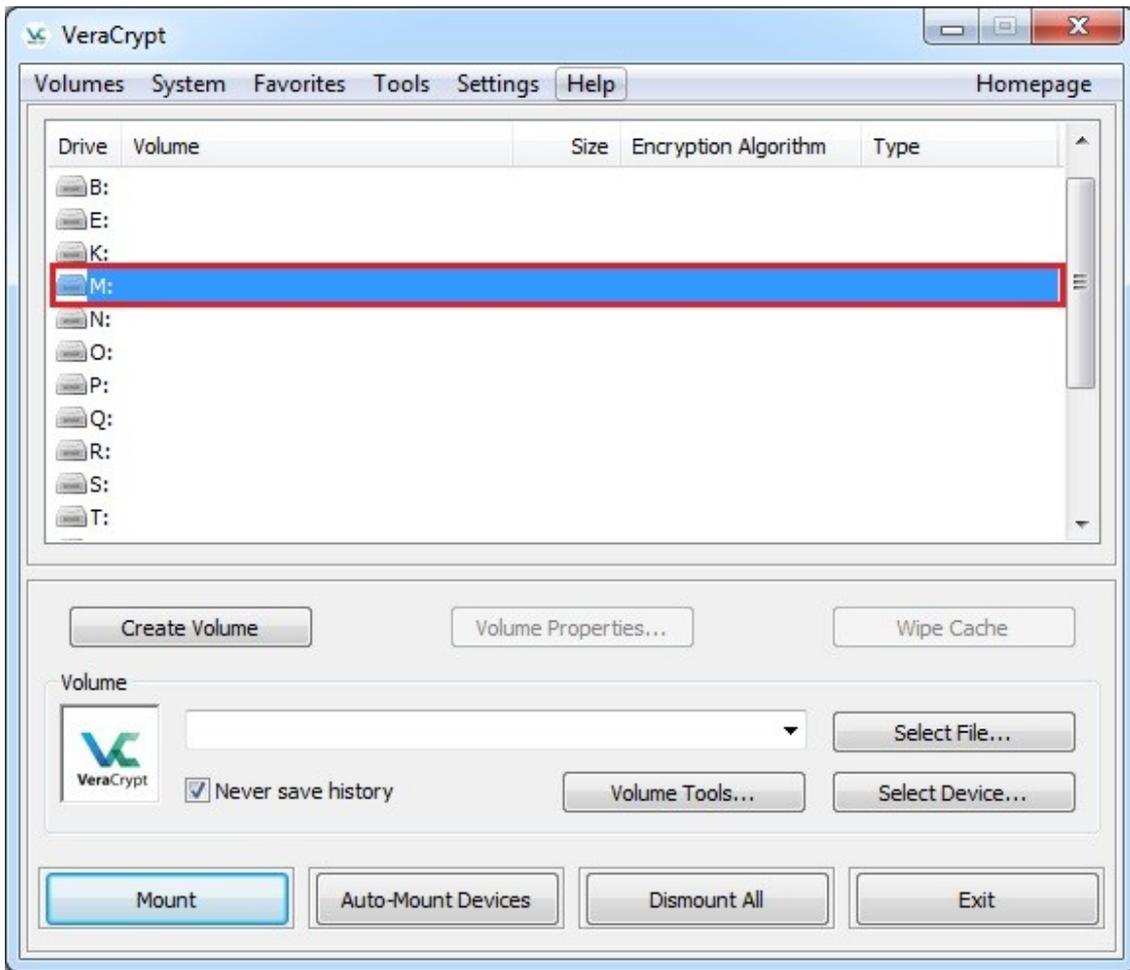
Select a drive letter from the list (marked with a red rectangle). This will be the drive letter to which the VeraCrypt container will be mounted.

Note: In this tutorial, we chose the drive letter M, but you may of course choose any other available drive letter.

STEP 14:
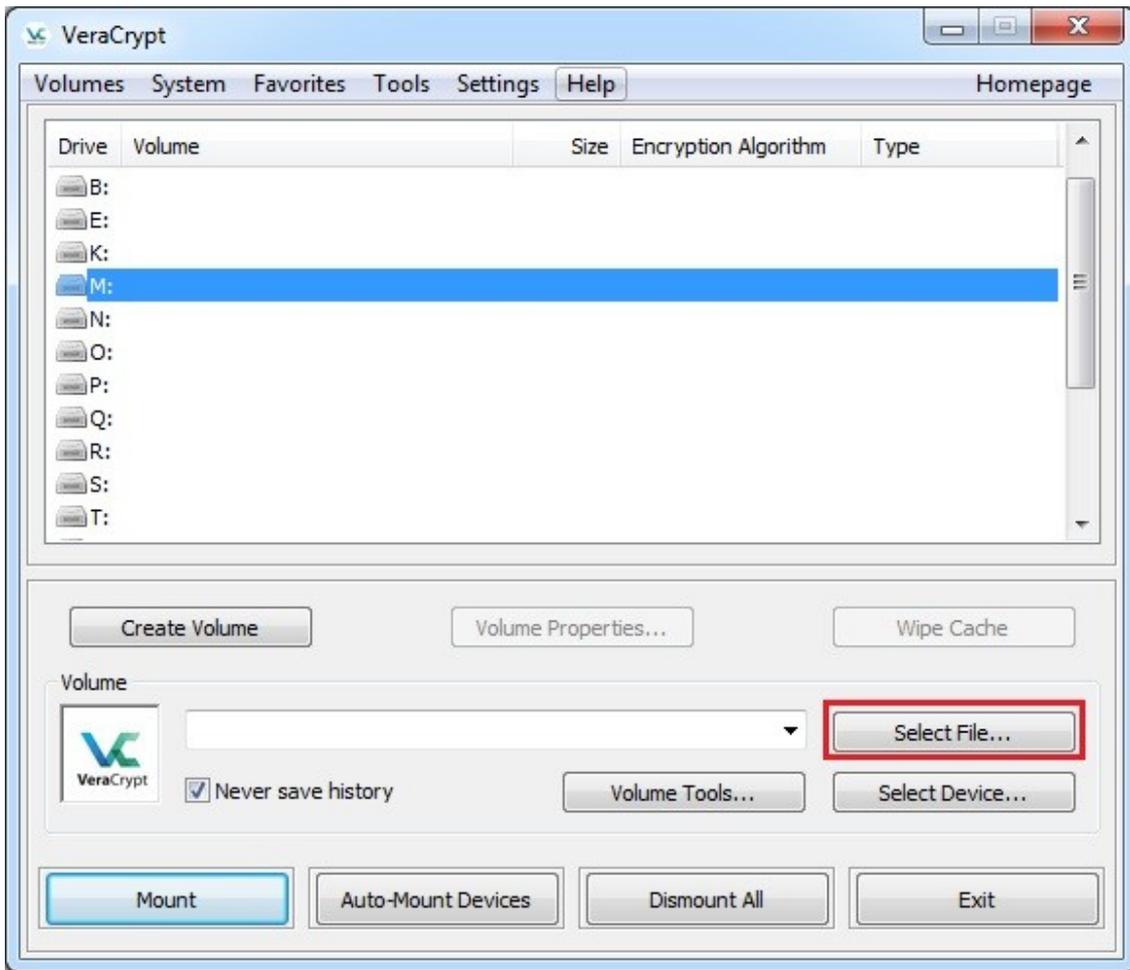
Click **Select File**.

The standard file selector window should appear.

STEP 15:
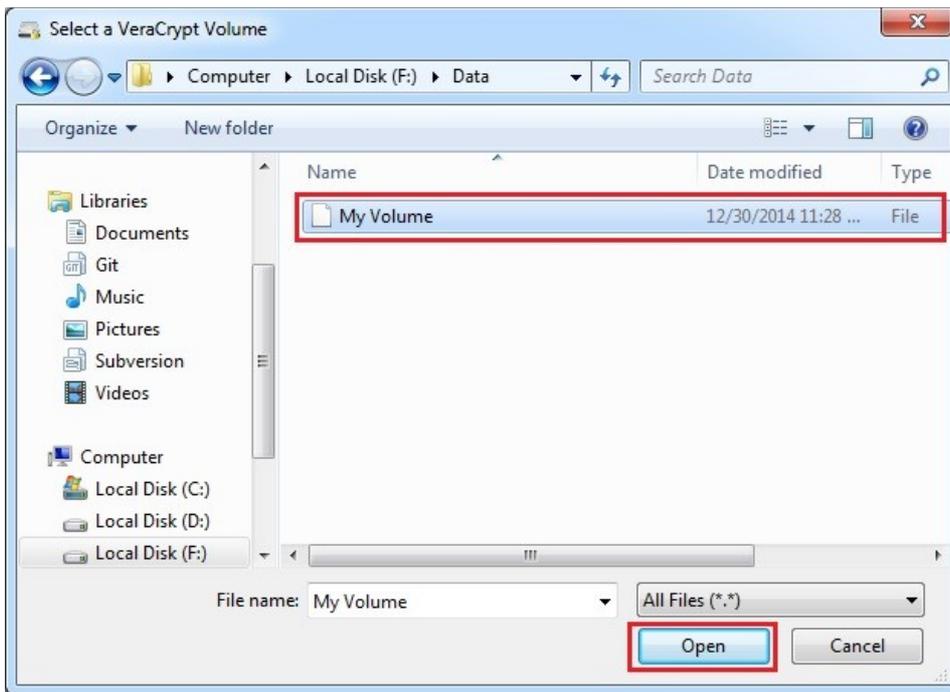
In the file selector, browse to the container file (which we created in Steps 6-11) and select it.

Click **Open** (in the file selector window).

The file selector window should disappear.

In the following steps, we will return to the main VeraCrypt window.

STEP 16:
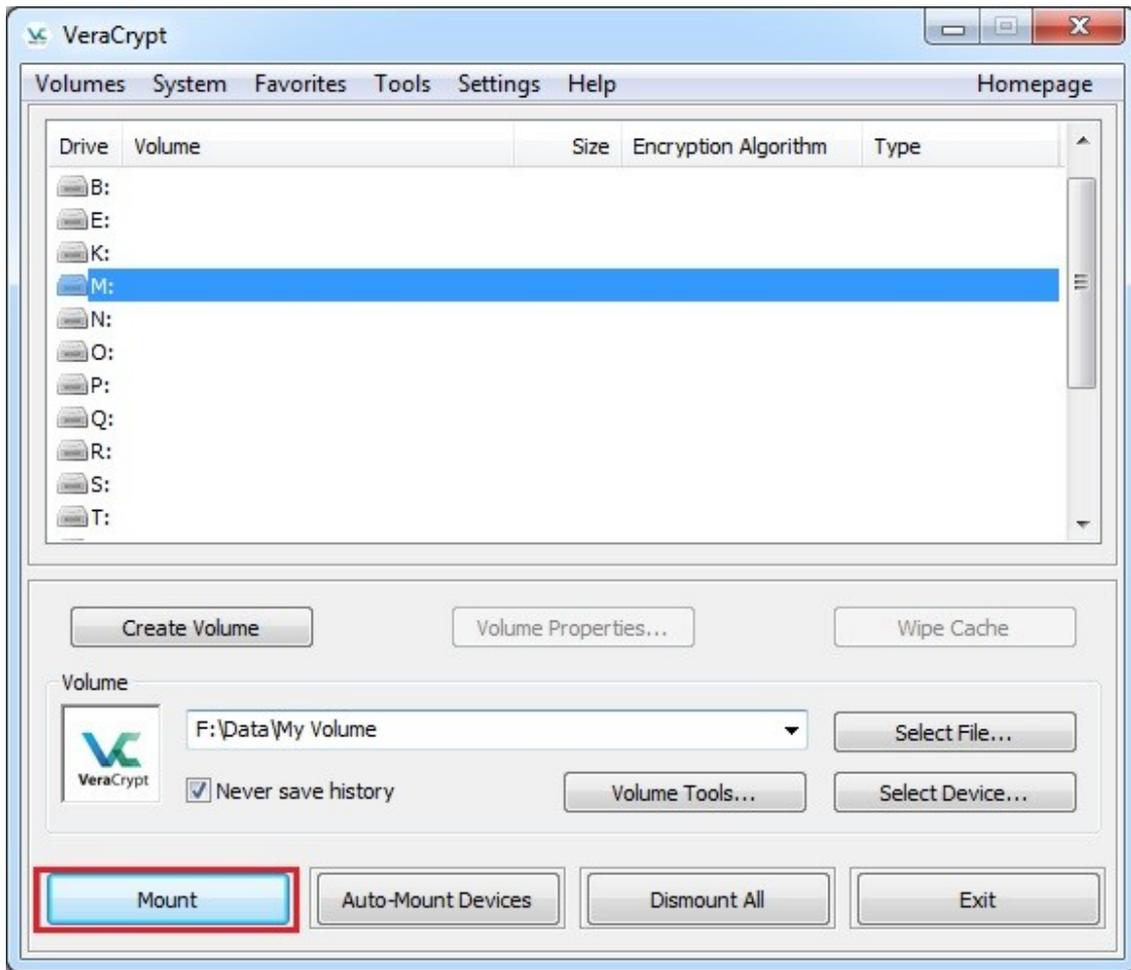
In the main VeraCrypt window, click **Mount**. Password

prompt dialog window should appear.

STEP 17:
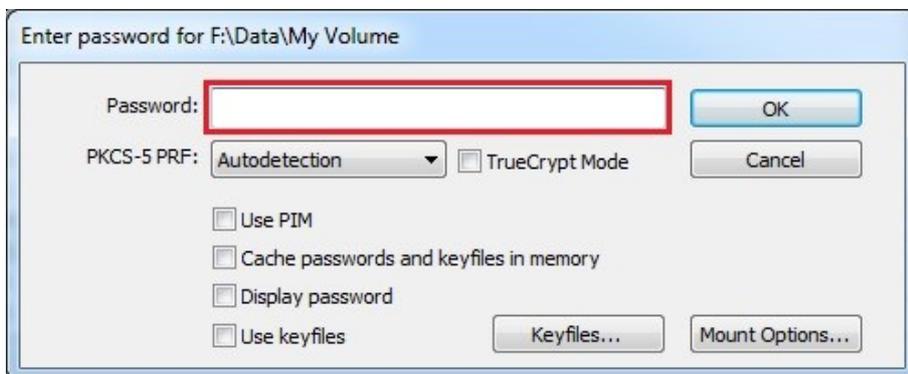
Type the password (which you specified in Step 10) in the password input field (marked with a red rectangle).

STEP 18:

Select the PRF algorithm that was used during the creation of the volume (SHA-512 is the default PRF used by VeraCrypt). If you don't remember which PRF was used, just leave it set to "autodetection" but the mounting process will take more time. Click **OK** after entering the password.

VeraCrypt will now attempt to mount the volume. If the password is incorrect (for example, if you typed it incorrectly), VeraCrypt will notify you and you will need to repeat the previous step (type the password again and click **OK**). If the password is correct, the volume will be mounted.
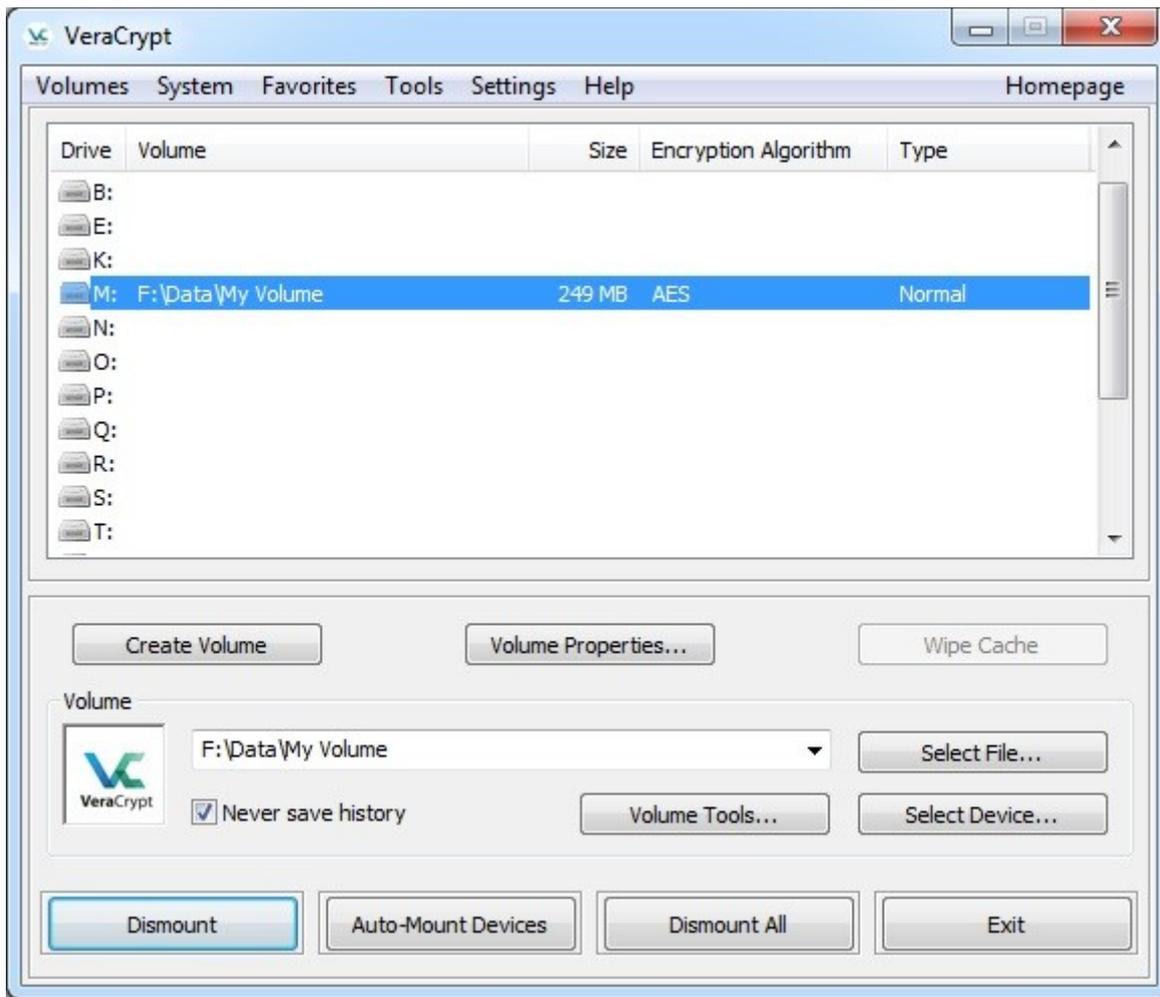
We have just successfully mounted the container as a virtual disk M:

The virtual disk is entirely encrypted (including file names, allocation tables, free space, etc.) and behaves like a real disk. You can save (or copy, move, etc.) files to this virtual disk and they will be encrypted on the fly as they are being written.

If you open a file stored on a VeraCrypt volume, for example, in media player, the file will be automatically decrypted to RAM (memory) on the fly while it is being read.

Important: Note that when you open a file stored on a VeraCrypt volume (or when you write/copy a file to/from the VeraCrypt volume) you will not be asked to enter the password again. You need to enter the correct password only when mounting the volume.

You can open the mounted volume, for example, by selecting it on the list as shown in the screenshot above (blue selection) and then double-clicking on the selected item.

You can also browse to the mounted volume the way you normally browse to any other types of volumes. For example, by opening the '*Computer*' (or '*My Computer*') list and double clicking the corresponding drive letter (in this case, it is the letter M).
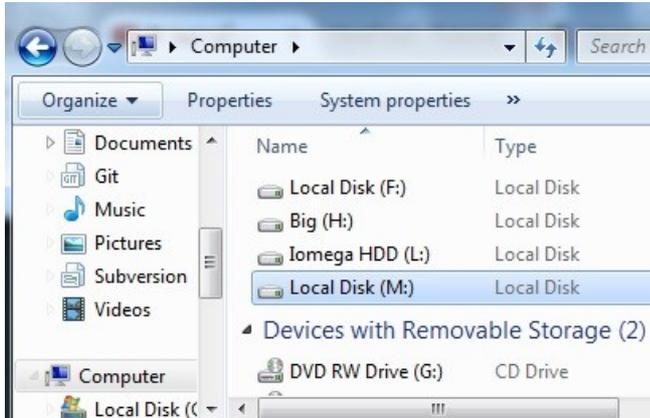
You can copy files (or folders) to and from the VeraCrypt volume just as you would copy them to any normal disk (for example, by simple drag-and-drop operations). Files that are being read or copied from the encrypted VeraCrypt volume are automatically decrypted on the fly in RAM (memory). Similarly, files that are being written or copied to the VeraCrypt volume are automatically   encrypted on the fly in RAM (right before they are written to the disk).

Note that VeraCrypt never saves any decrypted data to a disk – it only stores them temporarily in RAM (memory). Even when the volume is mounted, data stored in the volume is still encrypted. When you restart Windows or turn off your computer, the volume will be dismounted and all files stored on it will be inaccessible (and encrypted). Even when power supply is suddenly interrupted (without proper system shut down), all files stored on the volume will be inaccessible (and encrypted). To make them accessible again, you have to mount the volume. To do so, repeat Steps 13-18.

If you want to close the volume and make files stored on it inaccessible, either restart your operating system or dismount the volume. To do so, follow these steps:
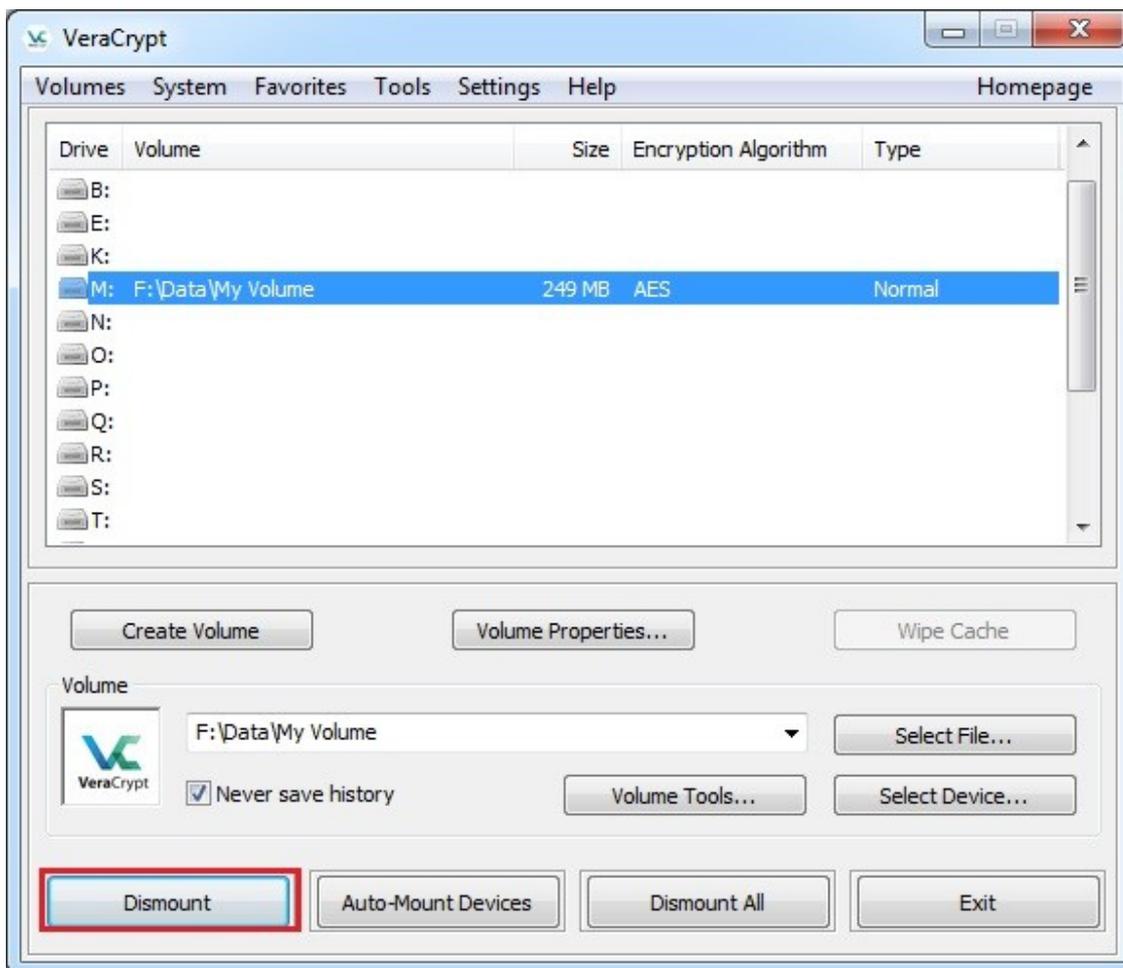
Select the volume from the list of mounted volumes in the main VeraCrypt window (marked with a red rectangle in the screenshot above) and then click **Dismount** (also marked with a red rectangle in the screenshot above). To make files stored on the volume accessible again, you will have to mount the volume. To do so, repeat Steps 13-18.

How to Create and Use a VeraCrypt-Encrypted Partition/Device

Instead of creating file containers, you can also encrypt physical partitions or drives (i.e., create VeraCrypt device-hosted volumes). To do so, repeat the steps 1-3 but in the step 3 select the second or third option. Then follow the remaining instructions in the wizard. When you create a device-hosted VeraCrypt volume within a *non-system* partition/drive, you can mount it by clicking *Auto-Mount Devices* in the main VeraCrypt window. For information pertaining to encrypted *system* partition/drives, see the chapter *System Encryption*.

Important: *We strongly recommend that you also read the other chapters of this manual, as they contain important information that has been omitted in this tutorial for simplicity.*

VeraCrypt Volume

There are two types of VeraCrypt volumes:
- File-hosted (container)
- Partition/device-hosted (non-system)

Note: In addition to creating the above types of virtual volumes, VeraCrypt can encrypt a physical partition/drive where Windows is installed (for more information, see the chapter *System Encryption*).

A VeraCrypt file-hosted volume is a normal file, which can reside on any type of storage device. It contains (hosts) a completely independent encrypted virtual disk device.

A VeraCrypt partition is a hard disk partition encrypted using VeraCrypt. You can also encrypt entire hard disks, USB hard disks, USB memory sticks, and other types of storage devices.

Creating a New VeraCrypt Volume

To create a new VeraCrypt file-hosted volume or to encrypt a partition/device (requires administrator privileges), click on 'Create Volume' in the main program window. VeraCrypt Volume Creation Wizard should appear. As soon as the Wizard appears, it starts collecting data that will be used in generating the master key, secondary key (XTS mode), and salt, for the new volume. The collected data, which should be as random as possible, include your mouse movements, key presses, and other values obtained from the system (for more information, please see the section *Random Number Generator*). The Wizard provides help and information necessary to successfully create a new VeraCrypt volume. However, several items deserve further explanation:

Hash Algorithm

Allows you to select which hash algorithm VeraCrypt will use. The selected hash algorithm is used by the random number generator (as a pseudorandom mixing function), which generates the master key, secondary key (XTS mode), and salt (for more information, please see the section *Random Number Generator*). It is also used in deriving the new volume header key and secondary header key (see the section *Header Key Derivation, Salt, and Iteration Count*).

For information about the implemented hash algorithms, see the chapter *Hash Algorithms*.

Note that the output of a hash function is *never* used directly as an encryption key. For more information, please refer to the chapter *Technical Details*.

Encryption Algorithm

This allows you to select the encryption algorithm with which your new volume will be encrypted. Note that the encryption algorithm cannot be changed after the volume is created. For more information, please see the chapter *Encryption Algorithms.*

Quick Format

If unchecked, each sector of the new volume will be formatted. This means that the new volume will be *entirely* filled with random data. Quick format is much faster but may be less secure because until the whole volume has been filled with files, it may be possible to tell how much data it contains (if the space was not filled with random data beforehand). If you are not sure whether to enable or disable Quick Format, we recommend that you leave this option unchecked. Note that Quick Format can only be enabled when encrypting partitions/devices.
Important: When encrypting a partition/device within which you intend to create a hidden volume afterwards, leave this option unchecked.

Dynamic

Dynamic VeraCrypt container is a pre-allocated NTFS sparse file whose physical size (actual disk space used) grows as new data is added to it. Note that the physical size of the container (actual disk space that the container uses) will not decrease when files are deleted on the VeraCrypt volume. The physical size of the container can only *increase* up to the maximum value that is specified by the user during the volume creation process. After the maximum specified size is reached, the physical size of the container will remain constant.

Note that sparse files can only be created in the NTFS file system. If you are creating a container in the FAT file system, the option *Dynamic* will be disabled ("grayed out").

Note that the size of a dynamic (sparse-file-hosted) VeraCrypt volume reported by Windows and by VeraCrypt will always be equal to its maximum size (which you specify when creating the volume). To find out current physical size of the container (actual disk space it uses), right-click the container file (in a Windows Explorer window, not in VeraCrypt), then select *Properties* and see the   *Size on disk* value.

WARNING: Performance of dynamic (sparse-file-hosted) VeraCrypt volumes is significantly worse than performance of regular volumes. Dynamic (sparse-file-hosted) VeraCrypt volumes are also less secure, because it is possible to tell which volume sectors are unused. Furthermore, if data is written to a dynamic volume when there is not enough free space in its host file system, the encrypted file system may get corrupted.

Cluster Size

Cluster is an allocation unit. For example, one cluster is allocated on a FAT file system for a one-byte file. When the file grows beyond the cluster boundary, another cluster is allocated. Theoretically, this means that the bigger the cluster size, the more disk space is wasted; however, the better the performance. If you do not know which value to use, use the default.

VeraCrypt Volumes on CDs and DVDs

If you want a VeraCrypt volume to be stored on a CD or a DVD, first create a file-hosted VeraCrypt container on a hard drive and then burn it onto a CD/DVD using any CD/DVD burning software (or, under Windows XP or later, using the CD burning tool provided with the operating system). Remember that if you need to mount a VeraCrypt volume that is stored on a read-only medium (such as a CD/DVD) under Windows 2000, you must format the VeraCrypt volume as FAT. The reason is that Windows 2000 cannot mount NTFS file system on read-only media (Windows XP and later versions of Windows can).

Hardware/Software RAID, Windows Dynamic Volumes

VeraCrypt supports hardware/software RAID as well as Windows dynamic volumes.

Windows Vista or later: Dynamic volumes are displayed in the 'Select Device' dialog window as `\Device\HarddiskVolume`*N*.

Windows XP/2000/2003: If you intend to format a Windows dynamic volume as a VeraCrypt volume, keep in mind that after you create the Windows dynamic volume (using the Windows Disk Management tool), you must restart the operating system in order for the volume to be available/displayed in the 'Select Device' dialog window of the VeraCrypt Volume Creation Wizard. Also note that, in the 'Select Device' dialog window, a Windows dynamic volume is *not* displayed as a single device (item). Instead, *all* volumes that the Windows dynamic volume consists of are displayed and you can select *any* of them in order to format the *entire* Windows dynamic volume.

Additional Notes on Volume Creation

After you click the 'Format' button in the Volume Creation Wizard window (the last step), there will be a short delay while your system is being polled for additional random data. Afterwards, the master key, header key, secondary key (XTS mode), and salt, for the new volume will be generated, and the master key and header key contents will be displayed.

For extra security, the portions of the randomness pool, master key, and header key can be prevented from being displayed by unchecking the checkbox in the upper right corner of the corresponding field:
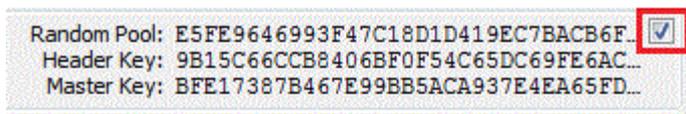
Note that only the first 128 bits of the pool/keys are displayed (not the entire contents).

You can create FAT (whether it will be FAT12, FAT16, or FAT32, is automatically determined from the number of clusters) or NTFS volumes (however, NTFS volumes can only be created by users with administrator privileges). Mounted VeraCrypt volumes can be reformatted as FAT12, FAT16, FAT32, or NTFS anytime. They behave as standard disk devices so you can right-click the drive letter of the mounted VeraCrypt volume (for example in the '*Computer*' or '*My Computer*' list) and select 'Format'.

For more information about creating VeraCrypt volumes, see also the section *Hidden Volume.*

Favorite Volumes

Favorite volumes are useful, for example, in any the following cases:

- You have a volume that always needs to be **mounted to a particular drive letter**.

- You have a volume that needs to be **automatically mounted when its host device gets connected to the computer** (for example, a container located on a USB flash drive or external USB hard drive).

- You have a volume that needs to be **automatically mounted when you log on** to the operating system.

- You have a volume that always needs to be **mounted as read-only** or removable medium.

To configure a VeraCrypt volume as a favorite volume, follow these steps:

1. Mount the volume (to the drive letter to which you want it to be mounted every time).
2. Right-click the mounted volume in the drive list in the main VeraCrypt window and select '*Add to Favorites*'.
3. The Favorite Volumes Organizer window should appear now. In this window, you can set various options for the volume (see below).
4. Click *OK*.

Favorite volumes can be mounted in several ways: To mount all favorite volumes, select *Favorites > Mount Favorite Volumes* or press the '*Mount Favorite Volumes*' hot key (*Settings > Hot Keys*). To mount only one of the favorite volumes, select it from the list contained in the *Favorites* menu. When you do so, you are asked for its password (and/or keyfiles) (unless it is cached) and if it is correct, the volume is mounted. If it is already mounted, an Explorer window is opened for it.

Selected or all favorite volumes can be mounted automatically whenever you log on to Windows. To set this up, follow these steps:

1. Mount the volume you want to have mounted automatically when you log on (mount it to the drive letter to which you want it to be mounted every time).
2. Right-click the mounted volume in the drive list in the main VeraCrypt window and select '*Add to Favorites*'.
3. The Favorites Organizer window should appear now. In this window, enable the option '*Mount selected volume upon logon*' and click *OK*.

Then, when you log on to Windows, you will be asked for the volume password (and/or keyfiles) and if it is correct, the volume will be mounted.

Note: VeraCrypt will not prompt you for a password if you have enabled caching of the pre-boot authentication password (*Settings > 'System Encryption'*) and the volumes use the same password as the system partition/drive.

Selected or all favorite volumes can be mounted automatically whenever its host device gets connected to the computer. To set this up, follow these steps:

1. Mount the volume (to the drive letter to which you want it to be mounted every time).
2. Right-click the mounted volume in the drive list in the main VeraCrypt window and select '*Add to Favorites*'.
3. The Favorites Organizer window should appear now. In this window, enable the option '*Mount selected volume when its host device gets connected*' and click *OK*.

Then, when you insert e.g. a USB flash drive on which a VeraCrypt volume is located into the USB port, you will be asked for the volume password (and/or keyfiles) (unless it is cached) and if it is correct, the volume will be mounted.

Note: VeraCrypt will not prompt you for a password if you have enabled caching of the pre-boot authentication password (*Settings* > '*System Encryption*') and the volume uses the same password as the system partition/drive.

A special label can be assigned to each favorite volume. This label is not the same as the filesystem label and it is shown within the VeraCrypt user interface instead of the volume path. To assign such a label, follow these steps:

1. Select *Favorites* > '*Organize Favorite Volumes*'.
2. The Favorite Volumes Organizer window should appear now. In this window, select the volume whose label you want to edit.
3. Enter the label in the '*Label of selected favorite volume*' input field and click OK.

Note that the Favorite Volumes Organizer window (*Favorites* > '*Organize Favorite Volumes*') allows you to **set various other options for each favorite volume**. For example, any of them can be mounted as read-only or as removable medium. To set any of these options, follow these steps:

1. Select *Favorites* > '*Organize Favorite Volumes*'.
2. The Favorite Volumes Organizer window should appear now. In this window, select the volume whose options you want to set.
3. Set the options and click OK.

The order in which system favorite volumes are displayed in the Favorites Organizer window (*Favorites* > '*Organize Favorite Volumes*') is **the order in which the volumes are mounted** when you select *Favorites* > *Mount Favorite Volumes* or when you press the '*Mount Favorite Volumes*' hotkey (*Settings* > *Hot Keys*). You can use the *Move Up* and *Move Down* buttons to change the order of the volumes.

Note that a favorite volume can also be a **partition that is within the key scope of system encryption mounted without pre-boot authentication** (for example, a partition located on the encrypted system drive of another operating system that is not running). When you mount such a volume and add it to favorites, you will no longer have to select *System > Mount Without Pre-Boot Authentication* or to enable the mount option '*Mount partition using system encryption without pre- boot authentication*'. You can simply mount the favorite volume (as explained above) without   setting any options, as the mode in which the volume is mounted is saved in the configuration file containing the list of your favorite volumes

Warning: When the drive letter assigned to a favorite volume (saved in the configuration file) is not free, the volume is not mounted and no error message is displayed.

To remove a volume form the list of favorite volumes, select *Favorites > Organize Favorite Volumes*, select the volume, click *Remove*, and click OK.

System Favorite Volumes

System favorites are useful, for example, in the following cases:

- You have volumes that need to be **mounted before system and application services start and before users start logging on**.

- There are network-shared folders located on VeraCrypt volumes. If you configure these volumes as system favorites, you will ensure that the **network shares will be automatically restored** by the operating system each time it is restarted.

- You need each such volume to be mounted as **the same drive letter** each time the operating system starts.

Note that, unlike the regular (non-system) favorites, **system favorite volumes use the pre-boot authentication password** and, therefore, require your system partition/drive to be encrypted (also note it is not required to enable caching of the pre-boot authentication password). Moreover, since the pre-boot password is typed using **US keyboard layout** (BIOS requirement), the password of the system favorite volume must be entered during its creation process using the **US keyboard layout** by typing the same keyboard keys you type when you enter the pre-boot authentication password. If the password of the system favorite volume is not identical to the pre-boot authentication password under the US keyboard layout, then **it will fail to mount**.

When creating a volume that you want to make a system favorite later, you must explicitly set the keyboard layout associated with VeraCrypt to US layout and you have to type the same keyboard keys you type when you enter the pre-boot authentication password.

System favorite volumes **can be configured to be available within VeraCrypt only to users with administrator privileges** (select *Settings* > '*System Favorite Volumes*' > '*Allow only administrators to view and dismount system favorite volumes in VeraCrypt*'). This option should be enabled on servers to ensure that system favorite volumes cannot be dismounted by users without administrator privileges. On non-server systems, this option can be used to prevent normal VeraCrypt volume actions (such as '*Dismount All*', auto-dismount, etc.) from affecting system favorite volumes. In addition, when VeraCrypt is run without administrator privileges (the default on Windows Vista and later), system favorite volumes will not be displayed in the drive letter list in the main VeraCrypt application window.

To configure a VeraCrypt volume as a system favorite volume, follow these steps:

1. Mount the volume (to the drive letter to which you want it to be mounted every time).
2. Right-click the mounted volume in the drive list in the main VeraCrypt window and select '*Add to System Favorites*'.
3. The System Favorites Organizer window should appear now. In this window, enable the option '*Mount system favorite volumes when Windows starts*' and click *OK*.

The order in which system favorite volumes are displayed in the System Favorites Organizer window (*Favorites* > '*Organize System Favorite Volumes*') is **the order in which the volumes are mounted**. You can use the *Move Up* and *Move Down* buttons to change the order of the volumes.

A special label can be assigned to each system favorite volume. This label is not the same as the filesystem label and it is shown within the VeraCrypt user interface instead of the volume path. To assign such a label, follow these steps:

1. Select *Favorites* > '*Organize System Favorite Volumes*'.
2. The System Favorites Organizer window should appear now. In this window, select the volume whose label you want to edit.
3. Enter the label in the '*Label of selected favorite volume*' input field and click OK.

Note that the System Favorites Organizer window (*Favorites* > '*Organize System Favorite Volumes*') allows you to **set various options for each system favorite volume**. For example, any of them can be mounted as read-only or as removable medium.

Warning: When the drive letter assigned to a system favorite volume (saved in the configuration file) is not free, the volume is not mounted and no error message is displayed.

Note that Windows needs to use some files (e.g. paging files, Active Directory files, etc.) before system favorite volumes are mounted. Therefore, such files cannot be stored on system favorite volumes. Note, however, that they *can* be stored on any partition that is within the key scope of system encryption (e.g. on the system partition or on any partition of a system drive that is entirely encrypted by VeraCrypt).

To remove a volume from the list of system favorite volumes, select *Favorites* > *Organize System Favorite Volumes*, select the volume, click *Remove*, and click OK.

System Encryption

VeraCrypt can on-the-fly encrypt a system partition or entire system drive, i.e. a partition or drive where Windows is installed and from which it boots.

System encryption provides the highest level of security and privacy, because all files, including any temporary files that Windows and applications create on the system partition (typically, without your knowledge or consent), hibernation files, swap files, etc., are always permanently encrypted (even when power supply is suddenly interrupted). Windows also records large amounts of potentially sensitive data, such as the names and locations of files you open, applications you run, etc. All such log files and registry entries are always permanently encrypted as well.

System encryption involves pre-boot authentication, which means that anyone who wants to gain access and use the encrypted system, read and write files stored on the system drive, etc., will need to enter the correct password each time before Windows boots (starts). Pre-boot authentication is handled by the VeraCrypt Boot Loader, which resides in the first track of the boot drive and on the VeraCrypt Rescue Disk (see below).

Note that VeraCrypt can encrypt an existing unencrypted system partition/drive in-place while the operating system is running (while the system is being encrypted, you can use your computer as usual without any restrictions). Likewise, a VeraCrypt-encrypted system partition/drive can be decrypted in-place while the operating system is running. You can interrupt the process of encryption or decryption anytime, leave the partition/drive partially unencrypted, restart or shut down the computer, and then resume the process, which will continue from the point it was stopped.

The mode of operation used for system encryption is XTS (see the section *Modes of Operation*). For further technical details of system encryption, see the section *Encryption Scheme* in the chapter *Technical Details*.

To encrypt a system partition or entire system drive, select *System > Encrypt System Partition/Drive* and then follow the instructions in the wizard. To decrypt a system partition/drive, select *System > Permanently Decrypt System Partition/Drive*.

Because of BIOS requirement, the pre-boot password is typed using **US keyboard layout.** During the system encryption process, VeraCrypt automatically and transparently switches the keyboard to US layout in order to ensure that the password value typed will match the one typed in pre-boot mode. Thus, in order to avoid wrong password errors, one must type the password using the same keys as when creating the system encryption.

Note: By default, Windows 7 and later boot from a special small partition. The partition contains files that are required to boot the system. Windows allows only applications that have administrator privileges to write to the partition (when the system is running). VeraCrypt encrypts the partition only if you choose to encrypt the whole system drive (as opposed to choosing to encrypt only the partition where Windows is installed).

Hidden Operating System

It may happen that you are forced by somebody to decrypt the operating system. There are many situations where you cannot refuse to do so (for example, due to extortion). VeraCrypt allows you to create a hidden operating system whose existence should be impossible to prove (provided that certain guidelines are followed). Thus, you will not have to decrypt or reveal the password for the hidden operating system. For more information, see the section *Hidden Operating System* in the chapter *Plausible Deniability*.

Operating Systems Supported for System Encryption

Note: After this version of VeraCrypt was released, a new version of an operating system may have been released and verified to be fully compatible with VeraCrypt. Therefore, if this is the latest stable version of VeraCrypt, you should check the online version of this chapter at: https://veracrypt.codeplex.com/wikipage?title=Supported%20Systems%20for%20System%20Encryption

VeraCrypt can currently encrypt the following operating systems (UEFI is supported only on 64-bit systems starting from Windows 8):

- Windows 10
- Windows 8 and 8.1
- Windows 7
- Windows Vista (SP1 or later)
- Windows XP
- Windows Server 2012
- Windows Server 2008 and Windows Server 2008 R2 (64-bit)
- Windows Server 2003

Note: The following operating systems (among others) are not supported: Windows RT, Windows 2003 IA-64, Windows 2008 IA-64,   Windows XP IA-64, and the Embedded/Tablet versions of Windows.

Also see the section *Supported Operating Systems*.

VeraCrypt Rescue Disk

During the process of preparing the encryption of a system partition/drive, VeraCrypt requires that you create a so-called VeraCrypt Rescue Disk (CD/DVD), which serves the following purposes:

- If the VeraCrypt Boot Loader screen does not appear after you start your computer (or if Windows does not boot), the **VeraCrypt Boot Loader may be damaged**. The VeraCrypt Rescue Disk allows you restore it and thus to regain access to your encrypted system and data (however, note that you will still have to enter the correct password then). In the Rescue Disk screen, select *Repair Options > Restore VeraCrypt Boot Loader*. Then press 'Y' to confirm the action, remove the Rescue Disk from your CD/DVD drive and restart your computer.

- If the **VeraCrypt Boot Loader is frequently damaged** (for example, by inappropriately designed activation software) or if **you do not want the VeraCrypt boot loader to reside on the hard drive** (for example, if you want to use an alternative boot loader/manager for other operating systems), you can boot directly from the VeraCrypt Rescue Disk (as it contains the VeraCrypt boot loader too) without restoring the boot loader to the hard drive. Just insert your Rescue Disk into your CD/DVD drive and then enter your password in the Rescue Disk screen.

- If you repeatedly enter the correct password but VeraCrypt says that the password is incorrect, it is possible that the **master key or other critical data are damaged**. The VeraCrypt Rescue Disk allows you to restore them and thus to regain access to your encrypted system and data (however, note that you will still have to enter the correct password then). In the Rescue Disk screen, select *Repair Options > Restore key data*. Then enter your password, press 'Y' to confirm the action, remove the Rescue Disk from

your CD/DVD drive, and restart your computer.

Note: This feature cannot be used to restore the header of a hidden volume within which a hidden operating system resides (see the section *Hidden Operating System*). To restore such a volume header, click *Select Device*, select the partition behind the decoy system partition, click *OK*, select *Tools > Restore Volume Header* and then follow the instructions.

WARNING: By restoring key data using a VeraCrypt Rescue Disk, you also restore the password that was valid when the VeraCrypt Rescue Disk was created. Therefore, whenever you change the password, you should destroy your VeraCrypt Rescue Disk and create a new one (select *System > Create Rescue Disk*). Otherwise, if an attacker knows your old password (for example, captured by a keystroke logger) and if he then finds your old VeraCrypt Rescue Disk, he could use it to restore the key data (the master key encrypted with the old password) and thus decrypt your system partition/drive.

- If **Windows is damaged and cannot start**, the VeraCrypt Rescue Disk allows you to permanently decrypt the partition/drive before Windows starts. In the Rescue Disk screen, select *Repair Options > Permanently decrypt system partition/drive*. Enter the correct password and wait until decryption is complete. Then you can e.g. boot your MS Windows setup CD/DVD to repair your Windows installation. Note that this feature cannot be used to decrypt a hidden volume within which a hidden operating system resides (see the section *Hidden Operating System*).

  Note: Alternatively, if Windows is damaged (cannot start) and you need to repair it (or access files on it), you can avoid decrypting the system partition/drive by following these steps: If you have multiple operating systems installed on your computer, boot the one that does not require pre-boot authentication. If you do not have multiple operating systems installed on your computer, you can boot a WinPE or BartPE CD/DVD or you can connect your system drive as a secondary or external drive to another computer and then boot the operating system installed on the computer. After you boot a system, run VeraCrypt, click *Select Device*, select the affected system partition, click *OK* , select *System > Mount Without Pre-Boot Authentication*, enter your pre-boot-authentication password and click *OK*. The partition will be mounted as a regular VeraCrypt volume (data will be on-the-fly decrypted/encrypted in RAM on access, as usual).

- Your VeraCrypt Rescue Disk contains a **backup of the original content of the first drive track** (made before the VeraCrypt Boot Loader was written to it) and allows you to restore it if necessary. The first track typically contains a system loader or boot manager. In the Rescue Disk screen, select *Repair Options > Restore original system loader*.

*Note that even if you lose your VeraCrypt Rescue Disk and an attacker finds it, he or she will **not** be able to decrypt the system partition or drive without the correct password.*

To boot a VeraCrypt Rescue Disk, insert it into your CD/DVD drive and restart your computer. If the VeraCrypt Rescue Disk screen does not appear (or if you do not see the 'Repair Options' item in the 'Keyboard Controls' section of the screen), it is possible that your BIOS is configured to attempt to boot from hard drives before CD/DVD drives. If that is the case, restart your computer, press F2 or Delete (as soon as you see a BIOS start-up screen), and wait until a BIOS configuration screen appears. If no BIOS configuration screen appears, restart (reset) the computer again and start pressing F2 or Delete repeatedly as soon as you restart (reset) the computer. When a BIOS configuration screen appears, configure your BIOS to boot from the CD/DVD drive first (for

information on how to do so, please refer to the documentation for your BIOS/motherboard or contact your computer vendor's technical support team for assistance). Then restart your computer. The VeraCrypt Rescue Disk screen should appear now. Note: In the VeraCrypt Rescue   Disk screen, you can select 'Repair Options' by pressing F8 on your keyboard.

If your VeraCrypt Rescue Disk is damaged, you can create a new one by selecting *System > Create Rescue Disk*. To find out whether your VeraCrypt Rescue Disk is damaged, insert it into your CD/DVD drive and select *System > Verify Rescue Disk*.

Plausible Deniability

In case an adversary forces you to reveal your password, VeraCrypt provides and supports two kinds of plausible deniability:

1. Hidden volumes (see the section *Hidden Volume* below) and hidden operating systems (see the section *Hidden Operating System*).

2. Until decrypted, a VeraCrypt partition/device appears to consist of nothing more than random data (it does not contain any kind of "signature"). Therefore, it should be impossible to *prove* that a partition or a device is a VeraCrypt volume or that it has been encrypted (provided that the security requirements and precautions listed in the chapter *Security Requirements and Precautions* are followed). A possible plausible explanation for the existence of a partition/device containing solely random data is that you have wiped (securely erased) the content of the partition/device using one of the tools that erase data by overwriting it with random data (in fact, VeraCrypt can be used to securely erase a partition/device too, by creating an empty encrypted partition/device-hosted volume within it). However, you need to prevent data leaks (see the section *Data Leaks*) and also note that, for system encryption, the first drive track contains the (unencrypted) VeraCrypt Boot Loader,   which can be easily identified as such (for more information, see the chapter *System Encryption*). When using system encryption, plausible deniability can be achieved by creating a hidden operating system (see the section *Hidden Operating System*).

   Although file-hosted VeraCrypt volumes (containers) do not contain any kind of "signature" either (until decrypted, they appear to consist solely of random data), they cannot provide this kind of plausible deniability, because there is practically no plausible explanation for the   existence of a file containing solely random data. However, plausible deniability can still be achieved with a file-hosted VeraCrypt volume (container) by creating a hidden volume   within it (see above).

Notes

- When formatting a hard disk partition as a VeraCrypt volume (or encrypting a partition in place), the partition table (including the partition type) is *never* modified (no VeraCrypt "signature" or "ID" is written to the partition table).

- There are methods to find files or devices containing random data (such as VeraCrypt volumes). Note, however, that this should *not* affect plausible deniability in any way. The adversary still should not be able to *prove* that the partition/device is a VeraCrypt volume or that the file, partition, or device, contains a hidden VeraCrypt volume (provided that you follow the security requirements and precautions listed in the chapter *Security Requirements and Precautions* and in the subsection *Security Requirements and Precautions Pertaining to Hidden Volumes*).

Hidden Volume

It may happen that you are forced by somebody to reveal the password to an encrypted volume. There are many situations where you cannot refuse to reveal the password (for example, due to extortion). Using a so-called hidden volume allows you to solve such situations without revealing the password to your volume.
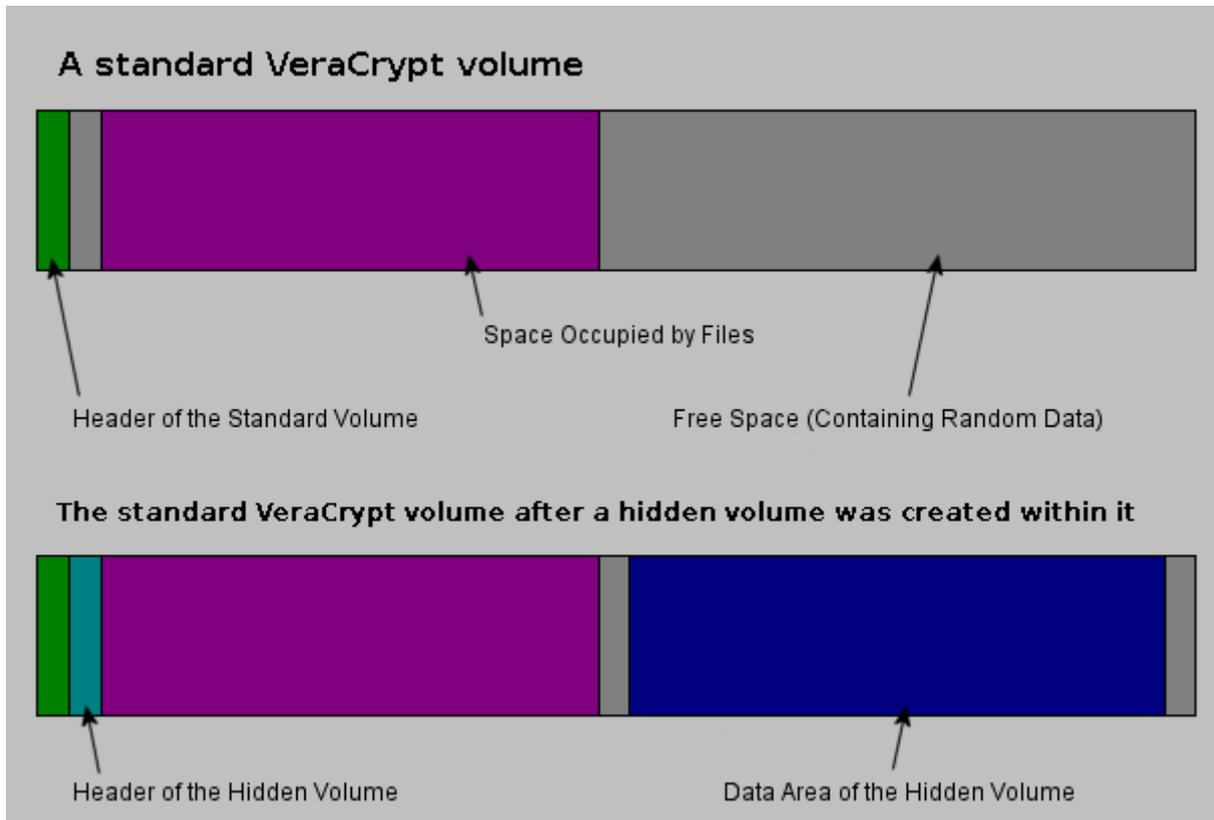
The layout of a standard VeraCrypt volume before and after a hidden volume was created within it.

The principle is that a VeraCrypt volume is created within another VeraCrypt volume (within the free   space on the volume). Even when the outer volume is mounted, it should be impossible to prove whether there is a hidden volume within it or not[*], because free space on *any* VeraCrypt volume is always filled with random data when the volume is created[†] and no part of the (dismounted) hidden volume can be distinguished from random data. Note that VeraCrypt does not modify the file system (information about free space, etc.) within the outer volume in any way.

The password for the hidden volume must be substantially different from the password for the outer volume. To the outer volume, (before creating the hidden volume within it) you should copy some sensitive-looking files that you actually do NOT want to hide. These files will be there for

---

[*] Provided that all the instructions in the VeraCrypt Volume Creation Wizard have been followed and provided that the requirements and precautions listed in the subsection '*Security Requirements and Precautions Pertaining to Hidden Volumes*' are followed.

† Provided that the options *Quick Format* and *Dynamic* are disabled and provided that the volume does not contain a filesystem that has been encrypted in place (VeraCrypt does not allow the user to create a hidden volume within such a volume). For information on the method used to fill free volume space with random data, see chapter *Technical Details*, section *VeraCrypt Volume Format Specification.*

anyone who would force you to hand over the password. You will reveal only the password for the outer volume, not for the hidden one. Files that really are sensitive will be stored on the hidden volume.

A hidden volume can be mounted the same way as a standard VeraCrypt volume: Click *Select File* or *Select Device* to select the outer/host volume (important: make sure the volume is *not* mounted). Then click *Mount*, and enter the password for the hidden volume. Whether the hidden or the outer volume will be mounted is determined by the entered password (i.e., when you enter the password for the outer volume, then the outer volume will be mounted; when you enter the password for the hidden volume, the hidden volume will be mounted).

VeraCrypt first attempts to decrypt the standard volume header using the entered password. If it fails, it loads the area of the volume where a hidden volume header can be stored (i.e. bytes 65536–131071, which contain solely random data when there is no hidden volume within the volume) to RAM and attempts to decrypt it using the entered password. Note that hidden volume headers cannot be identified, as they appear to consist entirely of random data. If the header is successfully decrypted (for information on how VeraCrypt determines that it was successfully decrypted, see the section *Encryption Scheme*), the information about the size of the hidden volume is retrieved from the decrypted header (which is still stored in RAM), and the hidden volume is mounted (its size also determines its offset).

A hidden volume can be created within any type of VeraCrypt volume, i.e., within a file-hosted volume or partition/device-hosted volume (requires administrator privileges). To create a hidden VeraCrypt volume, click on *Create Volume* in the main program window and select *Create a hidden VeraCrypt volume*. The Wizard will provide help and all information necessary to successfully create a hidden VeraCrypt volume.
When creating a hidden volume, it may be very difficult or even impossible for an inexperienced user to set the size of the hidden volume such that the hidden volume does not overwrite data on the outer volume. Therefore, the Volume Creation Wizard automatically scans the cluster bitmap of the outer volume (before the hidden volume is created within it) and determines the maximum possible size of the hidden volume.[*]

If there are any problems when creating a hidden volume, refer to the chapter *Troubleshooting* for possible solutions.

Note that it is also possible to create and boot an operating system residing in a hidden volume (see the section *Hidden Operating System* in the chapter *Plausible Deniability*).

---

* The wizard scans the cluster bitmap to determine the size of the uninterrupted area of free space (if there is any) whose end is aligned with the end of the outer volume. This area accommodates the hidden volume and therefore the size of this area limits the maximum possible size of the hidden volume. On Linux and Mac OS X, the wizard actually does not scan the cluster bitmap, but the driver detects any data written to the outer volume and uses their position as previously described.

Protection of Hidden Volumes Against Damage

If you mount a VeraCrypt volume within which there is a hidden volume, you may *read* data stored on the (outer) volume without any risk. However, if you (or the operating system) need to *save* data to the outer volume, there is a risk that the hidden volume will get damaged (overwritten). To prevent this, you should protect the hidden volume in a way described in this section.

When mounting an outer volume, type in its password and before clicking *OK,* click *Mount Options*:
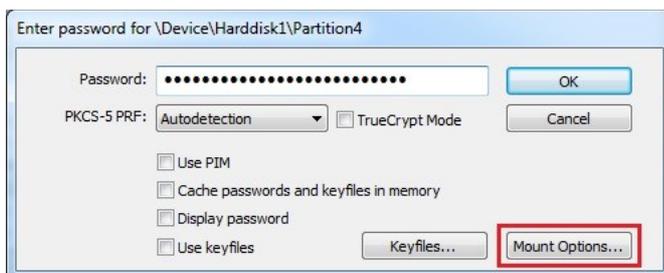
In the *Mount Options* dialog window, enable the option '*Protect hidden volume against damage caused by writing to outer volume* '. In the '*Password to hidden volume*' input field, type the password for the hidden volume. Click *OK* and, in the main password entry dialog, click *OK*.
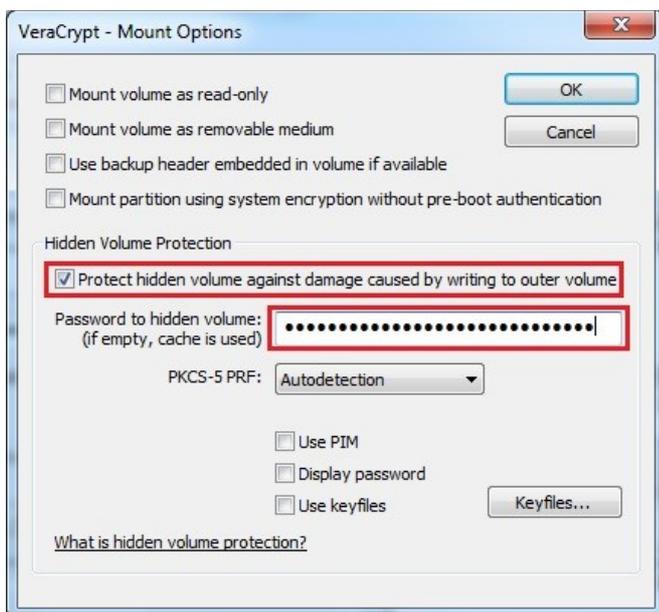
Both passwords must be correct; otherwise, the outer volume will not be mounted. When hidden volume protection is enabled, VeraCrypt does *not* actually mount the hidden volume. It only decrypts its header (in RAM) and retrieves information about the size of the hidden volume (from the decrypted header). Then, the outer volume is mounted and any attempt to save data to the area of the hidden volume will be rejected (until the outer volume is dismounted). **Note that VeraCrypt *never* modifies the filesystem (e.g., information about allocated clusters, amount of free space, etc.) within the outer volume in any way. As soon as the volume is dismounted, the protection is lost. When the volume is mounted again, it is *not* possible to determine whether the volume has used hidden volume protection or not. The hidden**

volume protection can be activated only by users who supply the correct password (and/or keyfiles) for the hidden volume (each time they mount the outer volume).

As soon as a write operation to the hidden volume area is denied/prevented (to protect the hidden volume), the entire host volume (both the outer and the hidden volume) becomes write-protected until dismounted (the VeraCrypt driver reports the 'invalid parameter' error to the system upon each attempt to write data to the volume). This preserves plausible deniability (otherwise certain kinds of inconsistency within the file system could indicate that this volume has used hidden volume protection). When damage to hidden volume is prevented, a warning is displayed (provided that the   VeraCrypt Background Task is enabled – see the chapter *VeraCrypt Background Task*).

Furthermore, the type of the mounted outer volume displayed in the main window changes to '*Outer(!)*':
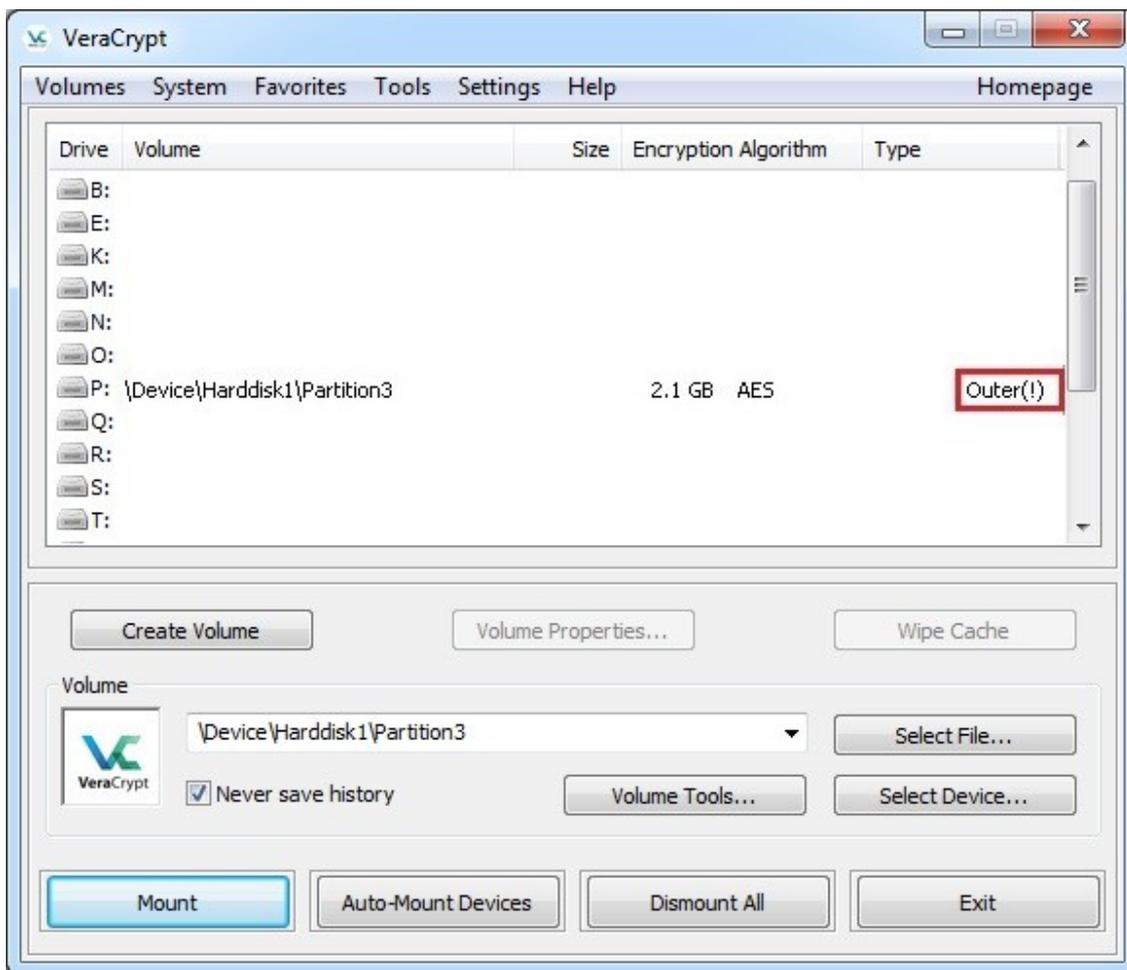
Moreover, the field *Hidden Volume Protected* in the *Volume Properties* dialog window says: '*Yes (damage prevented!)*'.

Note that when damage to hidden volume is prevented, *no* information about the event is written to the volume. When the outer volume is dismounted and mounted again, the volume properties will *not* display the string "*damage prevented*".

There are several ways to check that a hidden volume is being protected against damage:

1. A confirmation message box saying that hidden volume is being protected is displayed after the outer volume is mounted (if it is not displayed, the hidden volume is not protected!).
2. In the *Volume Properties* dialog, the field *Hidden Volume Protected* says '*Yes*':
3. The type of the mounted outer volume is *Outer*:
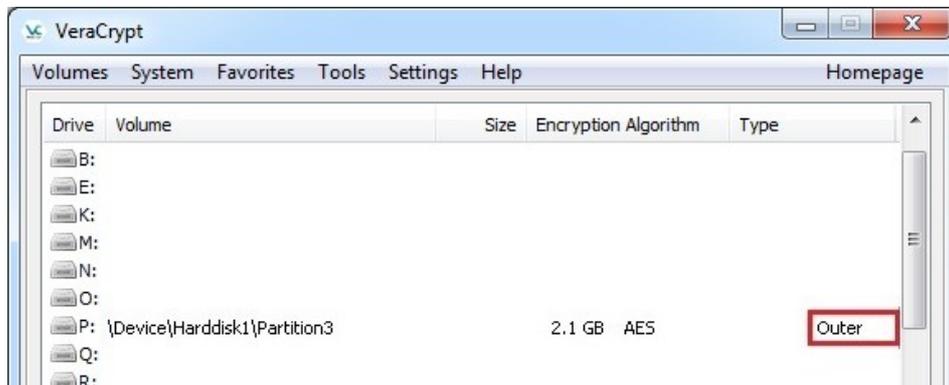
Important: You are the only person who can mount your outer volume with the hidden volume protection enabled (since nobody else knows your hidden volume password). When an adversary asks you to mount an outer volume, you of course must not mount it with the hidden volume protection enabled. You must mount it as a normal volume (and then VeraCrypt will not show the volume type "Outer" but "Normal"). The reason is that, during the time when an outer volume is mounted with the hidden volume protection enabled, the adversary can find out that a hidden volume exists within the outer volume (he/she will be able to find it out until the volume is dismounted and possibly even some time after the computer has been powered off – see [Unencrypted Data in RAM](#)).

Warning: Note that the option '*Protect hidden volume against damage caused by writing to outer volume*' in the *Mount Options* dialog window is automatically disabled after a mount attempt is completed, no matter whether it is successful or not (all hidden volumes that are already being protected will, of course, continue to be protected). Therefore, you need to check that option *each* time you attempt to mount the outer volume (if you wish the hidden volume to be protected):
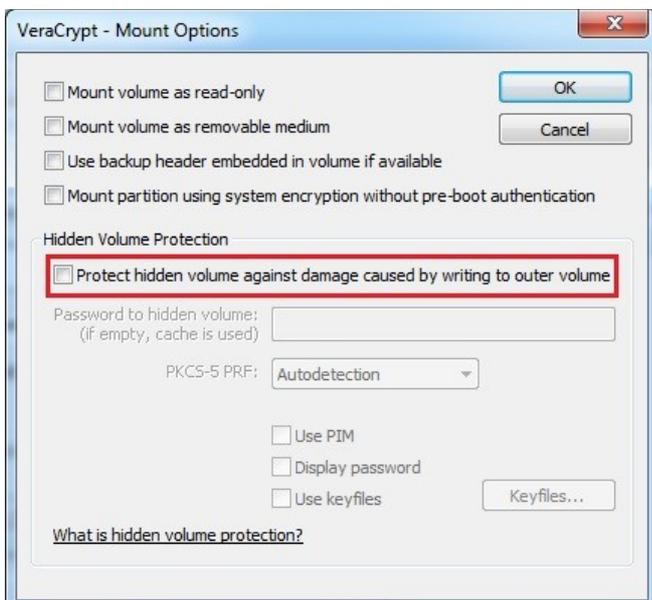
If you want to mount an outer volume and protect a hidden volume within using cached passwords, then follow these steps: Hold down the *Control* (*Ctrl*) key when clicking *Mount* (or select *Mount with Options* from the *Volumes* menu). This will open the *Mount Options* dialog. Enable the option '*Protect hidden volume against damage caused by writing to outer volume*' and leave the password box empty. Then click *OK*.

If you need to mount an outer volume and you know that you will not need to save any data to it, then the most comfortable way of protecting the hidden volume against damage is mounting the outer volume as read-only (see the section *Mount Options*).

Security Requirements and Precautions Pertaining to Hidden Volumes

If you use a hidden VeraCrypt volume, you must follow the security requirements and precautions listed below in this section. Disclaimer: This section is not guaranteed to contain a list of *all* security issues and attacks that might adversely affect or limit the ability of VeraCrypt to secure data stored in a hidden VeraCrypt volume and the ability to provide plausible deniability.

- If an adversary has access to a (dismounted) VeraCrypt volume at several points over time, he may be able to determine which sectors of the volume are changing. If you change the contents of a hidden volume (e.g., create/copy new files to the hidden volume or modify/delete/rename/move files stored on the hidden volume, etc.), the contents of sectors (ciphertext) in the hidden volume area will change. After being given the password to the outer volume, the adversary might demand an explanation why these sectors changed. Your failure to provide a plausible explanation might indicate the existence of a hidden volume within the outer volume.

  Note that issues similar to the one described above may also arise, for example, in the following cases:

  - The file system in which you store a file-hosted VeraCrypt container has been defragmented and a copy of the VeraCrypt container (or of its fragment) remains in the free space on the host volume (in the defragmented file system). To prevent this, do one of the following:
    - Use a partition/device-hosted VeraCrypt volume instead of file-hosted.
    - Securely erase free space on the host volume (in the defragmented file system) after defragmenting. On Windows, this can be done using the Microsoft free utility SDelete.   On Linux, the `shred` utility from GNU coreutils package can be used for this purpose.
    - Do not defragment file systems in which you store VeraCrypt volumes.

  - A file-hosted VeraCrypt container is stored in a journaling file system (such as NTFS). A copy of the VeraCrypt container (or of its fragment) may remain on the host volume. To prevent this, do one the following:
    - Use a partition/device-hosted VeraCrypt volume instead of file-hosted.
    - Store the container in a non-journaling file system (for example, FAT32).

  - A VeraCrypt volume resides on a device/filesystem that utilizes a wear-leveling mechanism (e.g. a flash-memory SSD or USB flash drive). A copy of (a fragment of) the VeraCrypt volume may remain on the device. Therefore, do not store hidden volumes on such devices/filesystems. For more information on wear-leveling, see the section *Wear-Leveling* in the chapter *Security Requirements and Precautions*.

  - A VeraCrypt volume resides on a device/filesystem that saves data (or on a device/filesystem that is controlled or monitored by a system/device that saves data)

(e.g. the value of a timer or counter) that can be used to determine that a block had been written earlier than another block and/or to determine how many times a block has been written/read. Therefore, do not store hidden volumes on such devices/filesystems. To find out whether a device/system saves such data, please refer to documentation supplied with the device/system or contact the vendor/manufacturer.

- o A VeraCrypt volume resides on a device that is prone to wear (it is possible to determine that a block has been written/read more times than another block). Therefore, do not store hidden volumes on such devices/filesystems. To find out whether a device is prone to such wear, please refer to documentation supplied with the device or contact the vendor/manufacturer.

- o You back up content of a hidden volume by cloning its host volume or create a new hidden volume by cloning its host volume. Therefore, you must not do so. Follow the instructions in the chapter *How to Back Up Securely* and in the section *Volume Clones*.

- Make sure that *Quick Format* is disabled when encrypting a partition/device within which you intend to create a hidden volume.

- On Windows, make sure you have not deleted any files within a volume within which you intend to create a hidden volume (the cluster bitmap scanner does not detect deleted files).

- On Linux or Mac OS X, if you intend to create a hidden volume within a file-hosted VeraCrypt volume, make sure that the volume is not sparse-file-hosted (the Windows version of VeraCrypt verifies this and disallows creation of hidden volumes within sparse files).

- When a hidden volume is mounted, the operating system and third-party applications may write to non-hidden volumes (typically, to the unencrypted system volume) unencrypted information about the data stored in the hidden volume (e.g. filenames and locations of recently accessed files, databases created by file indexing tools, etc.), the data itself in an unencrypted form (temporary files, etc.), unencrypted information about the filesystem residing in the hidden volume (which might be used e.g. to identify the filesystem and to determine whether it is the filesystem residing in the outer volume), the password/key for the hidden volume, or other types of sensitive data. Therefore, the following security requirements and precautions must be followed:

  - o *Windows*: Create a hidden operating system (for information on how to do so, see the section *Hidden Operating System*) and mount hidden volumes only when the hidden operating system is running. Note: When a hidden operating system is running, VeraCrypt ensures that all local unencrypted filesystems and non-hidden VeraCrypt volumes are read-only (i.e. no files can be written to such filesystems or VeraCrypt volumes).* Data is allowed to be written to filesystems within hidden VeraCrypt volumes. Alternatively, if a hidden operating system cannot be used, use a "live-CD" Windows PE system (entirely stored on and booted from a CD/DVD) that ensures that any data written to the system volume is written to a RAM disk. Mount hidden volumes only when such a "live-CD" system is running (if a hidden operating system cannot be used). In addition, during such a "live-CD" session, only filesystems that reside in hidden VeraCrypt volumes may be mounted in read-write mode (outer or unencrypted volumes/filesystems must be mounted as read-only or must not be mounted/accessible at all); otherwise, you must ensure that applications and the operating system do not write any sensitive data (see above) to non-hidden volumes/filesystems during the "live-CD" session.

---

* This does not apply to filesystems on CD/DVD-like media and on custom, untypical, or non-standard devices/media.

- *Linux*: Download or create a "live-CD" version of your operating system (i.e. a "live" Linux system entirely stored on and booted from a CD/DVD) that ensures that any data written to the system volume is written to a RAM disk. Mount hidden volumes only when such a "live-CD" system is running. During the session, only filesystems that reside in hidden VeraCrypt volumes may be mounted in read-write mode (outer or unencrypted volumes/filesystems must be mounted as read-only or must not be mounted/accessible at all). If you cannot comply with this requirement and you are not able to ensure that applications and the operating system do not write any sensitive data (see above) to non-hidden volumes/filesystems, you must not mount or create hidden VeraCrypt volumes under Linux.

  - *Mac OS X*: If you are not able to ensure that applications and the operating system do not write any sensitive data (see above) to non-hidden volumes/filesystems, you must not mount or create hidden VeraCrypt volumes under Mac OS X.

- When an outer volume is mounted with hidden volume protection enabled (see section *Protection of Hidden Volumes Against Damage*), you must follow the same security requirements and precautions that you are required to follow when a hidden volume is mounted (see above). The reason is that the operating system might leak the password/key for the hidden volume to a non-hidden or unencrypted volume.

- If you use an **operating system residing within a hidden volume** (see the section *Hidden Operating System*), then, in addition to the above, you must follow these security requirements and precautions:

  - You should use the decoy operating system as frequently as you use your computer. Ideally, you should use it for all activities that do not involve sensitive data. Otherwise, plausible deniability of the hidden operating system might be adversely affected (if you revealed the password for the decoy operating system to an adversary, he could find out that the system is not used very often, which might indicate the existence of a hidden operating system on your computer). Note that you can save data to the decoy system partition anytime without any risk that the hidden volume will get damaged (because the decoy system is not installed in the outer volume).

  - If the operating system requires activation, it must be activated before it is cloned (cloning is part of the process of creation of a hidden operating system — see the section *Hidden Operating System*) and the hidden operating system (i.e. the clone) must never be reactivated. The reason is that the hidden operating system is created by copying the content of the system partition to a hidden volume (so if the operating system is not activated, the hidden operating system will not be activated either). If you activated or reactivated a hidden operating system, the date and time of the activation (and other data) might be logged on a Microsoft server (and on the hidden operating system) but not on the decoy operating system. Therefore, if an adversary had access to the data stored on the server or intercepted your request to the server (and if you revealed the password for the decoy operating system to him), he might find out that the decoy operating system was activated (or reactivated) at a different time, which might indicate the existence of a hidden operating system on your computer.

    For similar reasons, any software that requires activation must be installed and activated before you start creating the hidden operating system.

  - When you need to shut down the hidden system and start the decoy system, do *not* restart the computer. Instead, shut it down or hibernate it and then leave it powered off for at least several minutes (the longer, the better) before turning the computer on and

booting the decoy system. This is required to clear the memory, which may contain sensitive data. For more information, see the section *Unencrypted Data in RAM* in the chapter *Security Requirements and Precautions*.

o   The computer may be connected to a network (including the internet) only when the decoy operating system is running. When the hidden operating system is running, the computer should not be connected to any network, including the internet (one of the most reliable ways to ensure it is to unplug the network cable, if there is one). Note that if data is downloaded from or uploaded to a remote server, the date and time of the connection, and other data, are typically logged on the server. Various kinds of data are also logged on the operating system (e.g. Windows auto-update data, application logs, error logs, etc.) Therefore, if an adversary had access to the data stored on the server or intercepted your request to the server (and if you revealed the password for the decoy operating system to him), he might find out that the connection was not made from within the decoy operating system, which might indicate the existence of a hidden operating system on your computer.

Also note that similar issues would affect you if there were any filesystem shared over a network under the hidden operating system (regardless of whether the filesystem is remote or local). Therefore, when the hidden operating system is running, there must be no filesystem shared over a network (in any direction).

o   Any actions that can be detected by an adversary (or any actions that modify any data outside mounted hidden volumes) must be performed only when the decoy operating system is running (unless you have a plausible alternative explanation, such as using a "live-CD" system to perform such actions). For example, the option '*Auto-adjust for daylight saving time*' option may be enabled only on the decoy system.

o   If the BIOS, EFI, or any other component logs power-down events or any other events that could indicate a hidden volume/system is used (e.g. by comparing such events with the events in the Windows event log), you must either disable such logging or ensure that the log is securely erased after each session (or otherwise avoid such an issue in an appropriate way).

In addition to the above, you must follow the security requirements and precautions listed in the following chapters:

- *Security Requirements and Precautions*
- *How to Back Up Securely*

Hidden Operating System

If your system partition or system drive is encrypted using VeraCrypt, you need to enter your pre-boot authentication password in the VeraCrypt Boot Loader screen after you turn on or restart your computer. It may happen that you are forced by somebody to decrypt the operating system or to reveal the pre-boot authentication password. There are many situations where you cannot refuse to do so (for example, due to extortion). VeraCrypt allows you to create a hidden operating system whose existence should be impossible to prove (provided that certain guidelines are followed — see below). Thus, you will not have to decrypt or reveal the password for the hidden operating system.

Before you continue reading this section, make sure you have read the section ***Hidden Volume*** and that you understand what a hidden VeraCrypt volume is.

A **hidden operating system** is a system (for example, Windows 7 or Windows XP) that is installed in a hidden VeraCrypt volume. It should be impossible to prove that a hidden VeraCrypt volume exists (provided that certain guidelines are followed; for more information, see the section *Hidden   Volume*) and, therefore, it should be impossible to prove that a hidden operating system exists.

However, in order to boot a system encrypted by VeraCrypt, an unencrypted copy of the VeraCrypt Boot Loader has to be stored on the system drive or on a VeraCrypt Rescue Disk. Hence, the mere presence of the VeraCrypt Boot Loader can indicate that there is a system encrypted by VeraCrypt on the computer. Therefore, to provide a plausible explanation for the presence of the VeraCrypt Boot Loader, the VeraCrypt wizard helps you create a second encrypted operating system, so- called **decoy operating system**, during the process of creation of a hidden operating system. A decoy operating system must not contain any sensitive files. Its existence is not secret (it is *not* installed in a hidden volume). The password for the decoy operating system can be safely revealed to anyone forcing you to disclose your pre-boot authentication password.[*]

You should use the decoy operating system as frequently as you use your computer. Ideally, you should use it for all activities that do not involve sensitive data. Otherwise, plausible deniability of the hidden operating system might be adversely affected (if you revealed the password for the decoy operating system to an adversary, he could find out that the system is not used very often, which might indicate the existence of a hidden operating system on your computer). Note that you can save data to the decoy system partition anytime without any risk that the hidden volume will get damaged (because the decoy system is *not* installed in the outer volume — see below).

There will be two pre-boot authentication passwords — one for the hidden system and the other for the decoy system. If you want to start the hidden system, you simply enter the password for the hidden system in the VeraCrypt Boot Loader screen (which appears after you turn on or restart   your computer). Likewise, if you want to start the decoy system (for example, when asked to do so by an adversary), you just enter the password for the decoy system in the VeraCrypt Boot Loader screen.

Note: When you enter a pre-boot authentication password, the VeraCrypt Boot Loader first attempts to decrypt (using the entered password) the last 512 bytes of the first logical track of the system drive (where encrypted master key data for non-hidden encrypted system partitions/drives

---

[*] It is not practical (and therefore is not supported) to install operating systems in two VeraCrypt volumes that are embedded within a single partition, because using the outer operating system would often require data to be written to the area of the hidden operating system (and if such write operations were prevented using the hidden volume protection feature, it would inherently cause system crashes, i.e. 'Blue Screen' errors).

are normally stored). If it fails and if there is a partition behind the active partition, the VeraCrypt Boot Loader (even if there is actually no hidden volume on the drive) automatically tries to decrypt (using the same entered password again) the area of the first partition behind the active partition[*] where the encrypted header of a possible hidden volume might be stored. Note that VeraCrypt never knows if there is a hidden volume in advance (the hidden volume header cannot be identified, as it appears to consist entirely of random data). If the header is successfully decrypted (for information on how VeraCrypt determines that it was successfully decrypted, see the section *Encryption Scheme*), the information about the size of the hidden volume is retrieved from the decrypted header (which is still stored in RAM), and the hidden volume is mounted (its size also determines its offset). For further technical details, see the section *Encryption Scheme* in the chapter *Technical Details*.

When running, the hidden operating system appears to be installed on the same partition as the original operating system (the decoy system). However, in reality, it is installed within the partition behind it (in a hidden volume). All read/write operations are transparently redirected from the system partition to the hidden volume. Neither the operating system nor applications will know that data written to and read from the system partition is actually written to and read from the partition behind it (from/to a hidden volume). Any such data is encrypted and decrypted on the fly as usual (with an encryption key different from the one that is used for the decoy operating system).

Note that there will also be a third password — the one for the **outer volume**. It is not a pre-boot authentication password, but a regular VeraCrypt volume password. It can be safely disclosed to anyone forcing you to reveal the password for the encrypted partition where the hidden volume (containing the hidden operating system) resides. Thus, the existence of the hidden volume (and of the hidden operating system) will remain secret. If you are not sure you understand how this is possible, or what an outer volume is, please read the section *Hidden Volume.* The outer volume should contain some sensitive-looking files that you actually do *not* want to hide.

To summarize, there will be three passwords in total. Two of them can be revealed to an attacker (for the decoy system and for the outer volume). The third password, for the hidden system, must remain secret.
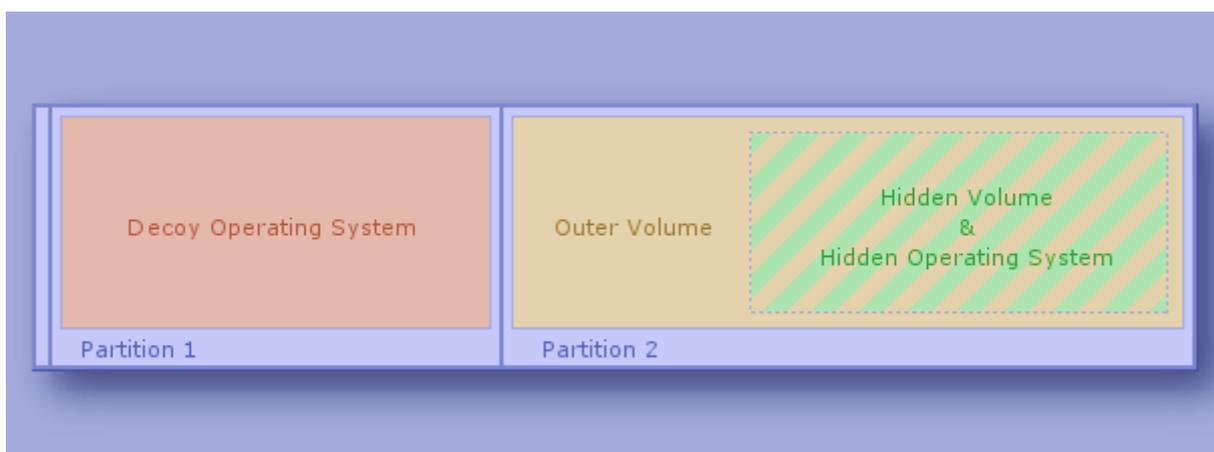
Example Layout of System Drive Containing Hidden Operating System

---

* If the size of the active partition is less than 256 MB, then the data is read from the *second* partition behind the active one (Windows 7 and later, by default, do not boot from the partition on which they are installed).

Process of Creation of Hidden Operating System

To start the process of creation of a hidden operating system, select *System > Create Hidden Operating System* and then follow the instructions in the wizard.

Initially, the wizard verifies that there is a suitable partition for a hidden operating system on the system drive. Note that before you can create a hidden operating system, you need to create a partition for it on the system drive. It must be the first partition behind the system partition and it must be at least 5% larger than the system partition (the system partition is the one where the currently running operating system is installed). However, if the outer volume (not to be confused with the system partition) is formatted as NTFS, the partition for the hidden operating system must be at least 110% (2.1 times) larger than the system partition (the reason is that the NTFS file system always stores internal data exactly in the middle of the volume and, therefore, the hidden volume, which is to contain a clone of the system partition, can reside only in the second half of the partition).

In the next steps, the wizard will create two VeraCrypt volumes (outer and hidden) within the first partition behind the system partition. The hidden volume will contain the hidden operating system. The size of the hidden volume is always the same as the size of the system partition. The reason is that the hidden volume will need to contain a clone of the content of the system partition (see below). Note that the clone will be encrypted using a different encryption key than the original. Before you start copying some sensitive-looking files to the outer volume, the wizard tells you the maximum recommended size of space that the files should occupy, so that there is enough free space on the outer volume for the hidden volume.

Remark: After you copy some sensitive-looking files to the outer volume, the cluster bitmap of the volume will be scanned in order to determine the size of uninterrupted area of free space whose end is aligned with the end of the outer volume. This area will accommodate the hidden volume, so it limits its maximum possible size. The maximum possible size of the hidden volume will be determined and it will be verified that it is greater than the size of the system partition (which is required, because the entire content of the system partition will need to be copied to the hidden volume — see below). This ensures that no data stored on the outer volume will be overwritten by data written to the area of the hidden volume (e.g., when the system is being copied to it). The size of the hidden volume is always the same as the size of the system partition.

Then, VeraCrypt will create the hidden operating system by copying the content of the system partition to the hidden volume. Data being copied will be encrypted on the fly with an encryption key different from the one that will be used for the decoy operating system. The process of copying the system is performed in the pre-boot environment (before Windows starts) and it may take a long time to complete; several hours or even several days (depending on the size of the system partition and on the performance of the computer). You will be able to interrupt the process, shut down   your computer, start the operating system and then resume the process. However, if you interrupt it, the entire process of copying the system will have to start from the beginning (because the content of the system partition must not change during cloning). The hidden operating system   will initially be a clone of the operating system under which you started the wizard.

Windows creates (typically, without your knowledge or consent) various log files, temporary files, etc., on the system partition. It also saves the content of RAM to hibernation and paging files located on the system partition. Therefore, if an adversary analyzed files stored on the partition where the original system (of which the hidden system is a clone) resides, he might find out, for example, that you used the VeraCrypt wizard in the hidden-system-creation mode (which might indicate the existence of a hidden operating system on your computer). To prevent such issues, VeraCrypt will securely erase the entire content of the partition where the original system resides

after the hidden system has been created. Afterwards, in order to achieve plausible deniability, VeraCrypt will prompt you to install a new system on the partition and encrypt it using VeraCrypt. Thus, you will create the decoy system and the whole process of creation of the hidden operating system will be completed.

Note: VeraCrypt will erase the content of the partition where the original system resides by filling it with random data entirely. If you revealed the password for the decoy system to an adversary and he asked you why the free space of the (decoy) system partition contains random data, you could answer, for example: "The partition previously contained a system encrypted by VeraCrypt, but I forgot the pre-boot authentication password (or the system was damaged and stopped booting), so I had to reinstall Windows and encrypt the partition again."

Plausible Deniability and Data Leak Protection

For security reasons, when a hidden operating system is running, VeraCrypt ensures that all local unencrypted filesystems and non-hidden VeraCrypt volumes are read-only (i.e. no files can be written to such filesystems or VeraCrypt volumes).[*] Data is allowed to be written to any filesystem that resides within a hidden VeraCrypt volume (provided that the hidden volume is not located in a container stored on an unencrypted filesystem or on any other read-only filesystem).

There are three main reasons why such countermeasures have been implemented:

1. It enables the creation of a secure platform for mounting of hidden VeraCrypt volumes. Note that we officially recommend that hidden volumes are mounted only when a hidden operating system is running. For more information, see the subsection *Security Requirements and Precautions Pertaining to Hidden Volumes*.

2. In some cases, it is possible to determine that, at a certain time, a particular filesystem was not mounted under (or that a particular file on the filesystem was not saved or accessed from within) a particular instance of an operating system (e.g. by analyzing and comparing filesystem journals, file timestamps, application logs, error logs, etc). This might indicate that a hidden operating system is installed on the computer. The countermeasures prevent these issues.

3. It prevents data corruption and allows safe hibernation. When Windows resumes from hibernation, it assumes that all mounted filesystems are in the same state as when the system entered hibernation. VeraCrypt ensures this by write-protecting any filesystem accessible both from within the decoy and hidden systems. Without such protection, the filesystem could become corrupted when mounted by one system while the other system is hibernated.

If you need to securely transfer files from the decoy system to the hidden system, follow these steps:

1. Start the decoy system.
2. Save the files to an unencrypted volume or to an outer/normal VeraCrypt volume.
3. Start the hidden system
4. If you saved the files to a VeraCrypt volume, mount it (it will be automatically mounted as read-only).
5. Copy the files to the hidden system partition or to another hidden volume.

---

* This does not apply to filesystems on CD/DVD-like media and on custom, atypical, or non-standard devices/media.

48

Possible Explanations for Existence of Two VeraCrypt Partitions on Single Drive

An adversary might ask why you created two VeraCrypt-encrypted partitions on a single drive (a system partition and a non-system partition) rather than encrypting the entire disk with a single encryption key. There are many possible reasons to do that. However, if you do not know any

(other than creating a hidden operating system), you can provide, for example, one of the following explanations:

- If there are more than two partitions on a system drive and you want to encrypt only two of them (the system partition and the one behind it) and to leave the other partitions unencrypted (for example, to achieve the best possible performance when reading and writing data, which is not sensitive, to such unencrypted partitions), the only way to do that is to encrypt both partitions separately (note that, with a single encryption key, VeraCrypt could encrypt the entire system drive and *all* partitions on it, but it cannot encrypt only two of   them — only one or all of the partitions can be encrypted with a single key). As a result, there will be two adjacent VeraCrypt partitions on the system drive (the first will be a system partition, the second will be a non-system one), each encrypted with a different key (which is also the case when you create a hidden operating system, and therefore it can be explained this way).

  If you do not know any good reason why there should be more than one partition on a system drive at all:

  It is generally recommended to separate non-system files (documents) from system files. One of the easiest and most reliable ways to do that is to create two partitions on the system drive; one for the operating system and the other for documents (non-system files). The reasons why this practice is recommended include:
  - If the filesystem on one of the partitions is damaged, files on the partition may get corrupted or lost, whereas files on the other partition are not affected.
  - It is easier to reinstall the system without losing your documents (reinstallation of an operating system involves formatting the system partition, after which all files stored on it are lost). If the system is damaged, full reinstallation is often the only option.

- A cascade encryption algorithm (e.g. AES-Twofish-Serpent) can be many times slower than a non-cascade one (e.g. AES). However, a cascade encryption algorithm may be more secure than a non-cascade one (for example, the probability that three distinct encryption algorithms will be broken, e.g. due to advances in cryptanalysis, is significantly lower than   the probability that only one of them will be broken). Therefore, if you encrypt the outer volume with a cascade encryption algorithm and the decoy system with a non-cascade encryption algorithm, you can answer that you wanted the best performance (and adequate security) for the system partition, and the highest possible security (but worse performance) for the non-system partition (i.e. the outer volume), where you store the most sensitive data, which you do not need to access very often (unlike the operating system, which you use very often, and therefore you need it to have the best possible performance). On the system partition, you store data that is less sensitive (but which you need to access very often)   than data you store on the non-system partition (i.e. on the outer volume).

- Provided that you encrypt the outer volume with a cascade encryption algorithm (e.g. AES-Twofish-Serpent) and the decoy system with a non-cascade encryption algorithm (e.g. AES), you can also answer that you wanted to prevent the problems about which VeraCrypt warns when the user attempts to choose a cascade encryption algorithm for system encryption (see below for a list of the problems). Therefore, to prevent those problems, you decided to encrypt the system partition with a non-cascade encryption algorithm. However, you still wanted to use a cascade encryption algorithm (because it is more secure than a non-cascade encryption algorithm) for the most sensitive data, so you decided to create a second partition, which those problems do *not* affect (because it is non-system) and to encrypt it with a cascade encryption algorithm. On the system partition, you store data that is less sensitive than data you store on the non-system partition (i.e. on the outer volume).

Note: When the user attempts to encrypt the system partition with a cascade encryption algorithm, VeraCrypt warns him or her that it can cause the following problems (and implicitly recommends to choose a non-cascade encryption algorithm instead):

- o For cascade encryption algorithms, the VeraCrypt Boot Loader is larger than normal and, therefore, there is not enough space in the first drive track for a backup of the VeraCrypt Boot Loader. Hence, *whenever* it gets damaged (which often happens, for example, during inappropriately designed anti-piracy activation procedures of certain programs), the user must use the VeraCrypt Rescue Disk to repair the VeraCrypt Boot Loader or to boot.
- o On some computers, resuming from hibernation takes longer.

- In contrast to a password for a non-system VeraCrypt volume, a pre-boot authentication password needs to be typed each time the computer is turned on or restarted. Therefore, if the pre-boot authentication password is long (which is required for security purposes), it may be very tiresome to type it so frequently. Hence, you can answer that it was more convenient for you to use a short (and therefore weaker) password for the system partition (i.e. the decoy system) and that it is more convenient for you to store the most sensitive data (which you do not need to access as often) in the non-system VeraCrypt partition (i.e. in the outer volume) for which you chose a very long password.

  As the password for the system partition is not very strong (because it is short), you do not intentionally store sensitive data on the system partition. However, you still prefer the system partition to be encrypted, because potentially sensitive or mildly sensitive data is stored on it as a result of your everyday use of the computer (for example, passwords to online forums you visit, which can be automatically remembered by your browser, browsing history, applications you run, etc.)

- When an attacker gets hold of your computer when a VeraCrypt volume is mounted (for example, when you use a laptop outside), he can, in most cases, read any data stored on the volume (data is decrypted on the fly as he reads it). Therefore, it may be wise to limit the time the volume is mounted to a minimum. Obviously, this may be impossible or difficult if the sensitive data is stored on an encrypted system partition or on an entirely encrypted system drive (because you would also have to limit the time you work with the computer to a minimum). Hence, you can answer that you created a separate partition (encrypted with a different key than your system partition) for your most sensitive data and that you mount it only when necessary and dismount it as soon as possible (so as to limit the time the volume is mounted to a minimum). On the system partition, you store data that is less sensitive (but which you need to access often) than data you store on the non-system partition (i.e. on the outer volume).

Safety/Security Precautions and Requirements Pertaining to Hidden Operating Systems

As a hidden operating system resides in a hidden VeraCrypt volume, a user of a hidden operating system must follow all of the security requirements and precautions that apply to normal hidden VeraCrypt volumes. These requirements and precautions, as well as additional requirements and   precautions pertaining specifically to hidden operating systems, are listed in the subsection *Security Requirements and Precautions Pertaining to Hidden Volumes*.

WARNING: If you do not protect the hidden volume (for information on how to do so, refer to the section *Protection of Hidden Volumes Against Damage*), do *not* write to the outer volume (note that the decoy operating system is *not* installed in the outer volume). Otherwise, you may overwrite and damage the hidden volume (and the hidden operating system within it)!

If all the instructions in the wizard have been followed and if the security requirements and precautions listed in the subsection *Security Requirements and Precautions Pertaining to Hidden Volumes* are followed, it should be impossible to prove that the hidden volume and hidden operating system exist, even when the outer volume is mounted or when the decoy operating system is decrypted or started.

Main Program Window

Select File

Allows you to select a file-hosted VeraCrypt volume. After you select it, you can perform various operations on it (e.g., mount it by clicking 'Mount'). It is also possible to select a volume by dragging its icon to the 'VeraCrypt.exe' icon (VeraCrypt will be automatically launched then) or to the main program window.

Select Device

Allows you to select a VeraCrypt partition or a storage device (such as a USB memory stick). After it is selected, you can perform various operations with it (e.g., mount it by clicking 'Mount').

Note: There is a more comfortable way of mounting VeraCrypt partitions/devices – see the section *Auto-Mount Devices* for more information.

Mount

After you click 'Mount', VeraCrypt will try to mount the selected volume using cached passwords (if there are any) and if none of them works, it prompts you for a password. If you enter the correct password (and/or provide correct keyfiles), the volume will be mounted.
Important: Note that when you exit the VeraCrypt application, the VeraCrypt driver continues working and no VeraCrypt volume is dismounted.

Auto-Mount Devices

This function allows you to mount VeraCrypt partitions/devices without having to select them manually (by clicking 'Select Device'). VeraCrypt scans headers of all available partitions/devices on your system (except DVD drives and similar devices) one by one and tries to mount each of them as a VeraCrypt volume. Note that a VeraCrypt partition/device cannot be identified, nor the cipher it has been encrypted with. Therefore, the program cannot directly "find" VeraCrypt partitions. Instead, it has to try mounting each (even unencrypted) partition/device using all encryption algorithms and all cached passwords (if there are any). Therefore, be prepared that this process may take a long time on slow computers.

If the password you enter is wrong, mounting is attempted using cached passwords (if there are any). If you enter an empty password and if *Use keyfiles* is unchecked, only the cached passwords   will be used when attempting to auto-mount partitions/devices. If you do not need to set mount options, you can bypass the password prompt by holding down the *Shift* key when clicking *Auto- Mount Devices* (only cached passwords will be used, if there are any).

Drive letters will be assigned starting from the one that is selected in the drive list in the main window.

Dismount

This function allows you to dismount the VeraCrypt volume selected in the drive list in the main window. To dismount a VeraCrypt volume means to close it and make it impossible to read/write from/to the volume.

Dismount All

Note: The information in this section applies to all menu items and buttons with the same or similar caption (for example, it also applies to the system tray menu item *Dismount All*).

This function allows you to dismount multiple VeraCrypt volumes. To dismount a VeraCrypt volume means to close it and make it impossible to read/write from/to the volume. This function dismounts all mounted VeraCrypt volumes except the following:

- Partitions/drives within the key scope of active system encryption (e.g., a system partition encrypted by VeraCrypt, or a non-system partition located on a system drive encrypted by VeraCrypt, mounted when the encrypted operating system is running).

- VeraCrypt volumes that are not fully accessible to the user account (e.g. a volume mounted from within another user account).

- VeraCrypt volumes that are not displayed in the VeraCrypt application window. For example, system favorite volumes attempted to be dismounted by an instance of VeraCrypt without administrator privileges when the option '*Allow only administrators to view and dismount system favorite volumes in VeraCrypt*' is enabled.

Wipe Cache

Clears all passwords (which may also contain processed keyfile contents) cached in driver memory. When there are no passwords in the cache, this button is disabled. For information on password cache, see the section *Cache Password in Driver Memory.*

Never Save History

If this option disabled, the file names and/or paths of the last twenty files/devices that were attempted to be mounted as VeraCrypt volumes will be saved in the History file (whose content can be displayed by clicking on the Volume combo-box in the main window).

When this option is enabled, VeraCrypt clears the registry entries created by the Windows file selector for VeraCrypt, and sets the "current directory" to the user's home directory (in portable mode, to the directory from which VeraCrypt was launched) whenever a container or keyfile is selected via the Windows file selector. Therefore, the Windows file selector will not remember the path of the last mounted container (or the last selected keyfile). However, note that the operations described in this paragraph are *not* guaranteed to be performed reliably and securely (see e.g. *Security Requirements and Precautions*) so we strongly recommend that you encrypt the system partition/drive instead of relying on them (see *System Encryption*).

Furthermore, if this option is enabled, the volume path input field in the main VeraCrypt window is cleared whenever you hide VeraCrypt.

Note: You can clear the volume history by selecting *Tools > Clear Volume History*.

Exit

Terminates the VeraCrypt application. The driver continues working and no VeraCrypt volumes are dismounted. When running in 'portable' mode, the VeraCrypt driver is unloaded when it is no longer needed (e.g., when all instances of the main application and/or of the Volume Creation Wizard are closed and no VeraCrypt volumes are mounted). However, if you force dismount on a

VeraCrypt volume when VeraCrypt runs in portable mode, or mount a writable NTFS-formatted volume on Windows Vista or later, the VeraCrypt driver may *not* be unloaded when you exit VeraCrypt (it will be unloaded only when you shut down or restart the system). This prevents various problems caused by a bug in Windows (for instance, it would be impossible to start VeraCrypt again as long as there are applications using the dismounted volume).

Volume Tools

Change Volume Password

See the section *Volumes > Change Volume Password.*

Set Header Key Derivation Algorithm

See the section *Volumes > Set Header Key Derivation Algorithm.*

Backup Volume Header

See the section *Tools > Backup Volume Header*.

Restore Volume Header

See the section *Tools > Restore Volume Header*.

Program Menu

Note: To save space, only the menu items that are not self-explanatory are described in this documentation.

Volumes > Auto-Mount All Device-Hosted Volumes

See the section *Auto-Mount Devices*.

Volumes > Dismount All Mounted Volumes

See the section *Dismount All*.

Volumes > Change Volume Password

Allows changing the password of the currently selected VeraCrypt volume (no matter whether the volume is hidden or standard). Only the header key and the secondary header key (XTS mode) are changed – the master key remains unchanged. This function re-encrypts the volume header using a header encryption key derived from a new password. Note that the volume header contains the master encryption key with which the volume is encrypted. Therefore, the data stored on the volume will *not* be lost after you use this function (password change will only take a few seconds).

To change a VeraCrypt volume password, click on *Select File* or *Select Device*, then select the volume, and from the *Volumes* menu select *Change Volume Password*.

Note: For information on how to change a password used for pre-boot authentication, please see the section *System > Change Password*.

See also the chapter *Security Requirements and Precautions*.

PKCS-5 PRF

In this field you can select the algorithm that will be used in deriving new volume header keys (for more information, see the section *Header Key Derivation, Salt, and Iteration Count*) and in generating the new salt (for more information, see the section *Random Number Generator*).

Note: When VeraCrypt re-encrypts a volume header, the original volume header is first overwritten many times (3, 7, 35 or 256 depending on the user choice) with random data to prevent adversaries from using techniques such as magnetic force microscopy or magnetic force scanning tunneling microscopy [17] to recover the overwritten header (however, see also the chapter *Security Requirements and Precautions*).

Volumes > Set Header Key Derivation Algorithm

This function allows you to re-encrypt a volume header with a header key derived using a different PRF function (for example, instead of HMAC-RIPEMD-160 you could use HMAC-Whirlpool). Note that the volume header contains the master encryption key with which the volume is encrypted. Therefore, the data stored on the volume will *not* be lost after you use this function. For more

information, see the section *Header Key Derivation, Salt, and Iteration Count*.

Note: When VeraCrypt re-encrypts a volume header, the original volume header is first overwritten many times (3, 7, 35 or 256 depending on the user choice) with random data to prevent adversaries from using techniques such as magnetic force microscopy or magnetic force scanning tunneling microscopy [17] to recover the overwritten header (however, see also the chapter *Security Requirements and Precautions*).

Volumes > Add/Remove Keyfiles to/from Volume Volumes > Remove All Keyfiles from Volume

See the chapter *Keyfiles*.

Favorites > Add Mounted Volume to Favorites
Favorites > Organize Favorite Volumes
Favorites > Mount Favorites Volumes

See the chapter *Favorite Volumes*.

Favorites > Add Mounted Volume to System Favorites
Favorites > Organize System Favorite Volumes

See the chapter *System Favorite Volumes*.

System > Change Password

Changes the password used for pre-boot authentication (see the chapter *System Encryption*).

WARNING: Your VeraCrypt Rescue Disk allows you to restore key data if it is damaged. By doing so, you also restore the password that was valid when the VeraCrypt Rescue Disk was created. Therefore, whenever you change the password, you should destroy your VeraCrypt Rescue Disk and create a new one (select *System > Create Rescue Disk*). Otherwise, an attacker could decrypt your system partition/drive using the old password (if he finds the old VeraCrypt Rescue Disk and uses it to restore the key data). See also the chapter *Security Requirements and Precautions*.

For more information on changing a password, please see the section *Volumes > Change Volume Password* above.

System > Mount Without Pre-Boot Authentication

Check this option, if you need to mount a partition that is within the key scope of system encryption without pre-boot authentication. For example, if you need to mount a partition located on the encrypted system drive of another operating system that is not running. This can be useful e.g. when you need to back up or repair an operating system encrypted by VeraCrypt (from within another operating system).

Note 1: If you need to mount multiple partitions at once, click *'Auto-Mount Devices'*, then click *'Mount Options'* and enable the option *'Mount partition using system encryption without pre-boot authentication'*.

Please note you cannot use this function to mount extended (logical) partitions that are located on an entirely encrypted system drive.

Tools > Clear Volume History

Clears the list containing the file names (if file-hosted) and paths of the last twenty successfully mounted volumes.

Tools > Traveler Disk Setup

See the chapter *Portable Mode.*

Tools > Keyfile Generator

See section *Tools > Keyfile Generator* in the chapter *Keyfiles*.

Tools > Backup Volume Header
Tools > Restore Volume Header

If the header of a VeraCrypt volume is damaged, the volume is, in most cases, impossible to mount. Therefore, each volume created by VeraCrypt (except system partitions) contains an embedded backup header, located at the end of the volume. For extra safety, you can also create external volume header backup files. To do so, click *Select Device* or *Select File*, select the volume, select *Tools > Backup Volume Header*, and then follow the instructions.

Note: For system encryption, there is no backup header at the end of the volume. For non-system volumes, a shrink operation is done first to ensure that all data are put at the beginning of the volume, leaving all free space at the end so that we have a place to put the backup header. For system partitions, we can't perform this needed shrink operation while Windows is running and so the backup header can't be created at the end of the partition. The alternative way in the case of system encryption is the use of the Rescue Disk.

Note: A backup header (embedded or external) is *not* a copy of the original volume header because it is encrypted with a different header key derived using a different salt (see the section *Header Key Derivation. Salt, and Iteration Count*). When the volume password and/or keyfiles are changed, or when the header is restored from the embedded (or an external) header backup, both the volume header and the backup header (embedded in the volume) are re-encrypted with header keys derived using newly generated salts (the salt for the volume header is different from the salt for the backup header). Each salt is generated by the VeraCrypt random number generator (see the section *Random Number Generator*).

Both types of header backups (embedded and external) can be used to repair a damaged volume header. To do so, click *Select Device* or *Select File*, select the volume, select *Tools > Restore Volume Header*, and then follow the instructions.

WARNING: Restoring a volume header also restores the volume password that was valid when the backup was created. Moreover, if keyfile(s) are/is necessary to mount a volume when the backup is created, the same keyfile(s) will be necessary to mount the volume

again after the volume header is restored. For more information, see the section *Encryption Scheme* in the chapter *Technical Details*.

After you create a volume header backup, you might need to create a new one only when you change the volume password and/or keyfiles. Otherwise, the volume header remains unmodified so the volume header backup remains up-to-date.

Note: Apart from salt (which is a sequence of random numbers), external header backup files do not contain   any unencrypted information and they cannot be decrypted without knowing the correct password and/or   supplying the correct keyfile(s). For more information, see the chapter *Technical Details*.

When you create an external header backup, both the standard volume header and the area where a hidden volume header can be stored is backed up, even if there is no hidden volume within the volume (to preserve plausible deniability of hidden volumes). If there is no hidden volume within the volume, the area reserved for the hidden volume header in the backup file will be filled with random data (to preserve plausible deniability).

When *restoring* a volume header, you need to choose the type of volume whose header you wish to restore (a standard or hidden volume). Only one volume header can be restored at a time. To restore both headers, you need to use the function twice (*Tools > Restore Volume Header*). You will need to enter the correct password (and/or to supply the correct keyfiles) that was/were valid when the volume header backup was created. The password (and/or keyfiles) will also automatically determine the type of the volume header to restore, i.e. standard or hidden (note that   VeraCrypt determines the type through the process of trial and error).

Note: If the user fails to supply the correct password (and/or keyfiles) twice in a row when trying to mount a volume, VeraCrypt will automatically try to mount the volume using the embedded backup header (in addition to trying to mount it using the primary header) each subsequent time that the user attempts to mount the volume (until he or she clicks *Cancel*). If VeraCrypt fails to decrypt the primary header but it successfully decrypts the embedded backup header at the same time, the volume is mounted and the user is warned that the volume header is damaged (and informed as to how to repair it).

Settings > Performance and Driver Options

Invokes the Performance dialog window, where you can change enable or disable AES Hardware acceleration and thread based parallelization. You can also change the following driver option:

Enable extended disk control codes support

If enabled, VeraCrypt driver will support returning extended technical information about mounted volumes through IOCTL_STORAGE_QUERY_PROPERTY control code. This control code is always supported by physical drives and it can be required by some applications to get technical information about a drive (e.g. the Windows fsutil program uses this control code to get the physical sector size of a drive.).
Enabling this option brings VeraCrypt volumes behavior much closer to that of physical disks and if it is disabled, applications can easily distinguish between physical disks and VeraCrypt volumes since sending this control code to a VeraCrypt volume will result in an error.
Disable this option if you experience stability issues (like volume access issues or system BSOD) which can be caused by poorly written software and drivers.

Settings > Preferences

Invokes the Preferences dialog window, where you can change, among others, the following options:

Wipe cached passwords on exit

If enabled, passwords (which may also contain processed keyfile contents) cached in driver memory will be cleared when VeraCrypt exits.

Cache passwords in driver memory

When checked, passwords and/or processed keyfile contents for up to last four successfully mounted VeraCrypt volumes are cached. This allows mounting volumes without having to type their passwords (and selecting keyfiles) repeatedly. VeraCrypt never saves any password to a disk (however, see the chapter *Security Requirements and Precautions*).
Password caching can be enabled/disabled in the Preferences (*Settings > Preferences*) and in the password prompt window. If the system partition/drive is encrypted, caching of the pre-boot authentication password can be enabled or disabled in the system encryption settings (*Settings > 'System Encryption'*).

Temporary Cache password during "Mount Favorite Volumes" operations

When this option is unchecked (this is the default), VeraCrypt will display the password prompt window for every favorite volume during the execution of the "Mount Favorite Volumes" operation and each password is erased once the volume is mounted (unless password caching is enabled).

If this option is checked and if there are two or more favorite volumes, then during the operation "Mount Favorite Volumes", VeraCrypt will first try the password of the previous favorite and if it doesn't work, it will display password prompt window. This logic applies starting from the second favorite volume onwards. Once all favorite volumes are processed, the password is erased from memory.

This option is useful when favorite volumes share the same password since the password prompt window will only be displayed once for the first favorite and VeraCrypt will automatically mount all subsequent favorites.

Please note that since we can't assume that all favorites use the same PRF (hash) nor the same TrueCrypt mode, VeraCrypt uses Autodetection for the PRF of subsequent favorite volumes and it tries both TrueCryptMode values (false, true) which means that the total mounting time will be slower compared to the individual mounting of each volume with the manual selection of the correct PRF and the correct TrueCryptMode.

Open Explorer window for successfully mounted volume

If this option is checked, then after a VeraCrypt volume has been successfully mounted, an Explorer window showing the root directory of the volume (e.g., `T:\`) will be automatically opened.

Use a different taskbar icon when there are mounted volumes

If enabled, the appearance of the VeraCrypt taskbar icon (shown within the system tray notification area) is different while a VeraCrypt volume is mounted, except the following:

- Partitions/drives within the key scope of active system encryption (e.g., a system partition encrypted by VeraCrypt, or a non-system partition located on a system drive encrypted by VeraCrypt, mounted when the encrypted operating system is running).

- VeraCrypt volumes that are not fully accessible to the user account (e.g. a volume mounted from within another user account).

- VeraCrypt volumes that are not displayed in the VeraCrypt application window. For example, system favorite volumes attempted to be dismounted by an instance of VeraCrypt without administrator privileges when the option '*Allow only administrators to view and dismount system favorite volumes in VeraCrypt*' is enabled.

VeraCrypt Background Task – Enabled

See the chapter *VeraCrypt Background Task*.

VeraCrypt Background Task – Exit when there are no mounted volumes

If this option is checked, the VeraCrypt background task automatically and silently exits as soon as there are no mounted VeraCrypt volumes. For more information, see the chapter *VeraCrypt Background Task*. Note that this option cannot be disabled when VeraCrypt runs in portable mode.

Auto-dismount volume after no data has been read/written to it for

After no data has been written/read to/from a VeraCrypt volume for *n* minutes, the volume is automatically dismounted.

Force auto-dismount even if volume contains open files or directories

This option applies only to auto-dismount (not to regular dismount). It forces dismount (without prompting) on the volume being auto-dismounted in case it contains open files or directories (i.e., file/directories that are in use by the system or applications).

Mounting Volumes

If you have not done so yet, please read the sections '*Mount*' and '*Auto-Mount Devices*' in the chapter *Main Program Window*.

Cache Password in Driver Memory

This option can be set in the password entry dialog so that it will apply only to that particular mount attempt. It can also be set as default in the Preferences. For more information, please see the section *Settings > Preferences*, subsection *Cache passwords in driver memory*.

Mount Options

Mount options affect the parameters of the volume being mounted. The *Mount Options* dialog can be opened by clicking on the *Mount Options* button in the password entry dialog. When a correct password is cached, volumes are automatically mounted after you click *Mount*. If you need to change mount options for a volume being mounted using a cached password, hold down the *Control* (*Ctrl*) key while clicking *Mount* or a favorite volume in the *Favorites* menu*,* or select *Mount with Options* from the *Volumes* menu.

Default mount options can be configured in the main program preferences (*Settings > Preferences).*

Mount volume as read-only

When checked, it will not be possible to write any data to the mounted volume.

Mount volume as removable medium

See section *Volume Mounted as Removable Medium*.

Use backup header embedded in volume if available

All volumes created by VeraCrypt contain an embedded backup header (located at the end of the volume). If you check this option, VeraCrypt will attempt to mount the volume using the embedded backup header. Note that if the volume header is damaged, you do not have to use this option. Instead, you can repair the header by selecting *Tools > Restore Volume Header*.

Mount partition using system encryption without pre-boot authentication

Check this option, if you need to mount a partition that is within the key scope of system encryption without pre-boot authentication. For example, if you need to mount a partition located on the encrypted system drive of another operating system that is not running. This can be useful e.g. when you need to back up or repair an operating system encrypted by VeraCrypt (from within another operating system). Note that this option can be enabled also when using the '*Auto-Mount Devices*' or '*Auto-Mount All Device-Hosted Volumes*' functions.

Hidden Volume Protection

Please see the section *Protection of Hidden Volumes Against Damage*.

Parallelization

When your computer has a multi-core processor (or multiple processors), VeraCrypt uses all of the cores (or processors) in parallel for encryption and decryption. For example, when VeraCrypt is to decrypt a chunk of data, it first splits the chunk into several smaller pieces. The number of the pieces is equal to the number of the cores (or processors). Then, all of the pieces are decrypted in parallel (piece 1 is decrypted by thread 1, piece 2 is decrypted by thread 2, etc). The same method is used for encryption.

So if your computer has, for example, a quad-core processor, then encryption and decryption are four times faster than on a single-core processor with equivalent specifications (likewise, they are twice faster on dual-core processors, etc).

Increase in encryption/decryption speed is directly proportional to the number of cores and/or processors.

Note: Processors with the Hyper-Threading technology provide multiple logical cores per one physical core (or multiple logical processors per one physical processor). When Hyper Threading is enabled in the computer firmware (e.g. BIOS) settings, VeraCrypt creates one thread for each logical core/processor. For example, on a 6-core processor that provides two logical cores per one physical core, VeraCrypt uses 12 threads.

When your computer has a multi-core processor/CPU (or multiple processors/CPUs), header key derivation is parallelized too. As a result, mounting of a volume is several times faster on a multi-core processor (or multi-processor computer) than on a single-core processor (or a single-processor computer) with equivalent specifications.

Pipelining

When encrypting or decrypting data, VeraCrypt uses so-called pipelining (asynchronous processing). While an application is loading a portion of a file from a VeraCrypt-encrypted volume/drive, VeraCrypt is automatically decrypting it (in RAM). Thanks to pipelining, the application does not have wait for any portion of the file to be decrypted and it can start loading other portions of the file right away. The same applies to encryption when writing data to an encrypted volume/drive.

Pipelining allows data to be read from and written to an encrypted drive as fast as if the drive was not encrypted (the same applies to file-hosted and partition-hosted VeraCrypt volumes).[*]

Note: Pipelining is implemented only in the Windows versions of VeraCrypt.

---

[*] Some solid-state drives compress data internally, which appears to increase the actual read/write speed when the data is compressible (for example, text files). However, encrypted data cannot be compressed (as it appears to consist solely of random "noise" without any compressible patterns). This may have various implications. For example, benchmarking software that reads or writes compressible data (such as sequences of zeroes) will report lower speeds on encrypted volumes than on unencrypted volumes (to avoid this, use benchmarking software that reads/writes random or other kinds of uncompressible data).

Hardware Acceleration

Some processors (CPUs) support hardware-accelerated AES encryption,[*] which is typically 4-8 times faster than encryption performed by the purely software implementation on the same processors.

By default, VeraCrypt uses hardware-accelerated AES on computers that have a processor where the Intel AES-NI instructions are available. Specifically, VeraCrypt uses the AES-NI instructions that perform so-called AES rounds (i.e. the main portions of the AES algorithm).[†] VeraCrypt does not use any of the AES-NI instructions that perform key generation.

Note: By default, VeraCrypt uses hardware-accelerated AES also when an encrypted Windows system is booting or resuming from hibernation (provided that the processor supports the Intel AES-NI instructions).

To find out whether VeraCrypt can use hardware-accelerated AES on your computer, select *Settings > Performance/Driver Configuration* and check the field labeled '*Processor (CPU) in this computer supports hardware acceleration for AES*'.

To find out whether a processor you want to purchase supports the Intel AES-NI instructions (also called "AES New Instructions"), which VeraCrypt uses for hardware-accelerated AES, please check the documentation for the processor or contact the vendor/manufacturer. Alternatively, click here to view an official list of Intel processors that support the AES-NI instructions. However, note that some Intel processors, which the Intel website lists as AES-NI-supporting, actually support the AES-NI instructions only with a Processor Configuration update (for example, i7-2630/2635QM, i7-2670/2675QM, i5-2430/2435M, i5-2410/2415M). In such cases, you should contact the manufacturer of the motherboard/computer for a BIOS update that includes the latest Processor Configuration update for the processor.

If you want to disable hardware acceleration of AES (e.g. because you want VeraCrypt to use only a fully open-source implementation of AES), you can do so by selecting *Settings > Performance and Driver Options* and disabling the option '*Accelerate AES encryption/decryption by using the AES instructions of the processor*'. Note that when this setting is changed, the operating system needs to be restarted to ensure that all VeraCrypt components internally perform the requested change of mode. Also note that when you create a VeraCrypt Rescue Disk, the state of this option is written to the Rescue Disk and used whenever you boot from it (affecting the pre-boot and initial boot phase).
To create a new VeraCrypt Rescue Disk, select *System > Create Rescue Disk*.

---

[*] In this chapter, the word 'encryption' also refers to decryption.
[†] Those instructions are *AESENC*, *AESENCLAST*, *AESDEC*, and *AESDECLAST* and they perform the following AES transformations: *ShiftRows*, *SubBytes*, *MixColumns*, *InvShiftRows*, *InvSubBytes*, *InvMixColumns*, and *AddRoundKey* (for more details about these transformations, see [3]).

Hot Keys

To set system-wide VeraCrypt hot keys, click *Settings > Hot Keys*. Note that hot keys work only when VeraCrypt or the VeraCrypt Background Task is running.

Keyfiles

Keyfile is a file whose content is combined with a password (for information on the method used to combine a keyfile with password, see the section *Keyfiles in the* chapter *Technical Details*). Until the   correct keyfile is provided, no volume that uses the keyfile can be mounted.

You do not have to use keyfiles. However, using keyfiles has some advantages:

- May improve protection against brute force attacks (significant particularly if the volume password is not very strong).

- Allows the use of security tokens and smart cards (see below).

- Allows multiple users to mount a single volume using different user passwords or PINs. Just give each user a security token or smart card containing the same VeraCrypt keyfile and let them choose their personal password or PIN that will protect their security token or smart card.

- Allows managing multi-user *shared* access (all keyfile holders must present their keyfiles before a volume can be mounted).

Any kind of file (for example, .txt, .exe, mp3[*], .avi) can be used as a VeraCrypt keyfile (however, we recommend that you prefer compressed files, such as .mp3, .jpg, .zip, etc). Note that VeraCrypt never modifies the keyfile contents.

You can select more than one keyfile; the order does not matter. You can also let VeraCrypt generate a file with random content and use it as a keyfile. To do so, select *Tools > Keyfile Generator*.

Note: Keyfiles are currently not supported for system encryption.

WARNING: If you lose a keyfile or if any bit of its first 1024 kilobytes changes, it will be impossible to mount volumes that use the keyfile!

WARNING: If password caching is enabled, the password cache also contains the processed contents of keyfiles used to successfully mount a volume. Then it is possible to **remount the volume even if the keyfile is not available/accessible.** *To prevent this, click '*Wipe Cache*' or disable password caching (for more information, please see the subsection 'Settings > Preferences', item 'Cache passwords in driver memory' in the section Program Menu).*

See also the section *Choosing Passwords and Keyfiles* in the chapter *Security Requirements and Precautions*.

Keyfiles Dialog Window

If you want to use keyfiles (i.e. "apply" them) when creating or mounting volumes, or changing passwords, look for the '*Use keyfiles*' option and the *Keyfiles* button below a password input field.

---

* However, if you use an MP3 file as a keyfile, you must ensure that no program modifies the ID3 tags (e.g. song title, name of artist, etc.) within the MP3 file. Otherwise, it will be impossible to mount volumes that use the keyfile.
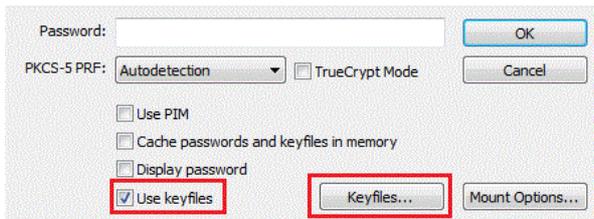
These control elements appear in various dialog windows and always have the same functions. Check the *Use keyfiles* option and click *Keyfiles.* The keyfile dialog window should appear where you can specify keyfiles (to do so, click *Add Files* or *Add Token Files*) *or* keyfile search paths (click *Add Path*).

Security Tokens and Smart Cards

VeraCrypt can directly use keyfiles stored on a security token or smart card that complies with the PKCS #11 (2.0 or later) standard [23] and that allows the user to store a file (data object) on the token/card. To use such files as VeraCrypt keyfiles, click *Add Token Files* (in the keyfile dialog window).

Access to a keyfile stored on a security token or smart card is typically protected by PIN codes, which can be entered either using a hardware PIN pad or via the VeraCrypt GUI. It can also be protected by other means, such as fingerprint readers.

In order to allow VeraCrypt to access a security token or smart card, you need to install a PKCS #11 (2.0 or later) software library for the token or smart card first. Such a library may be supplied with the device or it may be available for download from the website of the vendor or other third parties.

If your security token or smart card does not contain any file (data object) that you could use as a VeraCrypt keyfile, you can use VeraCrypt to import any file to the token or smart card (if it is supported by the device). To do so, follow these steps:

1. In the keyfile dialog window, click *Add Token Files*.
2. If the token or smart card is protected by a PIN, password, or other means (such as a fingerprint reader), authenticate yourself (for example, by entering the PIN using a hardware PIN pad).
3. The 'Security Token Keyfile' dialog window should appear. In it, click *Import Keyfile to Token* and then select the file you want to import to the token or smart card.

Note that you can import for example 512-bit keyfiles with random content generated by VeraCrypt (see *Tools > Keyfile Generator* below).

To close all opened security token sessions, either select *Tools > Close All Security Token Sessions* or define and use a hotkey combination (*Settings > Hot Keys > Close All Security Token Sessions*).

Keyfile Search Path

By adding a folder in the keyfile dialog window (click *Add Path*), you specify a *keyfile search path*. All files found in the keyfile search path[*] will be used as keyfiles except files that have the Hidden file attribute set.

Important: Note that folders (and files they contain) and hidden files found in a keyfile search path are ignored.

Keyfile search paths are especially useful if you, for example, store keyfiles on a USB memory stick that you carry with you. You can set the drive letter of the USB memory stick as a default keyfile search path. To do so, select *Settings > Default Keyfiles*. Then click *Add Path*, browse to the drive letter assigned to the USB memory stick, and click *OK*. Now each time you mount a volume (and if the option *Use keyfiles* is checked in the password dialog window), VeraCrypt will scan the path and use all files that it finds on the USB memory stick as keyfiles.

> ***WARNING: When you add a folder (as opposed to a file) to the list of keyfiles, only the path is remembered, not the filenames! This means e.g. that if you create a new file in the folder or if you copy an additional file to the folder, then all volumes that used keyfiles from the folder will be impossible to mount (until you remove the newly added file from the folder).***

Empty Password & Keyfile

When a keyfile is used, the password may be empty, so the keyfile may become the only item necessary to mount the volume (which we do not recommend). If default keyfiles are set and enabled when mounting a volume, then before prompting for a password, VeraCrypt first automatically attempts to mount using an empty password plus default keyfiles (however, this does not apply to the '*Auto-Mount Devices*' function). If you need to set Mount Options (e.g., mount as read-only, protect hidden volume etc.) for a volume being mounted this way, hold down the *Control* (*Ctrl*) key while clicking *Mount* (or select *Mount with Options* from the *Volumes* menu). This will open the *Mount Options* dialog.

Quick Selection

Keyfiles and keyfile search paths can be quickly selected in the following ways:

- Right-click the *Keyfiles* button in the password entry dialog window and select one of the menu items.

- Drag the corresponding file/folder icons to the keyfile dialog window or to the password entry dialog.

---

[*] Found at the time when you are mounting the volume, changing its password, or performing any other operation that involves re-encryption of the volume header.

Volumes > Add/Remove Keyfiles to/from Volume

This function allows you to re-encrypt a volume header with a header encryption key derived from any number of keyfiles (with or without a password), or no keyfiles at all. Thus, a volume which is possible to mount using only a password can be converted to a volume that require keyfiles (in addition to the password) in order to be possible to mount. Note that the volume header contains the master encryption key with which the volume is encrypted. Therefore, the data stored on the volume will *not* be lost after you use this function.

This function can also be used to change/set volume keyfiles (i.e., to remove some or all keyfiles, and to apply new ones).

Remark: This function is internally equal to the Password Change function.

When VeraCrypt re-encrypts a volume header, the original volume header is first overwritten 256 times with random data to prevent adversaries from using techniques such as magnetic force microscopy or magnetic force scanning tunneling microscopy [17] to recover the overwritten header (however, see also the chapter *Security Requirements and Precautions*).

Volumes > Remove All Keyfiles from Volume

This function allows you to re-encrypt a volume header with a header encryption key derived from a password and no keyfiles (so that it can be mounted using only a password, without any keyfiles). Note that the volume header contains the master encryption key with which the volume is encrypted. Therefore, the data stored on the volume will *not* be lost after you use this function.

Remark: This function is internally equal to the Password Change function.

When VeraCrypt re-encrypts a volume header, the original volume header is first overwritten 256 times with random data to prevent adversaries from using techniques such as magnetic force microscopy or magnetic force scanning tunneling microscopy [17] to recover the overwritten header (however, see also the chapter *Security Requirements and Precautions*).

Tools > Keyfile Generator

You can use this function to generate a file or more with random content, which you can use as a keyfile(s) (recommended). This function uses the VeraCrypt Random Number Generator. Note that, by default, only one key file is generated and the resulting file size is 64 bytes (i.e., 512 bits), which is also the maximum possible VeraCrypt password length. It is also possible to generate multiple files and specify their size (either a fixed value for all of them or let VeraCrypt choose file sizes randomly). In all cases, the file size must be comprised between 64 bytes and 1048576 bytes (which is equal to 1MB, the maximum number of a key file bytes processed by VeraCrypt).

Settings > Default Keyfiles

Use this function to set default keyfiles and/or default keyfile search paths. This function is particularly useful if you, for example, store keyfiles on a USB memory stick that you carry with you. You can add its drive letter to the default keyfile configuration. To do so, click *Add Path*, browse to the drive letter assigned to the USB memory stick, and click *OK*. Now each time you mount a volume (and if *Use keyfiles* is checked in the password dialog), VeraCrypt will scan the path and use all files that it finds there as keyfiles.

WARNING: When you add a folder (as opposed to a file) to your default keyfile list, only the path is remembered, not the filenames! This means e.g. that if you create a new file in the folder or if you copy an additional file to the folder, then all volumes that used keyfiles from the folder will be impossible to mount (until you remove the newly added file from the folder).

IMPORTANT: Note that when you set default keyfiles and/or default keyfile search paths, the filenames and paths are saved unencrypted in the file Default Keyfiles.xml. For more information, please see the chapter *VeraCrypt System Files & Application Data*.

Security Tokens & Smart Cards

VeraCrypt supports security (or cryptographic) tokens and smart cards that can be accessed using the PKCS #11 (2.0 or later) protocol [23]. For more information, please see the section *Security Tokens and Smart Cards* in the chapter *Keyfiles*.

Portable Mode

VeraCrypt can run in so-called portable mode, which means that it does not have to be installed on the operating system under which it is run. However, there are two things to keep in mind:

1) You need administrator privileges in order to be able to run VeraCrypt in portable mode (for the reasons, see the chapter *Using VeraCrypt Without Administrator Privileges*).

   > Note: No matter what kind of software you use, as regards personal privacy in most cases, it is *not* safe to work with sensitive data under systems where you do not have administrator privileges, as the administrator can easily capture and copy your sensitive data, including passwords and keys.

2) After examining the registry file, it may be possible to tell that VeraCrypt was run (and that a VeraCrypt volume was mounted) on a Windows system even if it had been run in portable mode.

Note: If that is a problem, see this question in the FAQ for a possible solution.

There are two ways to run VeraCrypt in portable mode:

1) After you extract files from the VeraCrypt self-extracting package, you can directly run *VeraCrypt.exe*.

   Note: To extract files from the VeraCrypt self-extracting package, run it, and then select *Extract* (instead of *Install*) on the second page of the VeraCrypt Setup wizard.

2) You can use the *Traveler Disk Setup* facility to prepare a special traveler disk and launch VeraCrypt from there.

The second option has several advantages, which are described in the following sections in this chapter.

Note: When running in 'portable' mode, the VeraCrypt driver is unloaded when it is no longer needed (e.g., when all instances of the main application and/or of the Volume Creation Wizard are closed and no VeraCrypt volumes are mounted). However, if you force dismount on a VeraCrypt volume when VeraCrypt runs in portable mode, or mount a writable NTFS-formatted volume on Windows Vista or later, the VeraCrypt driver may *not* be unloaded when you exit VeraCrypt (it will be unloaded only when you shut down or restart the system). This prevents various problems caused by a bug in Windows (for instance, it would be impossible to start VeraCrypt again as long as there are applications using the dismounted volume).

Tools > Traveler Disk Setup

You can use this facility to prepare a special traveler disk and launch VeraCrypt from there. Note that VeraCrypt 'traveler disk' is *not* a VeraCrypt volume but an *unencrypted* volume. A 'traveler disk' contains VeraCrypt executable files and optionally the 'autorun.inf' script (see the section *AutoRun Configuration* below). After you select *Tools > Traveler Disk Setup*, the *Traveler Disk Setup* dialog box should appear. Some of the parameters that can be set within the dialog deserve further explanation:

Include VeraCrypt Volume Creation Wizard

Check this option, if you need to create new VeraCrypt volumes using VeraCrypt run from the traveler disk you will create. Unchecking this option saves space on the traveler disk.

AutoRun Configuration (autorun.inf)

In this section, you can configure the 'traveler disk' to automatically start VeraCrypt or mount a specified VeraCrypt volume when the 'traveler disk' is inserted. This is accomplished by creating a special script file called '*autorun.inf*' on the traveler disk. This file is automatically executed by the   operating system each time the 'traveler disk' is inserted.

Note, however, that this feature only works for removable storage devices such as CD/DVD (Windows XP SP2, Windows Vista, or a later version of Windows is required for this feature to work on USB memory sticks) and only when it is enabled in the operating system. Depending on the operating system configuration, these auto-run and auto-mount features may work only when the traveler disk files are created on a non-writable CD/DVD-like medium (which is not a bug in VeraCrypt but a limitation of Windows).

Also note that the '*autorun.inf*' file must be in the root directory (i.e., for example *G:*, *X:*, or *Y:* etc.) of an **unencrypted** disk in order for this feature to work.

TrueCrypt Support

Starting from version 1.0f, VeraCrypt supports loading TrueCrypt volumes and partitions, both normal and hidden. In order to activate this, you have to check "TrueCrypt Mode" in the password prompt dialog as shown below.
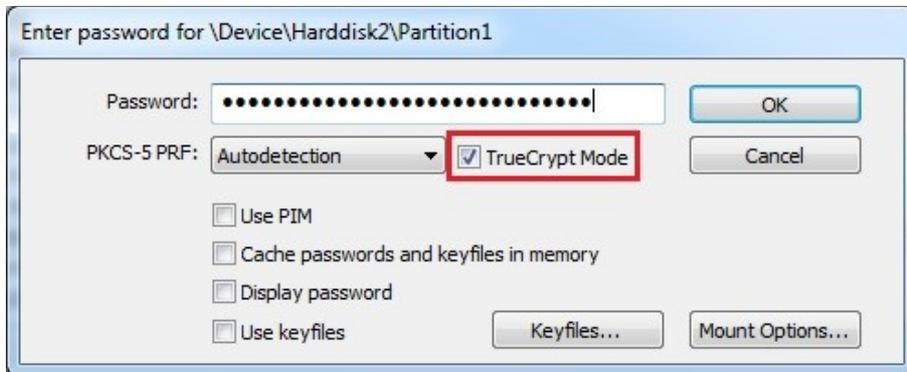
Note: Only volumes and partitions created using TrueCrypt versions **6.x** and **7.x** are supported.

Converting TrueCrypt volumes and partitions

Starting from version 1.0f, TrueCrypt volumes and non-system partitions can be converted to VeraCrypt format using any of the following actions:
- Change Volume Password
- Set Header Key Derivation Algorithm
- Add/Remove key files
- Remove all key files

"TrueCrypt Mode" must be checked in the dialog as show below:
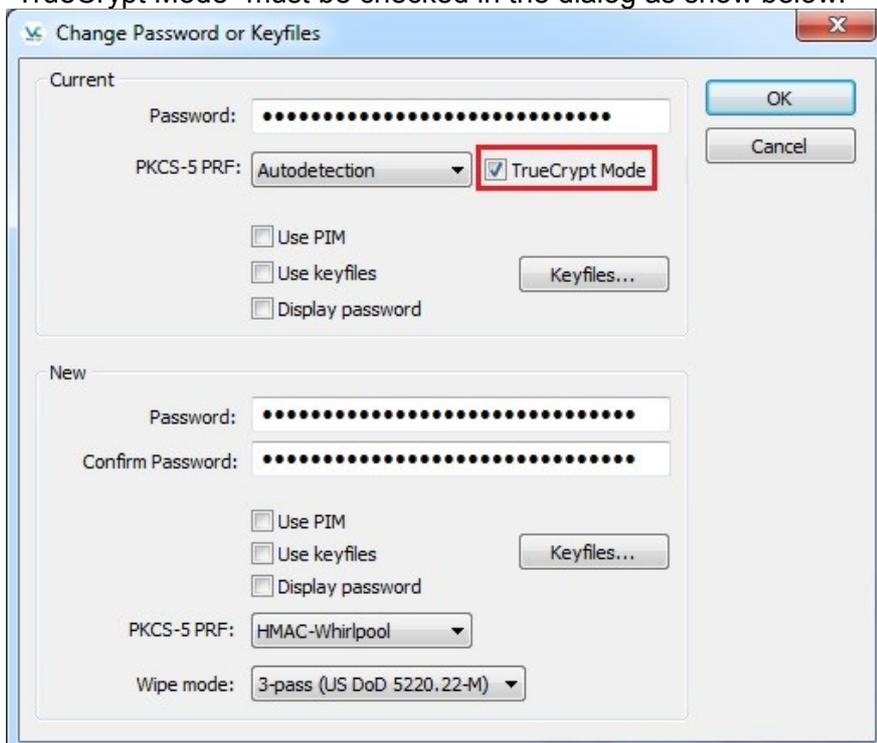
Note: Converting system partitions encrypted with TrueCrypt is not supported.

Default Mount Parameters

Starting from version 1.0f-2, it is possible to specify the PRF algorithm and the TrueCrypt mode that will be selected by default in the password dialog.

As show below, select the entry "Default Mount Parameters" under the menu "Settings":
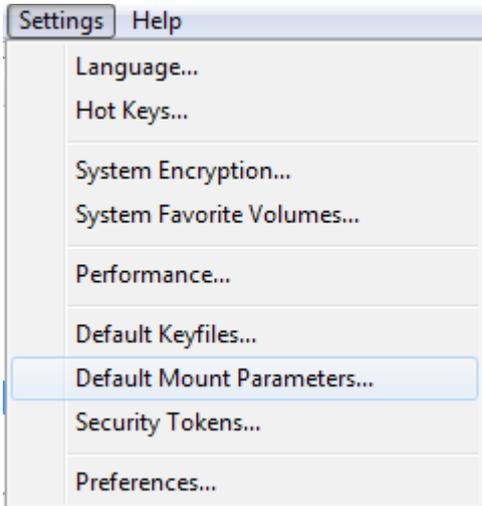
The following dialog will be displayed:
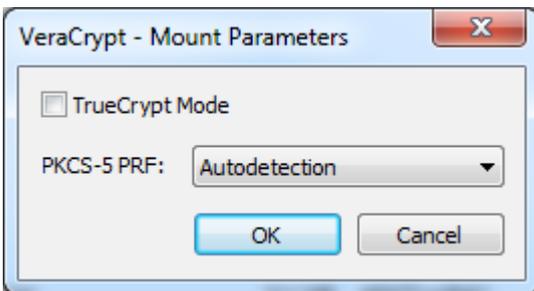
Make your modifications and then click OK.
The chosen values are then written to VeraCrypt main configuration file (Configuration.xml) making them persistent.

All subsequent password request dialogs will use the default values chosen previously. For example, if in the Default Mount Parameters dialog you check TrueCrypt Mode and you select SHA-512 as a PRF, then subsequent password dialogs will look like:
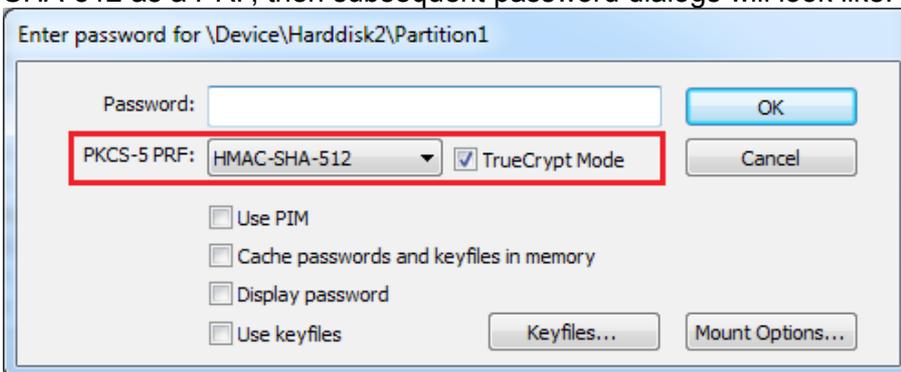
Note: The default mount parameters can be overridden by the Command Line switches **/tc** and **/hash** which always take precedence.

Language Packs

Language packs contain third-party translations of the VeraCrypt user interface texts. Note that language packs are   currently supported only by the Windows version of VeraCrypt.

Installation

Since version 1.0e, all language packs are included in the VeraCrypt Windows installer and they can be found in VeraCrypt installation directory. To select a new language, run VeraCrypt, select *Settings* > *Language*, then select your language and click *OK*.

To revert to English, select *Settings* > *Language*. Then select *English* and click *OK*.

You can still download an archive containing all language packs for the latest version (1.17) from [the following link](#).

Encryption Algorithms

VeraCrypt volumes can be encrypted using the following algorithms:

Algorithm	Designer(s)	Key Size (Bits)	Block Size (Bits)	Mode of Operation
AES	J. Daemen, V. Rijmen	256	128	XTS
Camellia	Mitsubishi Electric and NTT of Japan	256	128	XTS
Kuznyechik	National Standard of the Russian Federation GOST R 34.12-2015	256	128	XTS
Serpent	R. Anderson, E. Biham, L. Knudsen	256	128	XTS
Twofish	B. Schneier, J. Kelsey, D. Whiting, D. Wagner, C. Hall, N. Ferguson	256	128	XTS
AES-Twofish		256; 256	128	XTS
AES-Twofish-Serpent		256; 256; 256	128	XTS
Serpent-AES		256; 256	128	XTS
Serpent-Twofish-AES		256; 256; 256	128	XTS
Twofish-Serpent		256; 256	128	XTS

For information about XTS mode, please see the section *Modes of Operation*.

AES

The Advanced Encryption Standard (AES) specifies a FIPS-approved cryptographic algorithm (Rijndael, designed by Joan Daemen and Vincent Rijmen, published in 1998) that may be used by US federal departments and agencies to cryptographically protect sensitive information [3]. VeraCrypt uses AES with 14 rounds and a 256-bit key (i.e., AES-256, published in 2001) operating in XTS mode (see the section *Modes of Operation*).

In June 2003, after the NSA (US National Security Agency) conducted a review and analysis of AES, the U.S. CNSS (Committee on National Security Systems) announced in [1] that the design and strength of AES-256 (and AES-192) are sufficient to protect classified information up to the Top Secret level. This is applicable to all U.S. Government Departments or Agencies that are considering the acquisition or use of products incorporating the Advanced Encryption Standard (AES) to satisfy Information Assurance requirements associated with the protection of national security systems and/or national security information [1].

Serpent

Designed by Ross Anderson, Eli Biham, and Lars Knudsen; published in 1998. It uses a 256-bit key, 128-bit block, and operates in XTS mode (see the section *Modes of Operation*). Serpent was one of the AES finalists. It was not selected as the proposed AES algorithm even though it appeared to have a higher security margin than the winning Rijndael [4]. More concretely, Serpent appeared to have a *high* security margin, while Rijndael appeared to have only an *adequate* security margin [4]. Rijndael has also received some criticism suggesting that its mathematical structure might lead to attacks in the future [4].

In [5], the Twofish team presents a table of safety factors for the AES finalists. Safety factor is defined as: number of rounds of the full cipher divided by the largest number of rounds that has been broken. Hence, a broken cipher has the lowest safety factor 1. Serpent had the highest safety factor of the AES finalists: 3.56 (for all supported key sizes). Rijndael-256 had a safety factor of 1.56.

In spite of these facts, Rijndael was considered an appropriate selection for the AES for its combination of security, performance, efficiency, implementability, and flexibility [4]. At the last AES Candidate Conference, Rijndael got 86 votes, Serpent got 59 votes, Twofish got 31 votes, RC6 got 23 votes, and MARS got 13 votes [18, 19].*

Twofish

Designed by Bruce Schneier, John Kelsey, Doug Whiting, David Wagner, Chris Hall, and Niels Ferguson; published in 1998. It uses a 256-bit key and 128-bit block and operates in XTS mode (see the section *Modes of Operation*). Twofish was one of the AES finalists. This cipher uses key-dependent S-boxes. Twofish may be viewed as a collection of 2^{128} different cryptosystems, where 128 bits derived from a 256-bit key control the selection of the cryptosystem [4]. In [13], the Twofish team asserts that key-dependent S-boxes constitute a form of security margin against unknown attacks [4].

Camellia

Jointly developed by Mitsubishi Electric and NTT of Japan, Camellia is a 128-bit block cipher that was first published on 2000. It has been approved for use by the ISO/IEC, the European Union's NESSIE project and the Japanese CRYPTREC project.
VeraCrypt uses Camellia with 24 rounds and a 256-bit key operating in XTS mode (see the section Modes of Operation).

Kuznyechik

Kuznyechik is a 128-bit block cipher first published in 2015 and defined in the National Standard of the Russian Federation GOST R 34.12-2015 and also in RFC 7801. It supersedes the old GOST-89 block cipher although it doesn't obsolete it.

VeraCrypt uses Kuznyechik with 10 rounds and a 256-bit key operating in XTS mode (see the section Modes of Operation).

---

* These are positive votes. If negative votes are subtracted from the positive votes, the following results are obtained: Rijndael: 76 votes, Serpent: 52 votes, Twofish: 10 votes, RC6: -14 votes, MARS: -70 votes [19].

Cascades of ciphers

AES-Twofish

Two ciphers in a cascade [15, 16] operating in XTS mode (see the section *Modes of Operation*). Each 128-bit block is first encrypted with Twofish (256-bit key) in XTS mode and then with AES (256-bit key) in XTS mode. Each of the cascaded ciphers uses its own key. All encryption keys are mutually independent (note that header keys are independent too, even though they are derived from a single password – see *Header Key Derivation, Salt, and Iteration Count*). See above for information on the individual cascaded ciphers.

AES-Twofish-Serpent

Three ciphers in a cascade [15, 16] operating in XTS mode (see the section *Modes of Operation*). Each 128-bit block is first encrypted with Serpent (256-bit key) in XTS mode, then with Twofish (256-bit key) in XTS mode, and finally with AES (256-bit key) in XTS mode. Each of the cascaded ciphers uses its own key. All encryption keys are mutually independent (note that header keys are independent too, even though they are derived from a single password – see the section *Header Key Derivation, Salt, and Iteration Count*). See above for information on the individual cascaded ciphers.

Serpent-AES

Two ciphers in a cascade [15, 16] operating in XTS mode (see the section *Modes of Operation*). Each 128-bit block is first encrypted with AES (256-bit key) in XTS mode and then with Serpent (256-bit key) in XTS mode. Each of the cascaded ciphers uses its own key. All encryption keys are mutually independent (note that header keys are independent too, even though they are derived from a single password – see the section *Header Key Derivation, Salt, and Iteration Count*). See above for information on the individual cascaded ciphers.

Serpent-Twofish-AES

Three ciphers in a cascade [15, 16] operating in XTS mode (see the section *Modes of Operation*). Each 128-bit block is first encrypted with AES (256-bit key) in XTS mode, then with Twofish (256-bit key) in XTS mode, and finally with Serpent (256-bit key) in XTS mode. Each of the cascaded ciphers uses its own key. All encryption keys are mutually independent (note that header keys are independent too, even though they are derived from a single password – see the section *Header Key Derivation, Salt, and Iteration Count*). See above for information on the individual cascaded ciphers.

Twofish-Serpent

Two ciphers in a cascade [15, 16] operating in XTS mode (see the section *Modes of Operation*). Each 128-bit block is first encrypted with Serpent (256-bit key) in XTS mode and then with Twofish (256-bit key) in XTS mode. Each of the cascaded ciphers uses its own key. All encryption keys are mutually independent (note that header keys are independent too, even though they are derived from a single password – see the section *Header Key Derivation, Salt, and Iteration Count*). See above for information on the individual cascaded ciphers.

Hash Algorithms

In the Volume Creation Wizard, in the password change dialog window, and in the Keyfile Generator dialog window, you can select a hash algorithm. A user-selected hash algorithm is used by the VeraCrypt Random Number Generator as a pseudorandom "mixing" function, and by the header key derivation function (HMAC based on a hash function, as specified in PKCS #5 v2.0) as a pseudorandom function. When creating a new volume, the Random Number Generator generates the master key, secondary key (XTS mode), and salt. For more information, please see the section *Random Number Generator* and section *Header Key Derivation, Salt, and Iteration Count*.

RIPEMD-160

RIPEMD-160, published in 1996, is a hash algorithm designed by Hans Dobbertin, Antoon Bosselaers, and Bart Preneel in an open academic community. The size of the output of RIPEMD-160 is 160 bits. RIPEMD-160 is a strengthened version of the RIPEMD hash algorithm that was developed in the framework of the European Union's project RIPE (*RACE Integrity Primitives Evaluation*), 1988-1992. RIPEMD-160 was adopted by the International Organization for Standardization (ISO) and the IEC in the ISO/IEC 10118-3:2004 international standard [21].

SHA-256

SHA-256 is a hash algorithm designed by the NSA and published by NIST in FIPS PUB 180-2 [14] in 2002 (the first draft was published in 2001). The size of the output of this algorithm is 256 bits.

SHA-512

SHA-512 is a hash algorithm designed by the NSA and published by NIST in FIPS PUB 180-2 [14] in 2002 (the first draft was published in 2001). The size of the output of this algorithm is 512 bits.

Whirlpool

The Whirlpool hash algorithm was designed by Vincent Rijmen (co-designer of the AES encryption algorithm) and Paulo S. L. M. Barreto. The size of the output of this algorithm is 512 bits. The first version of Whirlpool, now called Whirlpool-0, was published in November 2000. The second version, now called Whirlpool-T, was selected for the NESSIE (*New European Schemes for Signatures, Integrity and Encryption*) portfolio of cryptographic primitives (a project organized by the European Union, similar to the AES competition). VeraCrypt uses the third (final) version of Whirlpool, which was adopted by the International Organization for Standardization (ISO) and the IEC in the ISO/IEC 10118-3:2004 international standard [21].

Streebog

Streebog is a family of two hash algorithms, Streebog-256 and Streebog-512, defined in the Russian national standard GOST R 34.11-2012 Information Technology - Cryptographic Information Security - Hash Function. It is also described in RFC 6986. It is the competitor of NIST SHA-3 standard. VeraCrypt uses only Streebog-512 which has an output size of 512 bits.

Supported Operating Systems

Note: After this version of VeraCrypt was released, a new version of an operating system may have been released, verified to be fully compatible with VeraCrypt and added to the list of supported systems. Therefore, if this is the latest stable version of VeraCrypt, you should check the online version of this chapter at https://veracrypt.codeplex.com/wikipage?title=Supported%20Operating%20Systems.

VeraCrypt currently supports the following operating systems:

- Windows 10
- Windows 8 and 8.1
- Windows 7
- Windows Vista
- Windows XP
- Windows Server 2012
- Windows Server 2008 R2 (64-bit)
- Windows Server 2008
- Windows Server 2003

- Mac OS X 10.11 El Capitan
- Mac OS X 10.10 Yosemite
- Mac OS X 10.9 Mavericks
- Mac OS X 10.8 Mountain Lion
- Mac OS X 10.7 Lion
- Mac OS X 10.6 Snow Leopard

- Linux x 8 6   (32-bit and 64-bit versions, kernel 2.6 or compatible)

Note: The following operating systems (among others) are not supported: Windows RT, Windows 2003 IA-64, Windows 2008 IA-64,   Windows XP IA-64, and the Embedded/Tablet versions of Windows.

Also see the section Operating Systems Supported for System Encryption.

Command Line Usage

Note that this section applies to the Windows version of VeraCrypt. For information on command line usage applying to the **Linux and Mac OS X versions**, please run: `veracrypt -h`

/help or */?*	Display command line help.
/truecrypt or /tc	Activate TrueCrypt compatibility mode which enables mounting volumes created with TrueCrypt 6.x and 7.x series.
/hash	It must be followed by a parameter indicating the PRF hash algorithm to use when mounting the volume. Possible values for /hash parameter are: sha256, sha-256, sha512, sha-512, whirlpool, ripemd160 and ripemd-160. When /hash is omitted, VeraCrypt will try all possible PRF algorithms thus lengthening the mount operation time.
/volume or */v*	It must be followed by a parameter indicating the file and path name of a VeraCrypt volume to mount (do not use when dismounting) or the Volume ID of the disk/partition to mount. The syntax of the volume ID is **ID:XXXXXX...XX** where the XX part is a 64 hexadecimal characters string that represent the 32-Bytes ID of the desired volume to mount. To mount a partition/device-hosted volume, use, for example, `/v \Device\Harddisk1\Partition3` (to determine the path to a partition/device, run VeraCrypt and click *Select Device*). You can also mount a partition or dynamic volume using its volume name (for example, `/v \\?\Volume{5cceb196-48bf-46ab-ad00-70965512253a}\`). To determine the volume name use e.g. `mountvol.exe`. Also note that device paths are case-sensitive. You can also specify the Volume ID of the partition/device-hosted volume to mount, for example: /v ID:53B9A8D59CC84264004DA8728FC8F3E2EE6C130145ABD3835695C 29FD601EDCA. The Volume ID value can be retrieved using the volume properties dialog.
/letter or */l*	It must be followed by a parameter indicating the driver letter to mount the volume as. When `/l` is omitted and when `/a` is used, the first free drive letter is used.
/explore or */e*	Open an Explorer window after a volume has been mounted.
/beep or */b*	Beep after a volume has been successfully mounted or dismounted.
/auto or */a*	If no parameter is specified, automatically mount the volume. If `devices` is specified as the parameter (e.g., `/a devices`), auto-mount all currently accessible device/partition-hosted VeraCrypt volumes. If `favorites` is specified as the parameter, auto-mount favorite volumes. Note that `/auto` is implicit if `/quit` and `/volume` are specified. If you need to prevent the application window from appearing, use `/quit`.
/dismount or */d*	Dismount volume specified by drive letter (e.g., `/d x`). When no drive letter is specified, dismounts all currently mounted VeraCrypt volumes.

/force or */f*	Forces dismount (if the volume to be dismounted contains files being used by the system or an application) and forces mounting in shared mode (i.e., without exclusive access).
/keyfile or */k*	It must be followed by a parameter specifying a keyfile or a keyfile search path. For multiple keyfiles, specify e.g.: `/k c:\keyfile1.dat /k d:\KeyfileFolder /k c:\kf2` To specify a keyfile stored on a security token or smart card, use the following syntax: `token://slot/`*SLOT_NUMBER*`/file/`*FILE_NAME*
/tryemptypass	ONLY when default keyfile configured or when a keyfile is specified in the command line. If it is followed by **y** or **yes** or if no parameter is specified: try to mount using an empty password and the keyfile before displaying password prompt. If it is followed by **n** or **no**: don't try to mount using an empty password and the keyfile, and display password prompt right away.
/nowaitdlg	If it is followed by **y** or **yes** or if no parameter is specified: don't display the waiting dialog while performing operations like mounting volumes. If it is followed by **n** or **no**: force the display waiting dialog is displayed while performing operations.
/tokenlib	It must be followed by a parameter indicating the PKCS #11 library to use for security tokens and smart cards. (e.g.: /tokenlib [c:\pkcs11lib.dll](c:\pkcs11lib.dll)).
/tokenpin	It must be followed by a parameter indicating the PIN to use in order to authenticate to the security token or smart card (e.g.: /tokenpin 0000). *Warning: This method of entering a smart card PIN may be insecure, for example, when an unencrypted command prompt history log is being saved to unencrypted disk.*
/cache or */c*	If it is followed by **y** or **yes** or if no parameter is specified: enable password cache. If it is followed by **n** or **no**: disable password cache (e.g., `/c n`). If it is followed by **f** or **favorites**: temporary cache password when mounting multiple favorites (e.g., /c f). Note that turning the password cache off will not clear it (use `/w` to clear the password cache).
/history or */h*	If it is followed by `y` or no parameter: enables saving history of mounted volumes; if it is followed by `n`: disables saving history of mounted volumes (e.g., `/h n`).
/wipecache or */w*	Wipes any passwords cached in the driver memory.
/password or */p*	It must be followed by a parameter indicating the volume password. If the password contains spaces, it must be enclosed in quotation marks (e.g., `/p "My Password"`). Use `/p ""` to specify an empty password. *Warning: This method of entering a volume password may be insecure, for example, when an unencrypted command prompt history log is being saved to unencrypted disk.*
/pim	It must be followed by a positive integer indicating the PIM (Personal Iterations Multiplier) to use for the volume.

/quit or */q*	Automatically perform requested actions and exit (main VeraCrypt window will not be displayed). If `preferences` is specified as the parameter (e.g., `/q preferences`), then program settings are loaded/saved and they override settings specified on the command line. `/q background` launches the VeraCrypt Background Task (tray icon) unless it is disabled in the Preferences.
/silent or */s*	If `/q` is specified, suppresses interaction with the user (prompts, error messages, warnings, etc.). If `/q` is not specified, this option has no effect.
/mountoption or */m*	It must be followed by a parameter which can have one of the values indicated below.

`ro` or `readonly`: Mount volume as read-only.

`rm` or `removable`: Mount volume as removable medium (see section *Volume Mounted as Removable Medium*).

`ts` or `timestamp`: Do not preserve container modification timestamp.

`sm` or `system`: Without pre-boot authentication, mount a partition that is within the key scope of system encryption (for example, a partition located on the encrypted system drive of another operating system that is not running). Useful e.g. for backup or repair operations.
Note: If you supply a password as a parameter of `/p`, make sure that the password has been typed using the standard US keyboard layout (in contrast, the GUI ensures this automatically). This is required due to the fact that the password needs to be typed in the pre-boot environment (before Windows starts) where non-US Windows keyboard layouts are not available.

`bk` or `headerbak`: Mount volume using embedded backup header.
Note: All volumes created by VeraCrypt contain an embedded backup header (located at the end of the volume).

`recovery`: Do not verify any checksums stored in the volume header. This option should be used only when the volume header is damaged and the volume cannot be mounted even with the mount option `headerbak`.

`label=LabelValue`: Use the given string value `LabelValue` as a label of the mounted volume in Windows Explorer. The maximum length for `LabelValue` is 32 characters for NTFS volumes and 11 characters for FAT volumes. For example, `/m label=MyDrive` will set the label of the drive in Explorer to `MyDrive`.

Example: `/m ro`

Please not that this switch may be present several times in the command line in order to specify multiple mount options (e.g.: `/m rm /m ts`)

VeraCrypt Format.exe (VeraCrypt Volume Creation Wizard):

/create	Create a container based volume in command line mode. It must be followed by the file name of the container to be created.

/size

(Only with /create)
It must be followed by a parameter indicating the size of the container file that will be created. This parameter is a number indicating the size in Bytes. It can have a suffixe 'K', 'M', 'G' or 'T' to indicate that the value is in Kilobytes, Megabytes, Gigabytes or Terabytes respectively. For example:

- /size 5000000: the container size will be 5000000 bytes

- /size 25K: the container size will be 25 KiloBytes.

- /size 100M: the container size will be 100 MegaBytes.

- /size 2G: the container size will be 2 GigaBytes.

- /size 1T: the container size will be 1 TeraBytes.

/password

(Only with /create)
It must be followed by a parameter indicating the password of the container that will be created.

/hash

(Only with /create)
It must be followed by a parameter indicating the PRF hash algorithm to use when creating the volume. It has the same syntax as VeraCrypt.exe.

/encryption

(Only with /create)
It must be followed by a parameter indicating the encryption algorithm to use. The default is AES if this switch is not specified. The parameter can have the following values (case insensitive):
AES
Serpent
Twofish
AES(Twofish)
AES(Twofish(Serpent))
Serpent(AES)
Serpent(Twofish(AES))
Twofish(Serpent)

/filesystem

(Only with /create)
It must be followed by a parameter indicating the file system to use for the volume. The parameter can have the following values:
None: don't use any filesystem
FAT: format using FAT/FAT32
NTFS: format using NTFS. Please not that in this case a UAC prompt will be displayed unless the process is run with full administrative privileges.

/dynamic

(Only with /create)
It has no parameters and it indicates that the volume will be created as a dynamic volume.

/force	*(Only with /create)* *It has no parameters and it indicates that overwrite will be forced without requiring user confirmation.*
/silent	*(Only with /create)* *It has no parameters and it indicates that no message box or dialog will be displayed to the user. If there is any error, the operation will fail silently.*
/noisocheck or */n*	Do not verify that VeraCrypt Rescue Disks are correctly burned. **WARNING**: *Never attempt to use this option to facilitate the reuse of a previously created VeraCrypt Rescue Disk. Note that every time you encrypt a system partition/drive, you must create a new VeraCrypt Rescue Disk even if you use the same password. A previously created VeraCrypt Rescue Disk cannot be reused as it was created for a different master key.*

Syntax

```
VeraCrypt.exe [/tc] [/hash {sha256|sha-256|sha512|sha-512|whirlpool |ripemd160|
ripemd-160}][/a [devices|favorites]] [/b] [/c [y|n|f]] [/d [drive letter]] [/e]
[/f] [/h [y|n]] [/k keyfile or search path] [tryemptypass [y|n]] [/l drive
letter] [/m {bk|rm|recovery|ro|sm|ts}] [/p password] [/pim pimvalue] [/q
[background|preferences]] [/s] [/tokenlib path] [/v volume] [/w]
```

```
"VeraCrypt Format.exe" [/n] [/create] [/size number[{K|M|G|T}]] [/p password]
[/encryption {AES|Serpent|Twofish|AES(Twofish)|AES(Twofish(Serpent))|Serpent(AES)|
Serpent(Twofish(AES))|Twofish(Serpent)}] [/hash {sha256|sha-256|sha512|sha-512|
whirlpool|ripemd160|ripemd-160}] [/filesystem {None|FAT|NTFS}] [/dynamic] [/force]
[/silent]
```

Note that the order in which options are specified does not matter.

Examples

Mount the volume *d:\myvolume* as the first free drive letter, using the password prompt (the main program window will not be displayed):

```
veracrypt /q /v d:\myvolume
```

Dismount a volume mounted as the drive letter *X* (the main program window will not be displayed):

```
veracrypt /q /d x
```

Mount a volume called *myvolume.tc* using the password *MyPassword*, as the drive letter *X*. VeraCrypt will open an explorer window and beep; mounting will be automatic:

```
veracrypt /v myvolume.tc /l x /a /p MyPassword /e /b
```

Create a 10 MB file container using the password test and formatted using FAT:

```
"C:\Program Files\VeraCrypt\VeraCrypt Format.exe" /create c:\Data\test.hc
/password test /hash sha512 /encryption serpent /filesystem FAT /size 10M /force
```

Security Model

> ***Note to security researchers***: *If you intend to report a security issue or publish an attack on VeraCrypt, please make sure it does not disregard the security model of VeraCrypt described below. If it does, the attack (or security issue report) will be considered invalid/bogus.*

VeraCrypt is a computer software program whose primary purposes are to:

- Secure data by encrypting it before it is written to a disk.
- Decrypt encrypted data after it is read from the disk.

VeraCrypt does **not**:

- Encrypt or secure any portion of RAM (the main memory of a computer).
- Secure any data on a computer[*] if an attacker has administrator privileges[†] under an operating system installed on the computer.
- Secure any data on a computer if the computer contains any malware (e.g. a virus, Trojan horse, spyware) or any other piece of software (including VeraCrypt or an operating system component) that has been altered, created, or can be controlled, by an attacker.
- Secure any data on a computer if an attacker has physical access to the computer before or while VeraCrypt is running on it.
- Secure any data on a computer if an attacker has physical access to the computer between the time when VeraCrypt is shut down and the time when the entire contents of all volatile memory modules connected to the computer (including memory modules in peripheral devices) have been permanently and irreversibly erased/lost.
- Secure any data on a computer if an attacker can remotely intercept emanations from the computer hardware (e.g. the monitor or cables) while VeraCrypt is running on it (or otherwise remotely monitor the hardware and its use, directly or indirectly, while VeraCrypt is running on it).
- Secure any data stored in a VeraCrypt volume[‡] if an attacker without administrator privileges can access the contents of the mounted volume (e.g. if file/folder/volume permissions do not prevent such an attacker from accessing it).
- Preserve/verify the integrity or authenticity of encrypted or decrypted data.
- Prevent traffic analysis when encrypted data is transmitted over a network.
- Prevent an attacker from determining in which sectors of the volume the content changed (and when and how many times) if he or she can observe the volume (dismounted or mounted) before and after data is written to it, or if the storage medium/device allows the attacker to determine such information (for example, the volume resides on a device that saves metadata that can be used to determine when data was written to a particular sector).
- Encrypt any existing unencrypted data in place (or re-encrypt or erase data) on devices/filesystems that use wear-leveling or otherwise relocate data internally.
- Ensure that users choose cryptographically strong passwords or keyfiles.

---

[*] In this section (*Security Model*), the phrase "data on a computer" means data on internal and external storage devices/media (including removable devices and network drives) connected to the computer.
[†] In this section (*Security Model*), the phrase "administrator privileges" does not necessarily refer to a valid administrator account. It may also refer to an attacker who does not have a valid administrator account but who is able (for example, due to improper configuration of the system or by exploiting a vulnerability in the operating system or a third-party application) to perform any action that only a user with a valid administrator account is normally allowed to perform (for example, to read or modify an arbitrary part of a drive or the RAM, etc.)
[‡] "VeraCrypt volume" also means a VeraCrypt-encrypted system partition/drive (see the chapter *System Encryption*).

- Secure any computer hardware component or a whole computer.
- Secure any data on a computer where the security requirements or precautions listed in the chapter *Security Requirements and Precautions* are not followed.
- Do anything listed in the section *Limitations* (chapter *Known Issues & Limitations*).

Under **Windows**, a user without administrator privileges can (assuming the default VeraCrypt and operating system configurations):

- Mount any file-hosted VeraCrypt volume provided that the file permissions of the container allow it.
- Mount any partition/device-hosted VeraCrypt volume.
- Complete the pre-boot authentication process and, thus, gain access to data on an encrypted system partition/drive (and start the encrypted operating system).
- Skip the pre-boot authentication process (this can be prevented by disabling the option *Settings* > '*System Encryption*' > '*Allow pre-boot authentication to be bypassed by pressing the Esc key*'; note that this option can be enabled or disabled only by an administrator).
- Dismount, using VeraCrypt, (and, in the VeraCrypt application window, see the path to and properties of) any VeraCrypt volume mounted by him or her. However, this does not apply to 'system favorite volumes', which he or she can dismount (etc.) regardless of who mounted them (this can be prevented by enabling the option *Settings* > '*System Favorite Volumes*' > '*Allow only administrators to view and dismount system favorite volumes in VeraCrypt*'; note that this option can be enabled or disabled only by an administrator).
- Create a file-hosted VeraCrypt volume containing a FAT or no file system (provided that the relevant folder permissions allow it).
- Change the password, keyfiles, and header key derivation algorithm for, and restore or back up the header of, a file-hosted VeraCrypt volume (provided that the file permissions allow it).
- Access the filesystem residing within a VeraCrypt volume mounted by another user on the system (however, file/folder/volume permissions can be set to prevent this).
- Use passwords (and processed keyfiles) stored in the password cache (note that caching can be disabled; for more information see the section *Settings > Preferences,* subsection *Cache passwords in driver memory*).
- View the basic properties (e.g. the size of the encrypted area, encryption and hash algorithms used, etc.) of the encrypted system partition/drive when the encrypted system is running.
- Run and use the VeraCrypt application (including the VeraCrypt Volume Creation Wizard) provided that the VeraCrypt device driver is running and that the file permissions allow it.

Under **Linux**, a user without administrator privileges can (assuming the default VeraCrypt and operating system configurations):

- Create a file-hosted or partition/device-hosted VeraCrypt volume containing a FAT or no file system provided that the relevant folder/device permissions allow it.
- Change the password, keyfiles, and header key derivation algorithm for, and restore or back up the header of, a file-hosted or partition/device-hosted VeraCrypt volume provided that the file/device permissions allow it.
- Access the filesystem residing within a VeraCrypt volume mounted by another user on the system (however, file/folder/volume permissions can be set to prevent this).
- Run and use the VeraCrypt application (including the VeraCrypt Volume Creation Wizard) provided that file permissions allow it.
- In the VeraCrypt application window, see the path to and properties of any VeraCrypt volume mounted by him or her.

Under **Mac OS X**, a user without administrator privileges can (assuming the default VeraCrypt and operating system configurations):

- Mount any file-hosted or partition/device-hosted VeraCrypt volume provided that the file/device permissions allow it.
- Dismount, using VeraCrypt, (and, in the VeraCrypt application window, see the path to and properties of) any VeraCrypt volume mounted by him or her.
- Create a file-hosted or partition/device-hosted VeraCrypt volume provided that the relevant folder/device permissions allow it.
- Change the password, keyfiles, and header key derivation algorithm for, and restore or back up the header of, a file-hosted or partition/device-hosted VeraCrypt volume (provided that the file/device permissions allow it).
- Access the filesystem residing within a VeraCrypt volume mounted by another user on the system (however, file/folder/volume permissions can be set to prevent this).
- Run and use the VeraCrypt application (including the VeraCrypt Volume Creation Wizard) provided that the file permissions allow it.

VeraCrypt does not support the set-euid root mode of execution.

Additional information and details regarding the security model are contained in the chapter *Security Requirements and Precautions*.

Security Requirements and Precautions

> **IMPORTANT**: If you want to use VeraCrypt, you must follow the security requirements and security precautions listed in this chapter.

The sections in this chapter specify security requirements for using VeraCrypt and give information about things that adversely affect or limit the ability of VeraCrypt to secure data and to provide plausible deniability. Disclaimer: This chapter is not guaranteed to contain a list of *all* security issues and attacks that might adversely affect or limit the ability of VeraCrypt to secure data and to provide plausible deniability.

Data Leaks

When a VeraCrypt volume is mounted, the operating system and third-party applications may write to unencrypted volumes (typically, to the unencrypted system volume) unencrypted information   about the data stored in the VeraCrypt volume (e.g. filenames and locations of recently accessed files, databases created by file indexing tools, etc.), or the data itself in an unencrypted form (temporary files, etc.), or unencrypted information about the filesystem residing in the VeraCrypt   volume. Note that Windows automatically records large amounts of potentially sensitive data, such as the names and locations of files you open, applications you run, etc.

Also, starting from Windows 8, every time a VeraCrypt volume that is formatted using NTFS is mounted, an Event 98 is written for the system Events Log and it will contain the device name (\\device\VeraCryptVolumeXX) of the volume. This event log "feature" was introduced in Windows 8 as part of newly introduced NTFS health checks as explained here. To avoid this leak, the VeraCrypt volume must be mounted as a removable medium. Big thanks to Liran Elharar for discovering this leak and its workaround.

In order to prevent data leaks, you must follow these steps (alternative steps may exist):

- If you do *not* need plausible deniability:

  - Encrypt the system partition/drive (for information on how to do so, see the chapter *System Encryption*) and ensure that only encrypted or read-only filesystems are mounted during each session in which you work with sensitive data.

    or,

  - If you cannot do the above, download or create a "live CD" version of your operating system (i.e. a "live" system entirely stored on and booted from a CD/DVD) that ensures that any data written to the system volume is written to a RAM disk. When you need to work with sensitive data, boot such a live CD/DVD and ensure that only encrypted and/or read-only filesystems are mounted during the session.

- If you need plausible deniability:

  - Create a hidden operating system. VeraCrypt will provide automatic data leak protection. For more information, see the *section Hidden Operating System.*

    or,

  - If you cannot do the above, download or create a "live CD" version of your operating system (i.e. a "live" system entirely stored on and booted from a CD/DVD) that

ensures that any data written to the system volume is written to a RAM disk. When you need to work with sensitive data, boot such a live CD/DVD. If you use hidden volumes, follow the security requirements and precautions listed in the subsection *Security Requirements and Precautions Pertaining to Hidden Volumes*. If you do not use hidden volumes, ensure that only non-system partition-hosted VeraCrypt volumes and/or read-only filesystems are mounted during the session.

Paging File

*Note: The issue described below does **not** affect you if the system partition or system drive is encrypted (for more information, see the chapter* System Encryption*) and if all paging files are located on one or more of the partitions within the key scope of system encryption, for example, on the partition where Windows is installed (for more information, see the fourth paragraph in this subsection).*

Paging files, also called swap files, are used by Windows to hold parts of programs and data files that do not fit in memory. This means that sensitive data, which you believe are only stored in RAM, can actually be written *unencrypted* to a hard drive by Windows without you knowing.

Note that VeraCrypt *cannot* prevent the contents of sensitive files that are opened in RAM from being saved *unencrypted* to a paging file (note that when you open a file stored on a VeraCrypt volume, for example, in a text editor, then the content of the file is stored *unencrypted* in RAM).

To prevent the issues described above, encrypt the system partition/drive (for information on how to do so, see the chapter *System Encryption*) and make sure that all paging files are located on one or more of the partitions within the key scope of system encryption (for example, on the partition where Windows is installed). Note that the last condition is typically met on Windows XP by default. However, Windows Vista and later versions of Windows are configured by default to create paging files on *any* suitable volume. Therefore, before, you start using VeraCrypt, you must follow these steps: Right-click the '*Computer*' (or '*My Computer*') icon on the desktop or in the *Start   Menu*, and then select *Properties* > (on Windows Vista or later: > *Advanced System Settings* >) *Advanced* tab > section *Performance* > *Settings* > *Advanced* tab > section *Virtual memory* > *Change*. On Windows Vista or later, disable '*Automatically manage paging file size for all drives*'. Then make sure that the list of volumes available for paging file creation contains only volumes within the intended key scope of system encryption (for example, the volume where Windows is installed). To disable paging file creation on a particular volume, select it, then select '*No paging file*' and click *Set*. When done, click *OK* and restart the computer.

Note: You may also want to consider creating a hidden operating system (for more information, see the section Hidden Operating System*).*

Memory Dump Files

*Note: The issue described below does **not** affect you if the system partition or system drive is encrypted (for more information, see the chapter* System Encryption*) and if the system is configured to write memory dump files to the system drive (which it typically is, by default).*

Most operating systems, including Windows, can be configured to write debugging information and contents of the system memory to so-called memory dump files (also called crash dump files) when an error occurs (system crash, "blue screen," bug check). Therefore, memory dump files   may contain sensitive data. VeraCrypt *cannot* prevent cached passwords, encryption keys, and the   contents of sensitive files opened in RAM from being saved *unencrypted* to memory dump files.
Note that when you open a file stored on a VeraCrypt volume, for example, in a text editor, then the content of the file is stored *unencrypted* in RAM (and it may remain *unencrypted* in RAM until the computer is turned off). Also note that when a VeraCrypt volume is mounted, its master key is

stored *unencrypted* in RAM. Therefore, you must disable memory dump file generation on your computer at least for each session during which you work with any sensitive data and during which you mount a VeraCrypt volume. To do so in Windows XP or later, right-click the '*Computer*' (or '*My Computer*') icon on the desktop or in the *Start Menu*, and then select *Properties* > (on Windows Vista or later: > *Advanced System Settings* >) *Advanced* tab > section *Startup and Recovery* > *Settings* > section *Write debugging information* > select *(none)* > *OK*.

Note for users of Windows XP/2003: As Windows XP and Windows 2003 do not provide any API for encryption of memory dump files, if the system partition/drive is encrypted by VeraCrypt and your Windows XP system is configured to write memory dump files to the system drive, the VeraCrypt driver automatically prevents Windows from writing any data to memory dump files.

Hibernation File

Note: The issue described below does not affect you if the system partition or system drive is encrypted[*] (for more information, see the chapter System Encryption*) and if the hibernation file is located on one the partitions within the key scope of system encryption (which it typically is, by default), for example, on the partition where Windows is installed. When the computer hibernates, data are encrypted on the fly before they are written to the hibernation file.*

When a computer hibernates (or enters a power-saving mode), the content of its system memory is written to a so-called hibernation file on the hard drive. You can configure VeraCrypt (*Settings* > *Preferences* > *Dismount all when: Entering power saving mode*) to automatically dismount all mounted VeraCrypt volumes, erase their master keys stored in RAM, and cached passwords (stored in RAM), if there are any, before a computer hibernates (or enters a power-saving mode). However, keep in mind, that if you do not use system encryption (see the chapter [System Encryption]), VeraCrypt still cannot reliably prevent the contents of sensitive files opened in RAM from being saved unencrypted to a hibernation file. Note that when you open a file stored on a VeraCrypt volume, for example, in a text editor, then the content of the file is stored unencrypted in RAM (and it may remain unencrypted in RAM until the computer is turned off).

Note that when Windows enters Sleep mode, it may be actually configured to enter so-called Hybrid Sleep mode, which involves hibernation. Also note that the operating system may be configured to hibernate or enter the Hybrid Sleep mode when you click or select "Shut down" (for more information, please see the documentation for your operating system).

To prevent the issues described above, encrypt the system partition/drive (for information on how to do so, see the chapter [System Encryption]) and make sure that the hibernation file is located on one of the partitions within the key scope of system encryption (which it typically is, by default), for example, on the partition where Windows is installed. When the computer hibernates, data will be encrypted on the fly before they are written to the hibernation file.

Note: You may also want to consider creating a hidden operating system (for more information, see the section [Hidden Operating System]*).*

Alternatively, if you cannot use system encryption, disable or prevent hibernation on your computer at least for each session during which you work with any sensitive data and during which you   mount a VeraCrypt volume.

---

[*] Disclaimer: As Windows XP and Windows 2003 do not provide any API for encryption of hibernation files, VeraCrypt has to modify undocumented components of Windows XP/2003 in order to allow users to encrypt hibernation files. Therefore, VeraCrypt cannot guarantee that Windows XP/2003 hibernation files will always be encrypted. In response to our public complaint regarding the missing API, Microsoft began providing a public API for encryption of hibernation files on Windows Vista and later versions of Windows. VeraCrypt has used this API and therefore is able to safely encrypt hibernation files under Windows Vista and later versions of Windows. Therefore, if you use Windows XP/2003 and want the hibernation file to   be safely encrypted, we strongly recommend that you upgrade to Windows Vista or later.

Unencrypted Data in RAM

It is important to note that VeraCrypt is *disk* encryption software, which encrypts only disks, not RAM (memory).

Keep in mind that most programs do not clear the memory area (buffers) in which they store unencrypted (portions of) files they load from a VeraCrypt volume. This means that after you exit such a program, unencrypted data it worked with may remain in memory (RAM) until the computer is turned off (and, according to some researchers, even for some time after the power is turned off[*]). Also note that if you open a file stored on a VeraCrypt volume, for example, in a text editor and then force dismount on the VeraCrypt volume, then the file will remain unencrypted in the area of memory (RAM) used by (allocated to) the text editor. This also applies to forced auto-dismount.

Inherently, unencrypted master keys have to be stored in RAM too. When a non-system VeraCrypt volume is dismounted, VeraCrypt erases its master keys (stored in RAM). When the computer is cleanly restarted (or cleanly shut down), all non-system VeraCrypt volumes are automatically dismounted and, thus, all master keys stored in RAM are erased by the VeraCrypt driver (except master keys for system partitions/drives — see below). However, when power supply is abruptly interrupted, when the computer is reset (not cleanly restarted), or when the system crashes, **VeraCrypt naturally stops running and therefore cannot** erase any keys or any other sensitive data. Furthermore, as Microsoft does not provide any appropriate API for handling hibernation and shutdown, master keys used for system encryption cannot be reliably (and are not) erased from RAM when the computer hibernates, is shut down or restarted.[†]

> To summarize, VeraCrypt **cannot** and does **not** ensure that RAM contains no sensitive data (e.g. passwords, master keys, or decrypted data). Therefore, after each session in which you work with a VeraCrypt volume or in which an encrypted operating system is running, you must shut down (or, if the hibernation file is encrypted, hibernate) the computer and then leave it powered off for at least several minutes (the longer, the better) before turning it on again. This is required to clear the RAM (also see the section *Hibernation File*).

Physical Security

If an attacker can physically access the computer hardware **and** you use it after the attacker has physically accessed it, then VeraCrypt may become unable to secure data on the computer.[‡] This is because the attacker may modify the hardware or attach a malicious hardware component to it (such as a hardware keystroke logger) that will capture the password or encryption key (e.g., when you mount a VeraCrypt volume) or otherwise compromise the security of the computer. Therefore, you must not use VeraCrypt on a computer that an attacker has physically accessed.

---

[*] Allegedly, for 1.5–35 seconds under normal operating temperatures (26–44 °C) and up to several hours when the memory modules are cooled (when the computer is running) to very low temperatures (e.g. –50 °C). New types of memory modules allegedly exhibit a much shorter decay time (e.g. 1.5–2.5 seconds) than older types (as of 2008).

[†] Before a key can be erased from RAM, the corresponding VeraCrypt volume must be dismounted. For non-system volumes, this does not cause any problems. However, as Microsoft currently does not provide any appropriate API for handling the final phase of the system shutdown process, paging files located on encrypted system volumes that are dismounted during the system shutdown process may still contain valid swapped-out memory pages (including portions of Windows system files). This could cause 'blue screen' errors. Therefore, to prevent 'blue screen' errors, VeraCrypt does not dismount encrypted system volumes and consequently cannot clear the master keys of the system volumes when the system is shut down or restarted.

[‡] In this section (*Physical Security*), the phrase "data on the computer" means data on internal and external storage devices/media (including removable devices and network drives) connected to the computer.

Furthermore, you must ensure that VeraCrypt (including its device driver) is not running when the attacker physically accesses the computer. Additional information pertaining to hardware attacks where the attacker has direct physical access is contained in the section Unencrypted Data in RAM.

Furthermore, even if the attacker cannot physically access the computer hardware *directly*, he or she may be able to breach the physical security of the computer by remotely intercepting and analyzing emanations from the computer hardware (including the monitor and cables). For example, intercepted emanations from the cable connecting the keyboard with the computer can reveal passwords you type. It is beyond the scope of this document to list all of the kinds of such attacks (sometimes called TEMPEST attacks) and all known ways to prevent them (such as shielding or radio jamming). It is your responsibility to prevent such attacks. If you do not, VeraCrypt may become unable to secure data on the computer.

Malware

The term 'malware' refers collectively to all types of malicious software, such as computer viruses, Trojan horses, spyware, or generally any piece of software (including VeraCrypt or an operating system component) that has been altered, prepared, or can be controlled, by an attacker. Some kinds of malware are designed e.g. to log keystrokes, including typed passwords (such captured passwords are then either sent to the attacker over the Internet or saved to an unencrypted local drive from which the attacker might be able to read it later, when he or she gains physical access to the computer). If you use VeraCrypt on a computer infected with any kind of malware, VeraCrypt   may become unable to secure data on the computer.[*] Therefore, you must not use VeraCrypt on such a computer.

It is important to note that VeraCrypt is encryption software, *not* anti-malware software. It is your responsibility to prevent malware from running on the computer. If you do not, VeraCrypt may become unable to secure data on the computer.

There are many rules that you should follow to help prevent malware from running on your computer. Among the most important rules are the following: Keep your operating system, Internet browser, and other critical software, up-to-date. In Windows XP or later, turn on DEP for all programs.[†] Do not open suspicious email attachments, especially executable files, even if they appear to have been sent by your relatives or friends (their computers might be infected with malware sending malicious emails from their computers/accounts without their knowledge). Do not follow suspicious links contained in emails or on websites (even if the email/website appears to be harmless or trustworthy). Do not visit any suspicious websites. Do not download or install any suspicious software. Consider using good, trustworthy, anti-malware software.

Multi-User Environment

Keep in mind, that the content of a mounted VeraCrypt volume is visible (accessible) to all logged on users. NTFS file/folder permissions can be set to prevent this, unless the volume is mounted as removable medium (see section *Volume Mounted as Removable Medium*) under a desktop edition of Windows Vista or later (sectors of a volume mounted as removable medium may be accessible

---

* In this section (*Malware*), the phrase "data on the computer" means data on internal and external storage devices/media (including removable devices and network drives) connected to the computer.
† DEP stands for Data Execution Prevention. For more information about DEP, please visit http://support.microsoft.com/kb/875352, http://technet.microsoft.com/en-us/library/cc700810.aspx, and http://windows.microsoft.com/en-US/windows-vista/What-is-Data-Execution-Prevention.

at the volume level to users without administrator privileges, regardless of whether it is accessible   to them at the file-system level).

Moreover, on Windows, the password cache is shared by all logged on users (for more information,   please see the section *Settings > Preferences*, subsection *Cache passwords in driver   memory*).

Also note that switching users in Windows XP or later (*Fast User Switching* functionality) does *not* dismount a successfully mounted VeraCrypt volume (unlike system restart, which dismounts all mounted VeraCrypt volumes).

On Windows 2000, the container file permissions are ignored when a file-hosted VeraCrypt volume is to be mounted. On all supported versions of Windows, users without administrator privileges can mount any partition/device-hosted VeraCrypt volume (provided that they supply the correct password and/or keyfiles). A user without administrator privileges can dismount only volumes that he or she mounted. However, this does not apply to system favorite volumes unless you enable the option (disabled by default) *Settings* > '*System Favorite Volumes*' > '*Allow only administrators to   view and dismount system favorite volumes in VeraCrypt*'.

Authenticity and Integrity

VeraCrypt uses encryption to preserve the *confidentiality* of data it encrypts. VeraCrypt neither preserves nor verifies the integrity or authenticity of data it encrypts or decrypts. Hence, if you allow an adversary to modify data encrypted by VeraCrypt, he can set the value of any 16-byte block   of the data to a random value or to a previous value, which he was able to obtain in the past.   Note that the adversary cannot choose the value that you will obtain when VeraCrypt decrypts the modified block — the value will be random — unless the attacker restores an older version of the encrypted block, which he was able to obtain in the past. It is your responsibility to verify the integrity and authenticity of data encrypted or decrypted by VeraCrypt (for example, by using appropriate third-party software).

See also: *Physical Security*, *Security Model*

Choosing Passwords and Keyfiles

It is very important that you choose a good password. You must avoid choosing one that contains only a single word that can be found in a dictionary (or a combination of such words). It must not contain any names, dates of birth, account numbers, or any other items that could be easy to guess. A good password is a random combination of upper and lower case letters, numbers, and special characters, such as @ ^ = $ * + etc. We strongly recommend choosing a password consisting of more than 20 characters (the longer, the better). Short passwords are easy to crack using brute-force techniques.

To make brute-force attacks on a keyfile infeasible, the size of the keyfile must be at least 30 bytes. If a volume uses multiple keyfiles, then at least one of the keyfiles must be 30 bytes in size or larger. Note that the 30-byte limit assumes a large amount of entropy in the keyfile. If the first 1024 kilobytes of a file contain only a small amount of entropy, it must not be used as a keyfile (regardless of the file size). If you are not sure what entropy means, we recommend that you let VeraCrypt generate a file with random content and that you use it as a keyfile (select *Tools > Keyfile Generator*).

When creating a volume, encrypting a system partition/drive, or changing passwords/keyfiles, you must not allow any third party to choose or modify the password/keyfile(s) before/while the volume is created or the password/keyfiles(s) changed. For example, you must not use any password generators (whether website applications or locally run programs) where you are not sure that they are high-quality and uncontrolled by an attacker, and keyfiles must not be files that you download from the internet or that are accessible to other users of the computer (whether they are administrators or not).

Changing Passwords and Keyfiles

Note that the volume header (which is encrypted with a header key derived from a password/keyfile) contains the master key (not to be confused with the password) with which the volume is encrypted. If an adversary is allowed to make a copy of your volume before you change the volume password and/or keyfile(s), he may be able to use his copy or fragment (the old header) of the VeraCrypt volume to mount your volume using a compromised password and/or compromised keyfiles that were necessary to mount the volume before you changed the volume password and/or keyfile(s).

If you are not sure whether an adversary knows your password (or has your keyfiles) and whether he has a copy of your volume when you need to change its password and/or keyfiles, it is strongly recommended that you create a new VeraCrypt volume and move files from the old volume to the new volume (the new volume will have a different master key).

Also note that if an adversary knows your password (or has your keyfiles) and has access to your volume, he may be able to retrieve and keep its master key. If he does, he may be able to decrypt your volume even after you change its password and/or keyfile(s) (because the master key does not change when you change the volume password and/or keyfiles). In such a case, create a new VeraCrypt volume and move all files from the old volume to this new one.

The following sections of this chapter contain additional information pertaining to possible security issues connected with changing passwords and/or keyfiles:

- *Security Requirements and Precautions*
- *Journaling File Systems*
- *Defragmenting*
- *Reallocated Sectors*

Trim Operation

Some storage devices (e.g., some solid-state drives, including USB flash drives) use so-called 'trim' operation to mark drive sectors as free e.g. when a file is deleted. Consequently, such sectors may contain unencrypted zeroes or other undefined data (unencrypted) even if they are located within a part of the drive that is encrypted by VeraCrypt. VeraCrypt does not block the trim operation on partitions that are within the key scope of system encryption (see chapter *System Encryption*) (unless a hidden operating system is running – see section *Hidden Operating System*) and under Linux on all volumes that use the Linux native kernel cryptographic services. In those cases, the adversary will be able to tell which sectors contain free space (and may be able to use this information for further analysis and attacks) and plausible deniability (see chapter *Plausible Deniability*) may be negatively affected. If you want to avoid those issues, do not use system encryption on drives that use the trim operation and, under Linux, either configure VeraCrypt not to

use the Linux native kernel cryptographic services or make sure VeraCrypt volumes are not located on drives that use the trim operation.

To find out whether a device uses the trim operation, please refer to documentation supplied with the device or contact the vendor/manufacturer.

Wear-Leveling

Some storage devices (e.g., some solid-state drives, including USB flash drives) and some file systems utilize so-called wear-leveling mechanisms to extend the lifetime of the storage device or medium. These mechanisms ensure that even if an application repeatedly writes data to the same logical sector, the data is distributed evenly across the medium (logical sectors are remapped to different physical sectors). Therefore, multiple "versions" of a single sector may be available to an attacker. This may have various security implications. For instance, when you change a volume password/keyfile(s), the volume header is, under normal conditions, overwritten with a re-encrypted version of the header. However, when the volume resides on a device that utilizes a wear-leveling mechanism, VeraCrypt cannot ensure that the older header is really overwritten. If an adversary found the old volume header (which was to be overwritten) on the device, he could use it to mount the volume using an old compromised password (and/or using compromised keyfiles that were necessary to mount the volume before the volume header was re-encrypted). Due to security reasons, we recommend that VeraCrypt volumes are not created/stored on devices (or in file systems) that utilize a wear-leveling mechanism (and that VeraCrypt is not used to encrypt any portions of such devices or filesystems).

If you decide not to follow this recommendation and you intend to use in-place encryption on a drive that utilizes wear-leveling mechanisms, make sure the partition/drive does not contain any sensitive data before you fully encrypt it (VeraCrypt cannot reliably perform secure in-place encryption of existing data on such a drive; however, after the partition/drive has been fully encrypted, any new data that will be saved to it will be reliably encrypted on the fly). That includes the following precautions: Before you run VeraCrypt to set up pre-boot authentication, disable the paging files and restart the operating system (you can enable the paging files after the system partition/drive has been fully encrypted). Hibernation must be prevented during the period between the moment when you start VeraCrypt to set up pre-boot authentication and the moment when the system partition/drive has been fully encrypted. However, note that even if you follow those steps, it is *not* guaranteed that you will prevent data leaks and that sensitive data on the device will be securely encrypted. For more information, see the sections *Data Leaks*, *Paging File,* *Hibernation File*, and *Hibernation File*.

If you need plausible deniability, you must not use VeraCrypt to encrypt any part of (or create encrypted containers on) a device (or file system) that utilizes a wear-leveling mechanism.

To find out whether a device utilizes a wear-leveling mechanism, please refer to documentation supplied with the device or contact the vendor/manufacturer.

Reallocated Sectors

Some storage devices, such as hard drives, internally reallocate/remap bad sectors. Whenever the   device detects a sector to which data cannot be written, it marks the sector as bad and remaps it to a sector in a hidden reserved area on the drive. Any subsequent read/write operations from/to the bad sector are redirected to the sector in the reserved area. This means that any existing data in the bad sector remains on the drive and it cannot be erased (overwritten with other data). This may

have various security implications. For instance, data that is to be encrypted in place may remain unencrypted in the bad sector. Likewise, data to be erased (for example, during the process of creation of a hidden operating system) may remain in the bad sector. Plausible deniability (see section *Plausible Deniability*) may be adversely affected whenever a sector is reallocated. Additional examples of possible security implications are listed in the section *Security Requirements and Precautions*. Please note that this list is not exhaustive (these are just examples). Also note that VeraCrypt *cannot* prevent any security issues related to or caused by reallocated sectors. To find out the number of reallocated sectors on a hard drive, you can use e.g. a third-party software tool for reading so-called S.M.A.R.T. data.

Defragmenting

When you (or the operating system) defragment the file system in which a file-hosted VeraCrypt container is stored, a copy of the VeraCrypt container (or of its fragment) may remain in the free space on the host volume (in the defragmented file system). This may have various security implications. For example, if you change the volume password/keyfile(s) afterwards, and an adversary finds the old copy or fragment (the old header) of the VeraCrypt volume, he might use it to mount the volume using an old compromised password (and/or using compromised keyfiles that were necessary to mount the volume before the volume header was re-encrypted). To prevent this and other possible security issues (such as those mentioned in the section *Volume Clones*), do one of the following:

- Use a partition/device-hosted VeraCrypt volume instead of file-hosted.

- *Securely* erase free space on the host volume (in the defragmented file system) after defragmenting.

- Do not defragment file systems in which you store VeraCrypt volumes.

Journaling File Systems

When a file-hosted VeraCrypt container is stored in a journaling file system (such as NTFS), a copy of the VeraCrypt container (or of its fragment) may remain in the free space on the host volume.
This may have various security implications. For example, if you change the volume password/keyfile(s) and an adversary finds the old copy or fragment (the old header) of the VeraCrypt volume, he might use it to mount the volume using an old compromised password (and/or using compromised keyfiles using an old compromised password (and/or using compromised keyfiles that were necessary to mount the volume before the volume header was re- encrypted). Some journaling file systems also internally record file access times and other potentially sensitive information. If you need plausible deniability (see section *Plausible Deniability*), you must not store file-hosted VeraCrypt containers in journaling file systems. To prevent possible security issues related to journaling file systems, do one the following:

- Use a partition/device-hosted VeraCrypt volume instead of file-hosted.

- Store the container in a non-journaling file system (for example, FAT32).

Volume Clones

Never create a new VeraCrypt volume by cloning an existing VeraCrypt volume. Always use the VeraCrypt Volume Creation Wizard to create a new VeraCrypt volume. If you clone a volume and then start using both this volume and its clone in a way that both eventually contain different data, then you might aid cryptanalysis (both volumes will share a single key set). This is especially critical when the volume contains a hidden volume. Also note that plausible deniability (see section *Plausible Deniability*) is impossible in such cases. See also the chapter *How to Back Up Securely*.

Additional Security Requirements and Precautions

In addition to the requirements and precautions described in this chapter (*Security Requirements and Precautions*), you must follow and keep in mind the security requirements, precautions, and limitations listed in the following chapters and sections:

- ***How to Back Up Securely***
- ***Limitations***
- ***Security Model***
- ***Security Requirements and Precautions Pertaining to Hidden Volumes***
- ***Plausible Deniability***

See also: *Digital Signatures*

How to Back Up Securely

Due to hardware or software errors/malfunctions, files stored on a VeraCrypt volume may become corrupted. Therefore, we strongly recommend that you backup all your important files regularly (this, of course, applies to any important data, not just to encrypted data stored on VeraCrypt volumes).

Non-System Volumes

To back up a non-system VeraCrypt volume securely, it is recommended to follow these steps:

1. Create a new VeraCrypt volume using the VeraCrypt Volume Creation Wizard (do not enable the *Quick Format* option or the *Dynamic* option). It will be your *backup* volume so its size should match (or be greater than) the size of your *main* volume.

   If the *main* volume is a hidden VeraCrypt volume (see the section *Hidden Volume*), the *backup* volume must be a hidden VeraCrypt volume too. Before you create the hidden *backup* volume, you must create a new host (outer) volume for it without enabling the *Quick Format* option. In addition, especially if the *backup* volume is file-hosted, the hidden *backup* volume should occupy only a very small portion of the container and the outer volume should be almost completely filled with files (otherwise, the plausible deniability of the hidden volume might be adversely affected).

2. Mount the newly created *backup* volume.

3. Mount the *main* volume.

4. Copy all files from the mounted *main* volume directly to the mounted *backup* volume.

IMPORTANT: If you store the backup volume in any location that an adversary can repeatedly access (for example, on a device kept in a bank's safe deposit box), you should repeat all of the above steps (including the step 1) each time you want to back up the volume (see below).

If you follow the above steps, you will help prevent adversaries from finding out:

- Which sectors of the volumes are changing (because you always follow step 1). This is particularly important, for example, if you store the backup volume on a device kept in a bank's safe deposit box (or in any other location that an adversary can repeatedly access) and the volume contains a hidden volume (for more information, see the subsection *Security Requirements and Precautions Pertaining to Hidden Volumes* in the chapter *Plausible Deniability*).

- That one of the volumes is a backup of the other.

System Partitions

Note: In addition to backing up files, we recommend that you also back up your VeraCrypt Rescue Disk (select *System > Create Rescue Disk*). For more information, see the section *VeraCrypt Rescue Disk*.

To back up an encrypted system partition securely and safely, it is recommended to follow these steps:

1. If you have multiple operating systems installed on your computer, boot the one that does not require pre-boot authentication.

   If you do not have multiple operating systems installed on your computer, you can boot a WinPE or BartPE CD/DVD ('live' Windows entirely stored on and booted from a CD/DVD; for more information, search the section *Frequently Asked Questions* for the keyword 'BartPE').

   If none of the above is possible, connect your system drive as a secondary drive to another computer and then boot the operating system installed on the computer.

   Note: For security reasons, if the operating system that you want to back up resides in a hidden VeraCrypt volume (see the section *Hidden Operating System*), then the operating system that you boot in this step must be either another hidden operating system or a "live-CD" operating system (see above). For more information, see the subsection *Security Requirements and Precautions Pertaining to Hidden Volumes* in the chapter *Plausible Deniability*.

2. Create a new non-system VeraCrypt volume using the VeraCrypt Volume Creation Wizard (do not enable the *Quick Format* option or the *Dynamic* option). It will be your *backup* volume so its size should match (or be greater than) the size of the system partition that you want to back up.

   If the operating system that you want to back up is installed in a hidden VeraCrypt volume (see the section *Hidden Operating System*), the *backup* volume must be a hidden VeraCrypt volume too. Before you create the hidden *backup* volume, you must create a new   host (outer) volume for it without enabling the *Quick Format* option. In addition, especially   if the *backup* volume is file-hosted, the hidden *backup* volume should occupy only   a very small portion of the container and the outer volume should be almost completely filled with files (otherwise, the plausible deniability of the hidden volume might be adversely affected).

3. Mount the newly created *backup* volume.

4. Mount the system partition that you want to back up by following these steps:

   a. Click *Select Device* and then select the system partition that you want to back up (in case of a hidden operating system, select the partition containing the hidden volume in which the operating system is installed).

   b. Click *OK*.

   c. Select *System > Mount Without Pre-Boot Authentication*.

   d. Enter your pre-boot authentication password and click *OK*.

5. Mount the *backup* volume and then use a third-party program or a Windows tool to create an image of the filesystem that resides on the system partition (which was mounted as a

regular VeraCrypt volume in the previous step) and store the image directly on the mounted *backup* volume.

IMPORTANT: If you store the backup volume in any location that an adversary can repeatedly access (for example, on a device kept in a bank's safe deposit box), you should repeat all of the above steps (including the step 2) each time you want to back up the volume (see below).

If you follow the above steps, you will help prevent adversaries from finding out:

- Which sectors of the volumes are changing (because you always follow step 2). This is particularly important, for example, if you store the backup volume on a device kept in a bank's safe deposit box (or in any other location that an adversary can repeatedly access) and the volume contains a hidden volume (for more information, see the subsection *Security Requirements and Precautions Pertaining to Hidden Volumes* in the chapter *Plausible Deniability*).

- That one of the volumes is a backup of the other.

General Notes

If you store the backup volume in any location where an adversary can make a copy of the volume, consider encrypting the volume with a cascade of ciphers (for example, with AES-Twofish- Serpent). Otherwise, if the volume is encrypted only with a single encryption algorithm and the algorithm is later broken (for example, due to advances in cryptanalysis), the attacker might be able to decrypt his copies of the volume. The probability that three distinct encryption algorithms   will be broken is significantly lower than the probability that only one of them will be broken.

Miscellaneous

Using VeraCrypt Without Administrator Privileges

In Windows, a user who does not have administrator privileges *can* use VeraCrypt, but only after a system administrator installs VeraCrypt on the system. The reason for that is that VeraCrypt needs a device driver to provide transparent on-the-fly encryption/decryption, and users without administrator privileges cannot install/start device drivers in Windows.

After a system administrator installs VeraCrypt on the system, users without administrator privileges will be able to run VeraCrypt, mount/dismount any type of VeraCrypt volume, load/save data from/to it, and create file-hosted VeraCrypt volumes on the system. However, users without administrator privileges cannot encrypt/format partitions, cannot create NTFS volumes, cannot install/uninstall VeraCrypt, cannot change passwords/keyfiles for VeraCrypt partitions/devices, cannot backup/restore headers of VeraCrypt partitions/devices, and they cannot run VeraCrypt in 'portable' mode.

<div style="color:red; border:1px solid black; padding:1em;">
Warning: No matter what kind of software you use, as regards personal privacy in most cases, it is *not* safe to work with sensitive data under systems where you do not have administrator   privileges, as the administrator can easily capture and copy your sensitive data, including passwords and keys.
</div>

Sharing over Network

If there is a need to access a single VeraCrypt volume simultaneously from multiple operating systems, there are two options:

1. A VeraCrypt volume is mounted only on a single computer (for example, on a server) and only the content of the mounted VeraCrypt volume (i.e., the file system within the VeraCrypt volume) is shared over a network. Users on other computers or systems will not mount the volume (it is already mounted on the server).

   Advantages: All users can write data to the VeraCrypt volume. The shared volume may be both file-hosted and partition/device-hosted.

   Disadvantage: Data sent over the network will not be encrypted. However, it is still possible to encrypt them using e.g. SSL, TLS, VPN, or other technologies.

   Remarks: Note that, when you restart the system, the network share will be automatically restored only if the volume is a system favorite volume or an encrypted system partition/drive (for information on how to configure a volume as a system favorite volume, see the chapter *System Favorite Volumes*).

2. A dismounted VeraCrypt file container is stored on a single computer (for example, on a server). This encrypted file is shared over a network. Users on other computers or systems will locally mount the shared file. Thus, the volume will be mounted simultaneously under multiple operating systems.

   Advantage: Data sent over the network will be encrypted (however, it is still recommended to encrypt them using e.g. SSL, TLS, VPN, or other appropriate technologies to make traffic analysis more difficult and to preserve the integrity of the data).

   Disadvantages: The shared volume may be only file-hosted (not partition/device-hosted). The volume must be mounted in read-only mode under each of the systems (see the section *Mount Options* for information on how to mount a volume in read-only mode). Note that this requirement applies to unencrypted volumes too. One of the reasons is, for example, the fact that data read from a conventional file system under one OS while the file system is being modified by another OS might be inconsistent (which could result in data corruption).

VeraCrypt Background Task

When the main VeraCrypt window is closed, the VeraCrypt Background Task takes care of the following tasks/functions:

1. Hot keys
2. Auto-dismount (e.g., upon logoff, inadvertent host device removal, time-out, etc.)
3. Auto-mount of favorite volumes
4. Notifications (e.g., when damage to hidden volume is prevented)
5. Tray icon

WARNING: If neither the VeraCrypt Background Task nor VeraCrypt is running, the above-mentioned tasks/functions are disabled.

The VeraCrypt Background Task is actually the *VeraCrypt.exe* application, which continues running in the background after you close the main VeraCrypt window. Whether it is running or not can be determined by looking at the system tray area. If you can see the VeraCrypt icon there, then the VeraCrypt Background Task is running. You can click the icon to open the main VeraCrypt window. Right-click on the icon opens a popup menu with various VeraCrypt-related functions.

You can shut down the Background Task at any time by right-clicking the VeraCrypt tray icon and selecting *Exit*. If you need to disable the VeraCrypt Background Task completely and permanently, select *Settings > Preferences* and uncheck the option *Enabled* in the *VeraCrypt Background Task* area of the *Preferences* dialog window.

Volume Mounted as Removable Medium

This section applies to VeraCrypt volumes mounted when one of the following options is enabled (as applicable):

- *Tools > Preferences > Mount volumes as removable media*

- *Mount Options > Mount volume as removable medium*

- *Favorites > Organize Favorite Volumes > Mount selected volume as removable medium*

- *Favorites > Organize System Favorite Volumes > Mount selected volume as removable medium*

VeraCrypt Volumes that are mounted as removable media have the following advantages and disadvantages:

- Windows is prevented from automatically creating the '*Recycled*' and/or the '*System Volume Information*' folders on VeraCrypt volumes (in Windows, these folders are used by the Recycle Bin and System Restore features).

- Windows 8 and later is prevented from writing an Event 98 to the Events Log that contains the device name (\\device\VeraCryptVolumeXX) of VeraCrypt volumes formatted using NTFS. This event log "feature" was introduced in Windows 8 as part of newly introduced NTFS health checks as [explained here](). Big thanks to Liran Elharar for discovering this.

- Windows may use caching methods and write delays that are normally used for removable media (for example, USB flash drives). This might slightly decrease the performance but at the same increase the likelihood that it will be possible to dismount the volume quickly without having to force the dismount.

- The operating system may tend to keep the number of handles it opens to such a volume to a minimum. Hence, volumes mounted as removable media might require fewer forced dismounts than other volumes.

- Under Windows Vista and earlier, the '*Computer*' (or '*My Computer*') list does not show the amount of free space on volumes mounted as removable (note that this is a Windows limitation, not a bug in VeraCrypt).

- Under desktop editions of Windows Vista or later, sectors of a volume mounted as removable medium may be accessible to all users (including users without administrator   privileges; see section *Multi-User Environment*).

VeraCrypt System Files & Application Data

Note: `%windir%` is the main Windows installation path (e.g., `C:\WINDOWS`)

VeraCrypt Driver

`%windir%\SYSTEM32\DRIVERS\veracrypt.sys`

Note: This file is not present when VeraCrypt is run in portable mode.

VeraCrypt Settings, Application Data, and Other System Files

WARNING: Note that VeraCrypt does *not* encrypt any of the files listed in this section (unless it encrypts the system partition/drive).

The following files are saved in the folder `%APPDATA%\VeraCrypt\`. In portable mode, these files are saved to the folder from which you run the file *VeraCrypt.exe* (i.e., the folder in which *VeraCrypt.exe* resides):

- `"Configuration.xml"` (the main configuration file).

- `"System Encryption.xml"` (temporary configuration file used during the initial process of in- place encryption/decryption of the system partition/drive).

- `"Default Keyfiles.xml"`

    o Note: This file may be absent if the corresponding VeraCrypt feature is not used.

- `"Favorite Volumes.xml"`
    o Note: This file may be absent if the corresponding VeraCrypt feature is not used.

- `"History.xml"` (the list of last twenty files/devices attempted to be mounted as VeraCrypt volumes or attempted to be used as hosts for VeraCrypt volumes; this feature can be disabled – for more information, see the section *Never Save History*)
    o Note: This file may be absent if the corresponding VeraCrypt feature is not used.

- `"In-Place Encryption"`
- `"In-Place Encryption Wipe Algo"`

(temporary configuration files used during the initial process of in-place encryption/decryption of a non-system volume).

- `"Post-Install Task - Tutorial"`
- `"Post-Install Task - Release Notes"`

(temporary configuration files used during the process of installation or upgrade of VeraCrypt).

The following files are saved in the folder `%ALLUSERSPROFILE%\VeraCrypt\`:

- "Original System Loader" (a backup of the original content of the first drive track made before the VeraCrypt Boot Loader was written to it).
    - Note: This file is absent if the system partition/drive has not been encrypted.

The following files are saved in the folder `%windir%\system32` (both on 32-bit systems and 64-bit systems):

- "VeraCrypt System Favorite Volumes.xml"
    - Note: This file may be absent if the corresponding VeraCrypt feature is not used.

- "VeraCrypt.exe"
    - Note: A copy of this file is located in this folder only when mounting of system favorite volumes is enabled.

How to Remove Encryption

Please note that VeraCrypt can in-place decrypt only **partitions and drives** (select *System > Permanently Decrypt System Partition/Drive* for system partition/drive and select *Volumes > Permanently Decrypt* for non-system partition/drive). If you need to remove encryption (e.g., if you no longer need encryption) from a **file-hosted volume**, please follow these steps:

1. Mount the VeraCrypt volume.

2. Move all files from the VeraCrypt volume to any location outside the VeraCrypt volume (note that the files will be decrypted on the fly).

3. Dismount the VeraCrypt volume.

4. Delete it (the container) just like you delete any other file.

If in-place decryption of non-system partitions/drives is not desired, it is also possible in this case to follow the steps 1-3 described above.

In all cases, if the steps 1-3 are followed, the following extra operations can be performed:

If the volume is partition-hosted (applies also to USB flash drives

a. Right-click the '*Computer*' (or '*My Computer*') icon on your desktop, or in the Start Menu, and select *Manage*. The '*Computer Management*' window should appear.
b. In the *Computer Management* window, from the list on the left, select '*Disk Management*' (within the *Storage* sub-tree).
c. Right-click the partition you want to decrypt and select '*Change Drive Letter and Paths*'.
d. The '*Change Drive Letter and Paths*' window should appear. If no drive letter is displayed in the window, click *Add*. Otherwise, click *Cancel*.
If you clicked *Add*, then in the '*Add Drive Letter or Path*' (which should have appeared), select a drive letter you want to assign to the partition and click *OK*.
e. In the *Computer Management* window, right-click the partition you want to decrypt again and select *Format*. The *Format* window should appear.
f. In the *Format* window, click *OK*. After the partition is formatted, it will no longer be required to mount it with VeraCrypt to be able to save or load files to/from the partition.

If the volume is device-hosted

a. Right-click the '*Computer*' (or '*My Computer*') icon on your desktop, or in the Start Menu, and select *Manage*. The '*Computer Management*' window should appear.
b. In the *Computer Management* window, from the list on the left, select '*Disk Management*' (within the *Storage* sub-tree).
c. The '*Initialize Disk*' window should appear. Use it to initialize the disk.
d. In the '*Computer Management*' window, right-click the area representing the storage space of the encrypted device and select '*New Partition*' or '*New Simple Volume*'.
e. WARNING: Before you continue, make sure you have selected the correct device, as all files stored on it will be lost. The '*New Partition Wizard*' or '*New Simple Volume Wizard*' window should appear now; follow its instructions to create a new partition on the device. After the partition is created, it will no longer be required to mount the device with VeraCrypt to be able to save or load files to/from the device.

Uninstalling VeraCrypt

To uninstall VeraCrypt on Windows XP, select *Start* menu > *Settings > Control Panel > Add or Remove Programs > VeraCrypt > Change/Remove*.

To uninstall VeraCrypt on Windows Vista or later, select *Start* menu > *Computer > Uninstall or change a program > VeraCrypt > Uninstall*.

No VeraCrypt volume will be removed when you uninstall VeraCrypt. You will be able to mount your VeraCrypt volume(s) again after you install VeraCrypt or when you run it in portable mode.

Digital Signatures

Why Verify Digital Signatures

It might happen that a VeraCrypt installation package you download from our server was created or modified by an attacker. For example, the attacker could exploit a vulnerability in the server software we use and alter the installation packages stored on the server, or he/she could alter any of the files en route to you.

Therefore, you should always verify the integrity and authenticity of each VeraCrypt distribution package you download or otherwise obtain from any source. In other words, you should always make sure that the file was created by us and it was not altered by an attacker. One way to do so is to verify so-called digital signature(s) of the file.

Types of Digital Signatures We Use

We currently use two types of digital signatures:

- **PGP** signatures (available for all binary and source code packages for all supported systems).

- **X.509** signatures (available for binary packages for Windows).

Advantages of X.509 Signatures

X.509 signatures have the following advantages, in comparison to PGP signatures:

- It is much easier to verify that the key that signed the file is really ours (not attacker's).
- You do not have to download or install any extra software to verify an X.509 signature (see below).
- You do not have to download and import our public key (it is embedded in the signed file).
- You do not have to download any separate signature file (the signature is embedded in the signed file).

Advantages of PGP Signatures

PGP signatures have the following advantages, in comparison to X.509 signatures:

- They do not depend on any certificate authority (which might be e.g. infiltrated or controlled by an adversary, or be untrustworthy for other reasons).

How to Verify X.509 Signatures

Please note that X.509 signatures are currently available only for the VeraCrypt self-extracting installation packages for Windows. An X.509 digital signature is embedded in each of those files along with the digital certificate of the IDRIX issued by a public certification authority. To verify the integrity and authenticity of a self-extracting installation package for Windows, follow these steps:

1. Download the VeraCrypt self-extracting installation package.

2. In the Windows Explorer, click the downloaded file ('*VeraCrypt Setup.exe*') with the right mouse button and select '*Properties*' from the context menu.

3. In the *Properties* dialog window, select the '*Digital Signatures*' tab.

4. On the '*Digital Signatures*' tab, in the '*Signature list*', double click the line saying "*IDRIX*" or "IDRIX SARL".

5. The '*Digital Signature Details*' dialog window should appear now. If you see the following sentence at the top of the dialog window, then the integrity and authenticity of the package have been successfully verified:

   "*This digital signature is OK.*"

   If you do not see the above sentence, the file is very likely corrupted. Note: On some obsolete versions of Windows, some of the necessary certificates are missing, which causes the signature verification to fail.

How to Verify PGP Signatures

To verify a PGP signature, follow these steps:

1. Install any public-key encryption software that supports PGP signatures. For Windows, you can download Gpg4win. For more information, you can visit https://www.gnupg.org/.
2. Create a private key (for information on how to do so, please see the documentation for the public-key encryption software).
3. Download our PGP public key from IDRIX website or from a trusted public key repository (ID=0x54DDD393), and import the downloaded key to your keyring (for information on how to do so, please see the documentation for the public-key encryption software). Please check that its fingerprint is **993B7D7E8E413809828F0F29EB559C7C54DDD393**.
4. Sign the imported key with your private key to mark it as trusted (for information on how to do so, please see the documentation for the public-key encryption software).
   Note: If you skip this step and attempt to verify any of our PGP signatures, you will receive an error message stating that the signing key is invalid.
5. Download the digital signature by clicking the *PGP Signature* button next to the file you want to verify (on one of the download pages).
6. Verify the downloaded signature (for information on how to do so, please see the documentation for the public-key encryption software).

Troubleshooting

It is recommended that you read also the latest online version of this chapter at:
https://veracrypt.codeplex.com/wikipage?title=Troubleshooting

This section presents possible solutions to common problems that you may run into when using VeraCrypt.

Note: If your problem is not listed here, it might be listed in one of the following sections:

- *Incompatibilities*
- *Known Issues & Limitations*
- *Frequently Asked Questions*

Make sure you use the latest stable version of VeraCrypt. If the problem is caused by a bug in an old version of VeraCrypt, it may have already been fixed. Note: Select **Help** > **About** to find out which version you use.

PROBLEM:

Writing/reading to/from volume is very slow even though, according to the benchmark, the speed of the cipher that I'm using is higher than the speed of the hard drive.

PROBABLE CAUSE:

This is probably caused by an interfering application.

POSSIBLE SOLUTION:

First, make sure that your VeraCrypt container does not have a file extension that is reserved for executable files (for example, .exe, .sys, or .dll). If it does, Windows and antivirus software may interfere with the container and adversely affect the performance of the volume.

Second, disable or uninstall any application that might be interfering, which usually is antivirus software or automatic disk defragmentation tool, etc. In case of antivirus software, it often helps to turn off real-time (on-access) scanning in the preferences of the antivirus software. If it does not help, try temporarily disabling the virus protection software. If this does not help either, try uninstalling it completely and restarting your computer subsequently.

PROBLEM:

A VeraCrypt volume cannot be mounted; VeraCrypt reports "Incorrect password or not a VeraCrypt volume".

POSSIBLE CAUSE:

The volume header may have been damaged by a third-party application or malfunctioning hardware component.

POSSIBLE SOLUTIONS:

- you can try to restore the volume header from the backup embedded in the volume by following these steps:

    1) Run VeraCrypt.

    2) Click *Select Device* or *Select File* to select your volume.

    3) Select *Tools > Restore Volume Header*.

PROBLEM:

After successfully mounting a volume, Windows reports "This device does not contain a valid file system" or a similar error.

PROBABLE CAUSE:

The file system on the VeraCrypt volume may be corrupted (or the volume is unformatted).

POSSIBLE SOLUTION:

You can use filesystem repair tools supplied with your operating system to attempt to repair the filesystem on the VeraCrypt volume. In Windows, it is the '*chkdsk*' tool. VeraCrypt provides an easy

way to use this tool on a VeraCrypt volume: First, make a backup copy of the VeraCrypt volume (because the '*chkdsk*' tool might damage the filesystem even more) and then mount it. Right-click the mounted volume in the main VeraCrypt window (in the drive list) and from the context menu select '*Repair Filesystem*'.

PROBLEM:

When trying to create a hidden volume, its maximum possible size is unexpectedly small (there is much more free space than this on the outer volume).

PROBABLE CAUSES:

1. The outer volume has been formatted as NTFS
2. Fragmentation
3. Too small cluster size + too many files/folders in the root directory of the outer volume.

POSSIBLE SOLUTIONS:

Solutions Related to Cause 1:

> Unlike the FAT filesystem, the NTFS filesystem always stores internal data exactly in the middle of the volume. Therefore, the hidden volume can reside only in the second half of the outer volume. If this constraint is unacceptable, do one of the following:
>
> - Reformat the outer volume as FAT and then create a hidden volume within it.
>
> - If the outer volume is too large to be formatted as FAT, split the volume to several 2-terabyte volumes (or 16-terabyte volumes if the device uses 4-kilobyte sectors) and format each of them as FAT.

Solution Related to Cause 2:

> Create a new outer volume (defragmentation is not a solution, because it would adversely affect plausible deniability – see section *Defragmenting*).

Solution Related to Cause 3:

> Note: The following solution applies only to hidden volumes created within FAT volumes.
>
> Defragment the outer volume (mount it, right-click its drive letter in the '*Computer*' or '*My Computer*' window, click *Properties*, select the *Tools* tab, and click '*Defragment Now*'). After the volume is defragmented, exit *Disk Defragmenter* and try to create the hidden volume again.
>
> If this does not help, delete *all* files and folders on the outer volume by pressing Shift+Delete, not by formatting, (do not forget to disable the Recycle Bin and System Restore for this drive beforehand) and try creating the hidden volume on this *completely empty* outer volume again (for testing purposes only). If the maximum possible size of the hidden volume does not change even now, the cause of the problem is very likely an extended root directory. If you did not use the '*Default*' cluster size (the last step in the Wizard), reformat the outer volume and this time leave the cluster size at '*Default*'.

If it does not help, reformat the outer volume again and copy less files/folders to its root folder than you did last time. If it does not help, keep reformatting and decreasing the number of files/folders in the root folder. If this is unacceptable or if it does not help, reformat the outer volume and select a larger cluster size. If it does not help, keep reformatting and increasing the cluster size, until the problem is solved. Alternatively, try creating a hidden volume within an NTFS volume.

PROBLEM:

One of the following problems occurs:

- ➢ A VeraCrypt volume cannot be mounted.
- ➢ NTFS VeraCrypt volumes cannot be created.

In addition, the following error may be reported: "*The process cannot access the file because it is being used by another process.*"

PROBABLE CAUSE:

This is probably caused by an interfering application. Note that this is not a bug in VeraCrypt. The operating system reports to VeraCrypt that the device is locked for an exclusive access by an application (so VeraCrypt is not allowed to access it).

POSSIBLE SOLUTION:

It usually helps to disable or uninstall the interfering application, which is usually an anti-virus utility,   a disk management application, etc.

PROBLEM:

In the VeraCrypt Boot Loader screen, I'm trying to type my password and/or pressing other keys but the VeraCrypt boot loader is not responding.

PROBABLE CAUSE:

You have a USB keyboard (not a PS/2 keyboard) and pre-boot support for USB keyboards is disabled in your BIOS settings.

POSSIBLE SOLUTION:

You need to enable pre-boot support for USB keyboards in your BIOS settings. To do so, follow the below steps:

Restart your computer, press F2 or Delete (as soon as you see a BIOS start-up screen), and wait until a BIOS configuration screen appears. If no BIOS configuration screen appears, restart (reset) the computer again and start pressing F2 or Delete repeatedly as soon as you restart (reset) the computer. When a BIOS configuration screen appears, enable pre-boot support for USB keyboards. This can typically be done by selecting: *Advanced > 'USB Configuration' > 'Legacy USB Support*' (or '*USB Legacy*') > *Enabled*. (Note that the word 'legacy' is in fact misleading, because pre-boot components of modern versions of MS Windows require this option to be enabled to allow user interaction/control.) Then save the BIOS settings (typically by pressing F10)

and restart your computer. For more information, please refer to the documentation for your BIOS/motherboard or contact your computer vendor's technical support team for assistance.

PROBLEM:

After the system partition/drive is encrypted, the computer cannot boot after it is restarted (it is also impossible to enter the BIOS configuration screen).

PROBABLE CAUSE:

A bug in the BIOS of your computer.

POSSIBLE SOLUTIONS:

- ➢ Follow these steps:

    1. Disconnect the encrypted drive.
    2. Connect an unencrypted drive with an installed operating system (or install it on the drive).
    3. Upgrade the BIOS.
    4. If it does not help, please report this bug to the manufacturer or vendor of the computer.

OR

- ➢ If the BIOS/motherboard/computer manufacturer/vendor does not provide any updates that resolve the issue and you use Windows 7 or later and there is an extra boot partition (whose size is less than 1 GB) on the drive, you can try reinstalling Windows without this extra boot partition (to work around a bug in the BIOS).

PROBLEM:

One of the following problems occurs:

- ➢ *After the pre-boot authentication password is entered during the system encryption pretest, the computer hangs (after the message* 'Booting*...' is displayed).*

- ➢ *When the system partition/drive is encrypted (partially or fully) and the system is restarted for the first time since the process of encryption of the system partition/drive started, the computer hangs after you enter the pre-boot authentication password (after the message 'Booting...' is displayed).*

- ➢ *After the hidden operating system is cloned and the password for it entered, the computer hangs (after the message 'Booting...' is displayed).*

PROBABLE CAUSE:

A bug in the BIOS of your computer or an issue with Windows bootloader.

POSSIBLE SOLUTIONS:

- Upgrade your BIOS (for information on how to do so, please refer to the documentation for your BIOS/motherboard or contact your computer vendor's technical support team for assistance).

- Use a different motherboard model/brand.

- If the BIOS/motherboard/computer manufacturer/vendor does not provide any updates that resolve the issue and you use Windows 7 or later and there is an extra boot partition (whose size is less than 1 GB) on the drive, you can try reinstalling Windows without this extra boot partition (to work around a bug in the BIOS).

- There two other known workarounds for this issue that require having a Windows Installation disk:
  - Boot your machine using a Windows Installation disk and select to repair your computer. Choose "Command Prompt" option and when it opens, type the commands below and then restart your system:
    - BootRec /fixmbr
    - BootRec /FixBoot
  - Delete the 100 MB System Reserved partition located at the beginning of your drive, set the system partition next to it as the active partition (both can be done using diskpart utility available in Windows Installation disk repair option). After that, run Startup Repair after rebooting on Windows Installation disk. The following link contains detailed instructions: http://www.sevenforums.com/tutorials/71363-system-reserved-partition-delete.html

---

PROBLEM:

When mounting or dismounting a VeraCrypt volume, the system crashes (a 'blue screen' error screen appears or the computer abruptly restarts).

OR

Since I installed VeraCrypt, the operating system has been crashing frequently.

POSSIBLE CAUSES:

- A bug in a third-party application (e.g. antivirus, system "tweaker", etc.)
- A bug in VeraCrypt
- A bug in Windows or a malfunctioning hardware component

POSSIBLE SOLUTIONS:

- Try disabling any antivirus tools, system "tweakers", and any other similar applications. If it does not help, try uninstalling them and restarting Windows.

  If the problem persists, run VeraCrypt and select *Help* > '*Analyze a System Crash*'. VeraCrypt will then analyze crash dump files that Windows automatically created when it crashed (if any). If VeraCrypt determines that a bug in a third party driver is likely to have caused the crash, it will show the name and provider of the driver (note that updating or uninstalling the driver might resolve the issue). Whatever the results, you will be able to choose to send us essential information about the system crash to help us determine whether it was caused by a bug in VeraCrypt.

PROBLEM:

When trying to encrypt the system partition/drive, during the pretest, the VeraCrypt Boot Loader always reports that the pre-boot authentication password I entered is incorrect (even though I'm sure it is correct).

POSSIBLE CAUSES:

- ➢ Different state of the *Num Lock* and/or *Caps Lock* key
- ➢ Data corruption

POSSIBLE SOLUTION:

1. When you set a pre-boot authentication password, remember whether the *Num Lock* and *Caps Lock* keys are on or off (depending on the manufacturer, the keys may have different labels, such as *Num LK*). Note: You can change the state of each of the keys as desired before you set the password, but you need to remember the states.

2. When you enter the password in the VeraCrypt Boot Loader screen, make sure the state of each of the keys is the same as when you set the password.

Note: For other possible solutions to this problem, see the other sections of this chapter.

PROBLEM:

When the system partition/drive is encrypted, the operating system 'freezes' for approx. 10-60 seconds every 5-60 minutes (100% CPU usage may co-occur).

PROBABLE CAUSE:

A CPU and/or motherboard issue.

POSSIBLE SOLUTIONS:

- ➢ Try upgrading the BIOS.

- ➢ Try disabling all power-saving-related features (including any special CPU enhanced halt functions) in the BIOS settings and in the 'Power Options' Windows control panel.

- ➢ Replace the processor with a different one (different type and/or brand).

- ➢ Replace the motherboard with a different one (different type and/or brand).

PROBLEM:

On Windows 7/Vista (and possibly later versions), the Microsoft Windows Backup tool cannot be used to backup data to a non-system VeraCrypt Volume.

CAUSE:

A bug in the Windows Backup tool.

POSSIBLE SOLUTION:

1. Mount the VeraCrypt volume to which you want to back up data.
2. Right-click a folder located on the volume (or right-click its drive letter in the '*Computer*' list) and select an item from the '*Share with*' submenu (on Windows Vista, select '*Share*').
3. Follow the instructions to share the folder with your user account.
4. In the Windows Backup tool, select the shared folder (the network location/path) as the destination.
5. Start the backup process.

Note: The above solution does **not** apply to the *Starter* and *Home* editions of Windows 7 (and possibly later versions).

PROBLEM:

The label of a filesystem in a VeraCrypt volume cannot be changed from within the 'Computer' window under Windows Vista or a later version of Windows.

CAUSE:

A Windows issue causes the label to be written only to the Windows registry file, instead of being written to the filesystem.

POSSIBLE SOLUTIONS:

➢ Right-click the mounted volume in the 'Computer' window, select Properties, and enter a new label for the volume.

PROBLEM:

I cannot encrypt a partition/device because VeraCrypt Volume Creation Wizard says it is in use.

POSSIBLE SOLUTION:

Close, disable, or uninstall all programs that might be using the partition/device in any way (for example an anti-virus utility). If it does not help, right-click the '*Computer*' (or '*My Computer*') icon on your desktop and select *Manage > Storage > Disk Management.* Then right-click the partition that you want to encrypt, and click *Change Drive Letter and Paths.* Then click *Remove* and *OK.* Restart the operating system.

PROBLEM:

When creating a hidden volume, the Wizard reports that the outer volume cannot be locked.

PROBABLE CAUSE:

The outer volume contains files being used by one or more applications.

POSSIBLE SOLUTION:

Close all applications that are using files on the outer volume. If it does not help, try disabling or uninstalling any anti-virus utility you use and restarting the system subsequently.

PROBLEM:

When accessing a file-hosted container shared over a network, "insufficient memory" or "not enough server storage is available" error is reported.

PROBABLE CAUSE:

IRPStackSize in the Windows registry may have been set to a too small value.

POSSIBLE SOLUTION:

Locate the *IRPStackSize* key in the Windows registry and set it to a higher value. Then restart the system. If the key does not exist in the Windows registry, create it at *HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\LanmanServer\Parameters* and set its value to 16 or higher. Then restart the system. For more information, see: http://support.microsoft.com/kb/285089/ and   http://support.microsoft.com/kb/177078/

Incompatibilities

> It is recommended that you read also the latest online version of this chapter at:
> https://veracrypt.codeplex.com/wikipage?title=Incompatibilities

Activation of Adobe Photoshop® and Other Products Using FLEXnet Publisher® / SafeCast

*Note: The issue described below does **not** affect you if you use a non-cascade encryption algorithm (i.e., AES, Serpent, or Twofish).[*] The issue also does **not** affect you if you do not use pre-boot authentication (see the chapter System Encryption).*

Acresso FLEXnet Publisher activation software, formerly Macrovision SafeCast, (used for activation   of third-party software, such as *Adobe Photoshop*) writes data to the first drive track. If this   happens when your system partition/drive is encrypted by VeraCrypt, a portion of the VeraCrypt   Boot Loader will be damaged and you will not be able to start Windows. In that case, please   use your VeraCrypt Rescue Disk to regain access to your system. There are two ways to do so:

1. You may keep the third-party software activated but you will need to boot your system from the VeraCrypt Rescue Disk CD/DVD *every time*. Just insert your Rescue Disk into your CD/DVD drive and then enter your password in the Rescue Disk screen.

2. If you do not want to boot your system from the VeraCrypt Rescue Disk CD/DVD every time, you can restore the VeraCrypt Boot Loader on the system drive. To do so, in the Rescue Disk screen, select *Repair Options > Restore VeraCrypt Boot Loader*. However, note that this will deactivate the third-party software.

For information on how to use your VeraCrypt Rescue Disk, please see the chapter *VeraCrypt Rescue Disk*.

Possible permanent solution: Decrypt the system partition/drive, and then re-encrypt it using a non-cascade encryption algorithm (i.e., AES, Serpent,   or Twofish).*

Please note that this not a bug in VeraCrypt (the issue is caused by inappropriate design of the third-party activation software).

---

*The reason is that the VeraCrypt Boot Loader is smaller than the one used for cascades of ciphers and, therefore, there is enough space in the first drive track for a backup of the VeraCrypt Boot Loader. Hence, whenever the VeraCrypt Boot Loader is damaged, its backup copy is run automatically instead.

Known Issues & Limitations

Known Issues

- On Windows, it may happen that two drive letters are assigned to a mounted volume instead of a single one. This is caused by an issue with Windows Mount Manager cache and it can be solve by typing the command "**mountvole.exe /r**" in an elevated command prompt (run as an administrator) before mounting any volume. If the issue persists after rebooting, the following procedure can be used to solve it:
  - Check the registry key "HKEY_LOCAL_MACHINE\SYSTEM\MountedDevices" using regedit. Scroll down and you'll find entries starting with "\DosDevices\" or "\Global??\" which indicate the drive letters that are taken by the system. Before mounting any volume, double click on each one and remove the ones contains the name "VeraCrypt" and "TrueCrypt".
    Also, there are other entries whose name start with "#{" and "\??\Volume{": double click on each one of them and remove the ones whose data value contains the name "VeraCrypt" and "TrueCrypt".

Limitations

- [*Note: This limitation does not apply to users of Windows Vista and later versions of Windows.*] On Windows XP/2003, VeraCrypt does not support encrypting an entire system drive that contains extended (logical) partitions. You can encrypt an entire system drive provided that it contains only primary partitions. Extended (logical) partitions must not be created on any system drive that is partially or fully encrypted (only primary partitions may be created on it). *Note*: If you need to encrypt an entire drive containing extended partitions, you can encrypt the system partition and, in addition, create partition-hosted VeraCrypt volumes within any non- system partitions on the drive. Alternatively, you may want to consider upgrading to Windows Vista or a later version of Windows.

- VeraCrypt currently does not support encrypting a system drive that has been converted to a dynamic disk.

- To work around a Windows XP issue, the VeraCrypt boot loader is always automatically configured for the version of the operating system under which it is installed. When the version of the system changes (for example, the VeraCrypt boot loader is installed when Windows Vista is running but it is later used to boot Windows XP) you may encounter various known and unknown issues (for example, on some notebooks, Windows XP may fail to display the log-on screen). Note that this affects multi-boot configurations, VeraCrypt Rescue Disks, and decoy/hidden operating systems (therefore, if the hidden system is e.g. Windows XP, the decoy system should be Windows XP too).

- The ability to mount a partition that is within the key scope of system encryption without pre- boot authentication (for example, a partition located on the encrypted system drive of another operating system that is not running), which can be done e.g. by selecting *System > Mount Without Pre-Boot Authentication,* is limited to primary partitions (extended/logical partitions cannot be mounted this way).

- Due to a Windows 2000 issue, VeraCrypt does not support the Windows Mount Manager under Windows 2000. Therefore, some Windows 2000 built-in tools, such as Disk Defragmenter, do not work on VeraCrypt volumes. Furthermore, it is not possible to use the Mount Manager services under Windows 2000, e.g., assign a mount point to a VeraCrypt volume (i.e., attach a VeraCrypt volume to a folder).

- VeraCrypt does not support pre-boot authentication for operating systems installed within VHD files, except when booted using appropriate virtual-machine software such as Microsoft Virtual PC.

- The Windows Volume Shadow Copy Service is currently supported only for partitions within the key scope of system encryption (e.g. a system partition encrypted by VeraCrypt, or a non-system partition located on a system drive encrypted by VeraCrypt, mounted when the encrypted operating system is running). Note: For other types of volumes, the Volume Shadow Copy Service is not supported because the documentation for the necessary API is not available.

- Windows boot settings cannot be changed from within a hidden operating system if the system does not boot from the partition on which it is installed. This is due to the fact that, for security reasons, the boot partition is mounted as read-only when the hidden system is running. To be able to change the boot settings, please start the decoy operating system.

- Encrypted partitions cannot be resized except partitions on an entirely encrypted system drive that are resized while the encrypted operating system is running.

- When the system partition/drive is encrypted, the system cannot be upgraded (for example, from Windows XP to Windows Vista) or repaired from within the pre-boot environment (using a Windows setup CD/DVD or the Windows pre-boot component). In such cases, the system partition/drive must be decrypted first. Note: A running operating system can be *updated* (security patches, service packs, etc.) without any problems even when the system partition/drive is encrypted.

- System encryption is supported only on drives that are connected locally via an ATA/SCSI interface (note that the term ATA also refers to SATA and eSATA).

- When system encryption is used (this also applies to hidden operating systems), VeraCrypt does not support multi-boot configuration changes (for example, changes to the number of operating systems and their locations). Specifically, the configuration must remain the same as it was when the VeraCrypt Volume Creation Wizard started to prepare the process of encryption of the system partition/drive (or creation of a hidden operating system).

  Note: The only exception is the multi-boot configuration where a running VeraCrypt-encrypted operating system is always located on drive #0, and it is the only operating system located on the drive (or there is one VeraCrypt-encrypted decoy and one VeraCrypt-encrypted hidden operating system and no other operating system on the drive), and the drive is connected or disconnected before the computer is turned on (for example, using the power switch on an external eSATA drive enclosure). There may be any additional operating systems (encrypted or unencrypted) installed on other drives connected to the computer (when drive #0 is disconnected, drive #1 becomes drive #0, etc.)

- When the notebook battery power is low, Windows may omit sending the appropriate messages to running applications when the computer is entering power saving mode. Therefore, VeraCrypt may fail to auto-dismount volumes in such cases.

- Preserving of any timestamp of any file (e.g. a container or keyfile) is not guaranteed to be reliably and securely performed (for example, due to filesystem journals, timestamps of

file attributes, or the operating system failing to perform it for various documented and undocumented reasons). Note: When you write to a file-hosted hidden volume, the timestamp of the container may change. This can be plausibly explained as having been caused by changing the (outer) volume password. Also note that VeraCrypt never preserves timestamps of system favorite volumes (regardless of the settings).

- Special software (e.g., a low-level disk editor) that writes data to a disk drive in a way that circumvents drivers in the driver stack of the class 'DiskDrive' (GUID of the class is 4D36E967-E325-11CE-BFC1-08002BE10318) can write unencrypted data to a non-system drive hosting a mounted VeraCrypt volume ('Partition0') and to encrypted partitions/drives that are within the key scope of active system encryption (VeraCrypt does not encrypt such data written that way). Similarly, software that writes data to a disk drive circumventing drivers in the driver stack of the class 'Storage Volume' (GUID of the class is 71A27CDD-812A-11D0-BEC7- 08002BE2092F) can write unencrypted data to VeraCrypt partition-hosted volumes (even if they are mounted).

- For security reasons, when a hidden operating system is running, VeraCrypt ensures that all local unencrypted filesystems and non-hidden VeraCrypt volumes are read-only. However, this does not apply to filesystems on CD/DVD-like media and on custom, atypical, or non-standard devices/media (for example, any devices/media whose class is other than the Windows device class 'Storage Volume' or that do not meet the requirements of this class (GUID of the class is 71A27CDD-812A-11D0-BEC7-08002BE2092F)).

- Device-hosted VeraCrypt volumes located on floppy disks are not supported. Note: You can still create file-hosted VeraCrypt volumes on floppy disks.

- Windows Server editions don't allow the use of mounted VeraCrypt volumes as a path for server backup. This can solved by activating sharing on the VeraCrypt volume through Explorer interface (of course, you have to put the correct permission to avoid unauthorized access) and then choosing the option "Remote shared folder" (it is not remote of course but Windows needs a network path). There, you can type the path of the shared drive (for example \\ServerName\sharename) and the backup will be configured correctly.

- Due to Microsoft design flaws in NTFS sparse files handling, you may encounter system errors when writing data to large Dynamic volumes (more than few hundreds GB). To avoid this, the recommended size for a Dynamic volume container file for maximum compatibility is 300 GB. The following link gives more details concerning this limitation: http://www.flexhex.com/docs/articles/sparse-files.phtml#msdn

- Windows 8 introduced a new feature called "**Hybrid boot and shutdown**" to give users the impression that booting is quick. This feature is enabled by default and it has side effects on VeraCrypt volumes usage. It is advised to disable this feature (e.g. this link explains how). Some examples of issues:
  - ➤ After a shutdown and a restart, mounted volume will continue to be mounted without typing the password: this due to the fact the new Windows 8 shutdown is not a real shutdown but a disguised hibernate/sleep.
  - ➤ When using system encryption and when there are System Favorites configured to be mounted at boot time: after shutdown and restart, these system favorites will not be mounted.

- Windows system Repair/Recovery Disk can't be created when a VeraCrypt volume is mounted as a fixed disk (which is the default). To solve this, either dismount all volumes or mount volumes are removable media.

- Further limitations are listed in the section *Security Model*.

Frequently Asked Questions

Note: The latest version of the VeraCrypt FAQ is available at
https://veracrypt.codeplex.com/wikipage?title=FAQ.

Can TrueCrypt and VeraCrypt be running on the same machine?

Yes. There are generally no conflicts between TrueCrypt and VeraCrypt, thus they can be installed and used on the same machine. On Windows however, if they are both used to mount the same volume, two drives may appear when mounting it. This can be solved by running the following command in an elevated command prompt (using Run as an administrator) before mounting any volume: **mountvol.exe /r**.

Can I use my TrueCrypt volumes in VeraCrypt?

Yes. Starting from version 1.0f, VeraCrypt supports mounting TrueCrypt volumes.

Can I convert my TrueCrypt volumes to VeraCrypt format?

Yes. Starting from version 1.0f, VeraCrypt offers the possibility to convert TrueCrypt containers and non-system partitions to VeraCrypt format. This can achieved using the "Change Volume Password" or "Set Header Key Derivation Algorithm" actions. Just check the "TrueCrypt Mode", enter you TrueCrypt password and perform the operation. After that, you volume will have the VeraCrypt format.
Before doing the conversion, it is advised to backup the volume header using TrueCrypt. You can delete this backup safely once the conversion is done and after checking that the converted volume is mounted properly by VeraCrypt.

What's the difference between TrueCrypt and VeraCrypt?

VeraCrypt adds enhanced security to the algorithms used for system and partitions encryption making it immune to new developments in brute-force attacks.
It also solves many vulnerabilities and security issues found in TrueCrypt. The following post describes parts of the major enhancements and corrections done in version 1.0e:
https://veracrypt.codeplex.com/discussions/569777#PostContent_1313325
As an example, when the system partition is encrypted, TrueCrypt uses PBKDF2-RIPEMD160 with 1000 iterations whereas in VeraCrypt we use 327661. And for standard containers and other partitions, TrueCrypt uses at most 2000 iterations but VeraCrypt uses 655331 for RIPEMD160 and 500000 iterations for SHA-2 and Whirlpool.
This enhanced security adds some delay only to the opening of encrypted partitions without any performance impact to the application use phase. This is acceptable to the legitimate owner but it makes it much harder for an attacker to gain access to the encrypted data.

I forgot my password – is there any way ('backdoor') to recover the files from my VeraCrypt volume?

We have not implemented any 'backdoor' in VeraCrypt (and will never implement any even if asked to do so by a government agency), because it would defeat the purpose of the software. VeraCrypt does not allow decryption of data without knowing the correct password or key. We cannot recover your data because we do not know and cannot determine the password you chose or the key you generated using VeraCrypt. The only way to recover your files is to try to "crack" the password or the key, but it could take thousands or millions of years (depending on the length and quality of the password or keyfiles, on the software/hardware performance, algorithms, and other factors). Back in 2010, there was news about the FBI failing to decrypt a TrueCrypt volume after a

year of trying. *While we can't verify if this is true or just a "psy-op" stunt, in VeraCrypt we have increased the security of the key derivation to a level where any brute-force of the password is virtually impossible, provided that all security requirements are respected.*

Is there a "Quick Start Guide" or some tutorial for beginners?

Yes. The first chapter, Beginner's Tutorial, *contains screenshots and step-by-step instructions on how to create, mount, and use a VeraCrypt volume.*

Can I encrypt a partition/drive where Windows is installed?

Yes (see the chapter System Encryption*).*

The system encryption Pre Test fails because the bootloader hangs with the messaging "booting" after successfully verifying the password. How to make the Pre Test succeed?

There two known workarounds for this issue (Both require having a Windows Installation disk):

1. *Boot your machine using a Windows Installation disk and select to repair your computer. Choose "Command Prompt" option and when it opens, type the commands below and then restart your system:*

   o *BootRec /fixmbr*

   o *BootRec /FixBoot*

2. *Delete the 100 MB System Reserved partition located at the beginning of your drive, set the system partition next to it as the active partition (both can be done using diskpart utility available in Windows Installation disk repair option). After that, run Startup Repair after rebooting on Windows Installation disk. The following link contains detailed instructions:* http://www.sevenforums.com/tutorials/71363-system-reserved-partition-delete.html

The system encryption Pre Test fails even though the password was correctly entered in the bootloader. How to make the Pre Test succeed?

  This can be caused by the TrueCrypt driver that clears BIOS memory before VeraCrypt is able to read it. In this case, uninstalling TrueCrypt solves the issue.
 This can also be caused by some hardware drivers and other software that access BIOS memory. There is no generic solution for this and affected users should identify such software and remove it from the system.

Can I directly play a video (.avi, .mpg, etc.) stored on a VeraCrypt volume?

Yes, VeraCrypt-encrypted volumes are like normal disks. You provide the correct password (and/or keyfile) and mount (open) the VeraCrypt volume. When you double click the icon of the video file, the operating system launches the application associated with the file type – typically a media player. The media player then begins loading a small initial portion of the video file from the VeraCrypt-encrypted volume to RAM (memory) in order to play it. While the portion is being loaded, VeraCrypt is automatically decrypting it (in RAM). The decrypted portion of the video (stored in RAM) is then played by the media player. While this portion is being played, the media

player begins loading another small portion of the video file from the VeraCrypt-encrypted volume to RAM (memory) and the process repeats.

The same goes for video recording: Before a chunk of a video file is written to a VeraCrypt volume, VeraCrypt encrypts it in RAM and then writes it to the disk. This process is called on-the-fly encryption/decryption and it works for all file types (not only for video files).

Will VeraCrypt be open-source and free forever?

Yes, it will. We will never create a commercial version of VeraCrypt, as we believe in open-source and free security software.

Is it possible to donate to the VeraCrypt project?

Yes, you can use the donation buttons at https://veracrypt.codeplex.com.

Why is VeraCrypt open-source? What are the advantages?

As the source code for VeraCrypt is publicly available, independent researchers can verify that the source code does not contain any security flaw or secret 'backdoor'. If the source code were not available, reviewers would need to reverse-engineer the executable files. However, analyzing and understanding such reverse-engineered code is so difficult that it is practically impossible *to do (especially when the code is as large as the VeraCrypt code).*

Remark: A similar problem also affects cryptographic hardware. It is very difficult to reverse-engineer it to verify that it does not contain any security flaw or secret 'backdoor'.

VeraCrypt is open-source, but has anybody actually reviewed the source code?

Yes. In fact, the source code is constantly being reviewed by many independent researchers and users. We know this because many bugs and several security issues have been discovered by independent researchers (including some well-known ones) while reviewing the source code.

As VeraCrypt is open-source software, independent researchers can verify that the source code does not contain any security flaw or secret 'backdoor'. Can they also verify that the official executable files were built from the published source code and contain no additional code?

Yes, they can. In addition to reviewing the source code, independent researchers can compile the source code and compare the resulting executable files with the official ones. They may find some differences (for example, timestamps or embedded digital signatures) but they can analyze the differences and verify that they do not form malicious code.

How can I use VeraCrypt on a USB flash drive?

You have three options:

1) *Encrypt the entire USB flash drive. However, you will not be able run VeraCrypt from the USB flash drive.*
2) Create two or more partitions on your USB flash drive. Leave the first partition non encrypted and encrypt the other partition(s). You can store VeraCrypt on the first partition in order to run it directly from the USB flash drive.

Note: Windows can only access the primary partition of a USB flash drive, nevertheless the extra partitions remain accessible through VeraCrypt.

3) *Create a VeraCrypt file container on the USB flash drive (for information on how to do so, see the chapter* Beginner's Tutorial*). If you leave enough space on the USB flash drive (choose an appropriate size for the VeraCrypt container), you will also be able to store VeraCrypt on the USB flash drive (along with the container – not* in *the container) and you will be able to run VeraCrypt from the USB flash drive (see also the chapter* Portable Mode*).*

Does VeraCrypt also encrypt file names and folder names?

Yes. The entire file system within a VeraCrypt volume is encrypted (including file names, folder names, and contents of every file). This applies to both types of VeraCrypt volumes – i.e., to file containers (virtual VeraCrypt disks) and to VeraCrypt-encrypted partitions/devices.

Does VeraCrypt use parallelization?

Yes. Increase in encryption/decryption speed is directly proportional to the number of cores/processors your computer has. For more information, please see the chapter Parallelization in the documentation.

Can data be read from and written to an encrypted volume/drive as fast as if the drive was not encrypted?

Yes, since VeraCrypt uses pipelining and parallelization. For more information, please see the chapters Pipelining *and* Parallelization*.*

Does VeraCrypt support hardware-accelerated encryption?

Yes. For more information, please see the chapter Hardware Acceleration*.*

Is it possible to boot Windows installed in a hidden VeraCrypt volume?

Yes, it is. For more information, please see the section Hidden Operating   System.

Will I be able to mount my VeraCrypt volume on any computer?

*Yes, VeraCrypt volumes are independent of the operating system. You will be able to mount your VeraCrypt volume on any computer on which you can run VeraCrypt (see also the question "*Can I use VeraCrypt in Windows if I do not have administrator privileges?*").*

Can I unplug or turn off a hot-plug device (for example, a USB flash drive or USB hard drive) when there is a mounted VeraCrypt volume on it?

Before you unplug or turn off the device, you should always dismount the VeraCrypt volume in VeraCrypt first, and then perform the 'Eject' operation if available (right-click the device in the 'Computer' or 'My Computer' list), or use the 'Safely Remove Hardware' function (built in Windows, accessible via the taskbar notification area). Otherwise, data loss may occur.

What is a hidden operating system?

See the section *Hidden Operating System.*

What is plausible deniability?

See the chapter *Plausible Deniability*.

Will I be able to mount my VeraCrypt partition/container after I reinstall or upgrade the operating system?

Yes, VeraCrypt volumes are independent of the operating system. However, you need to make sure your operating system installer does not format the partition where your VeraCrypt volume resides.

Note: If the system partition/drive is encrypted and you want to reinstall or upgrade Windows, you need to decrypt it first (select System > Permanently Decrypt System Partition/Drive). However, a running operating system can be updated (security patches, service packs, etc.) without any problems even when the system partition/drive is encrypted.

Can I upgrade from an older version of VeraCrypt to the latest version without any problems?

Generally, yes. However, before upgrading, please read the *release notes* for all versions of VeraCrypt that have been released since your version was released. If there are any known issues or incompatibilities related to upgrading from your version to a newer one, they will be listed in the release notes.

Can I upgrade VeraCrypt if the system partition/drive is encrypted or do I have to decrypt it first?

Generally, you can upgrade to the latest version without decrypting the system partition/drive (just run the VeraCrypt installer and it will automatically upgrade VeraCrypt on the system). However, before upgrading, please read the *release notes* for all versions of VeraCrypt that have been released since your version was released. If there are any known issues or incompatibilities related to upgrading from your version to a newer one, they will be listed in the release notes. Note that this FAQ answer is also valid for users of a hidden operating system. Also note that you cannot **down**grade VeraCrypt if the system partition/drive is encrypted.

I use pre-boot authentication. Can I prevent a person (adversary) that is watching me start my computer from knowing that I use VeraCrypt?

Yes. To do so, boot the encrypted system, start VeraCrypt, select Settings > System Encryption, enable the option 'Do not show any texts in the pre-boot authentication screen' and click OK. Then, when you start the computer, no texts will be displayed by the VeraCrypt boot loader (not even when you enter the wrong password). The computer will appear to be "frozen" while you can type your password. It is, however, important to note that if the adversary can analyze the content of the hard drive, he can still find out that it contains the VeraCrypt boot loader.

I use pre-boot authentication. Can I configure the VeraCrypt Boot Loader to display only a fake error message?

Yes. To do so, boot the encrypted system, start VeraCrypt, select Settings > System Encryption, *enable the option '*Do not show any texts in the pre-boot authentication screen*' and enter the fake error message in the corresponding field (for example, the "*Missing operating system*" message, which is normally displayed by the Windows boot loader if it finds no Windows boot partition). It is, however, important to note that if the adversary can analyze the content of the hard drive, he can still find out that it contains the VeraCrypt boot loader.*

Can I configure VeraCrypt to mount automatically whenever Windows starts a non-system VeraCrypt volume that uses the same password as my system partition/drive (i.e. my pre-boot authentication password)?

Yes. To do so, follow these steps:

1. *Mount the volume (to the drive letter to which you want it to be mounted every time).*
2. *Right-click the mounted volume in the drive list in the main VeraCrypt window and select '*Add to System Favorites*'.*
3. *The System Favorites Organizer window should appear now. In this window, enable the option '*Mount system favorite volumes when Windows starts*' and click* OK.

*For more information, see the chapter '*System Favorite Volumes*'.*

Can a volume be automatically mounted whenever I log on to Windows?

Yes. To do so, follow these steps:

1. *Mount the volume (to the drive letter to which you want it to be mounted every time).*
2. *Right-click the mounted volume in the drive list in the main VeraCrypt window and select '*Add to Favorites*'.*
3. *The Favorites Organizer window should appear now. In this window, enable the option '*Mount selected volume upon logon*' and click* OK.

Then, when you log on to Windows, you will be asked for the volume password (and/or keyfiles) and if it is correct, the volume will be mounted.

Alternatively, if the volumes are partition/device-hosted and if you do not need to mount them to particular drive letters every time, you can follow these steps:

1. *Select* Settings > Preferences. *The Preferences window should appear now.*
2. *In the section '*Actions to perform upon logon to Windows*', enable the option '*Mount all devices-hosted VeraCrypt volumes*' and click* OK.

*Note: VeraCrypt will not prompt you for a password if you have enabled caching of the pre-boot authentication password (*Settings > '*System Encryption*'*) and the volumes use the same password as the system partition/drive.*

Can a volume be automatically mounted whenever its host device gets connected to the computer?

Yes. For example, if you have a VeraCrypt container on a USB flash drive and you want VeraCrypt to mount it automatically when you insert the USB flash drive into the USB port, follow these steps:

1. Mount the volume (to the drive letter to which you want it to be mounted every time).
2. Right-click the mounted volume in the drive list in the main VeraCrypt window and select 'Add to Favorites'.
3. The Favorites Organizer window should appear now. In this window, enable the option 'Mount selected volume when its host device gets connected' and click OK.

Then, when you insert the USB flash drive into the USB port, you will be asked for the volume password (and/or keyfiles) (unless it is cached) and if it is correct, the volume will be mounted.

Note: VeraCrypt will not prompt you for a password if you have enabled caching of the pre-boot authentication password (Settings > 'System Encryption') and the volume uses the same password as the system partition/drive.

Can my pre-boot authentication password be cached so that I can use it mount non-system volumes during the session?

Yes. Select 'Settings' > 'System Encryption' and enable the following option: 'Cache pre-boot authentication password in driver memory'.

I live in a country that violates basic human rights of its people. Is it possible to use VeraCrypt without leaving any 'traces' on unencrypted Windows?

Yes. This can be achieved by running VeraCrypt in portable mode under BartPE or in a similar environment. BartPE stands for "Bart's Preinstalled Environment", which is essentially the Windows operating system prepared in a way that it can be entirely stored on and booted from a CD/DVD (registry, temporary files, etc., are stored in RAM – hard drive is not used at all and does not even have to be present). The freeware Bart's PE Builder can transform a Windows XP installation CD into a BartPE CD. Note that you do not even need any special VeraCrypt plug-in for BartPE. Follow these steps:

1. Create a BartPE CD and boot it. (Note: You must perform each of the following steps from within BartPE.)

2. Download the VeraCrypt self-extracting package to the RAM disk (which BartPE automatically creates).

   Note: If the adversary can intercept data you send or receive over the Internet and you need to prevent the adversary from knowing you downloaded VeraCrypt, consider downloading it via **I2P**, **Tor**, or a similar anonymizing network.

3. Verify the digital signatures of the downloaded file (see the section Digital Signatures for more information).

4. *Run the downloaded file, and select* Extract *(instead of* Install*) on the second page of the VeraCrypt Setup wizard. Extract the contents to the RAM disk.*

5. *Run the file* VeraCrypt.exe *from the RAM disk.*

Note: You may also want to consider creating a hidden operating system (see the section Hidden Operating System*). See also the chapter* Plausible Deniability*.*

Can I encrypt my system partition/drive if I don't have a US keyboard?

*Yes, VeraCrypt supports all keyboard layouts. Because of BIOS requirement, the pre-boot password is typed using **US keyboard layout.** During the system encryption process, VeraCrypt automatically and transparently switches the keyboard to US layout in order to ensure that the password value typed will match the one typed in pre-boot mode. Thus, in order to avoid wrong password errors, one must type the password using the same keys as when creating the system encryption.*

Can I save data to the decoy system partition without risking damage to the hidden system partition?

Yes. You can write data to the decoy system partition anytime without any risk that the hidden volume will get damaged (because the decoy system is not *installed within the same partition as the hidden system). For more information, see the section* Hidden Operating System*.*

Can I use VeraCrypt in Windows if I do not have administrator privileges?

*See the chapter '*Using VeraCrypt Without Administrator Privileges*'.*

Does VeraCrypt save my password to a disk?

No.

How does VeraCrypt verify that the correct password was entered?

See the chapter Technical Details*, section* Encryption Scheme*.*

Can I encrypt a partition/drive without losing the data currently stored on it?

Yes, but the following conditions must be met:

- *If you want to encrypt an entire system drive (which may contain multiple partitions) or a system partition (in other words, if you want to encrypt a drive or partition where Windows is installed), you can do so provided that you use Windows XP or a later version of Windows (such as Windows 7) (select '*System*' > '*Encrypt System Partition/Drive*' and then follow the instructions in the wizard).*

- *If you want to encrypt a non-system partition in place, you can do so provided that it contains an NTFS filesystem and that you use Windows Vista or a later version of Windows (for example, Windows 7) (click '*Create Volume*'*
*> '*Encrypt a non-system partition*' > '*Standard volume*' > '*Select Device*' > '*Encrypt partition in place*' and then follow the instructions in the wizard).*

Can I run VeraCrypt if I don't install it?

Yes, see the chapter [Portable Mode](#).

Some encryption programs use TPM to prevent attacks. Will VeraCrypt use it too?

No. Those programs use TPM to protect against attacks that **require** the attacker to have administrator privileges, or physical access to the computer, and the attacker needs you to use the computer after such an access. **However, if any of these conditions is met, it is actually impossible to secure the computer** (see below) and, therefore, you must stop using it (instead of relying on TPM).

If the attacker has administrator privileges, he can, for example, reset the TPM, capture the content of RAM (containing master keys) or content of files stored on mounted VeraCrypt volumes (decrypted on the fly), which can then be sent to the attacker over the Internet or saved to an unencrypted local drive (from which the attacker might be able to read it later, when he gains physical access to the computer).

If the attacker can physically access the computer hardware (and you use it after such an access), he can, for example, attach a malicious component to it (such as a hardware keystroke logger) that will capture the password, the content of RAM (containing master keys) or content of files stored on mounted VeraCrypt volumes (decrypted on the fly), which can then be sent to the attacker over the Internet or saved to an unencrypted local drive (from which the attacker might be able to read it later, when he gains physical access to the computer again).

The only thing that TPM is almost guaranteed to provide is a false sense of security (even the name itself, "Trusted Platform Module", is misleading and creates a false sense of security). As for real security, TPM is actually redundant (and implementing redundant features is usually a way to create so-called bloatware). Features like this are sometimes referred to as 'security theater' [6].

For more information, please see the sections [Physical Security](#) and [Malware](#).

Why does Windows Vista (and later versions of Windows) ask me for permission to run VeraCrypt every time I run it in 'portable' mode?

When you run VeraCrypt in portable mode, VeraCrypt needs to load and start the VeraCrypt device driver. VeraCrypt needs a device driver to provide transparent on-the-fly encryption/decryption, and   users without administrator privileges cannot start device drivers in Windows. Therefore, Windows   Vista and later versions of Windows ask you for permission to run VeraCrypt with administrator   privileges.

Note that if you install VeraCrypt on the system (as opposed to running VeraCrypt in portable mode), you will not be asked for permission every time you run it.

Do I have to dismount VeraCrypt volumes before shutting down or restarting Windows?

No. VeraCrypt automatically dismounts all mounted VeraCrypt volumes on system shutdown/restart.

Which type of VeraCrypt volume is better – partition or file container?

File containers are normal files so you can work with them as with any normal files (file containers can be, for example, moved, renamed, and deleted the same way as normal files). Partitions/drives may be better as regards performance. Note that reading and writing to/from a file container may take significantly longer when the container is heavily fragmented. To solve this problem, defragment the file system in which the container is stored (when the VeraCrypt volume is dismounted).

What's the recommended way to back up a VeraCrypt volume?

See the chapter *[How to Back Up Securely](#)*.

What will happen if I format a VeraCrypt partition?

See the question "*Is it possible to change the file system of an encrypted volume?*" in this FAQ.

Is it possible to change the file system of an encrypted volume?

Yes, when mounted, VeraCrypt volumes can be formatted as FAT12, FAT16, FAT32, NTFS, or any other file system. VeraCrypt volumes behave as standard disk devices so you can right-click the device icon (for example in the 'Computer' or 'My Computer' list) and select 'Format'. The actual volume contents will be lost. However, the whole volume will remain encrypted. If you format a VeraCrypt-encrypted partition when the VeraCrypt volume that the partition hosts is not mounted, then the volume will be destroyed, and the partition will not be encrypted anymore (it will be empty).

Is it possible to mount a VeraCrypt container that is stored on a CD or DVD?

Yes. However, if you need to mount a VeraCrypt volume that is stored on a read-only medium (such as a CD or DVD) under Windows 2000, the file system within the VeraCrypt volume must be FAT (Windows 2000 cannot mount an NTFS file system on read-only media).

Is it possible to change the password for a hidden volume?

Yes, the password change dialog works both for standard and hidden volumes. Just type the password for the hidden volume in the 'Current Password' field of the 'Volume Password Change' dialog.

Remark: VeraCrypt first attempts to decrypt the standard volume header and if it fails, it attempts to decrypt the area within the volume where the hidden volume header may be stored (if there is a hidden volume within). In case it is successful, the password change applies to the hidden volume. (Both attempts use the password typed in the '*Current Password*' field.)

When I use HMAC-RIPEMD-160, is the size of the header encryption key only 160 bits?

No, VeraCrypt never uses an output of a hash function (nor of a HMAC algorithm) directly as an encryption key. See the section ['Header Key Derivation, Salt, and Iteration Count'](#) *for more information.*

How do I burn a VeraCrypt container larger than 2 GB onto a DVD?

The DVD burning software you use should allow you to select the format of the DVD. If it does, select the UDF format (ISO format does not support files larger than 2 GB).

Can I use tools like chkdsk, Disk Defragmenter, etc. on the contents of a mounted VeraCrypt volume?

Yes, VeraCrypt volumes behave like real physical disk devices, so it is possible to use any filesystem checking/repairing/defragmenting tools on the contents of a mounted VeraCrypt volume.

Does VeraCrypt support 64-bit versions of Windows?

Yes.

Can I mount my VeraCrypt volume under Windows, Mac OS X, and Linux?

Yes, VeraCrypt volumes are fully cross-platform.

Is it possible to install an application to a VeraCrypt volume and run it from there?

Yes.

What will happen when a part of a VeraCrypt volume becomes corrupted?

In encrypted data, one corrupted bit usually corrupts the whole ciphertext block in which it occurred. The ciphertext block size used by VeraCrypt is 16 bytes (i.e., 128 bits). The [mode of operation](#) used by VeraCrypt ensures that if data corruption occurs within a block, the remaining blocks are not affected. See also the question 'What do I do when the encrypted filesystem on my VeraCrypt volume is corrupted?'

What do I do when the encrypted filesystem on my VeraCrypt volume is corrupted?

File system within a VeraCrypt volume may become corrupted in the same way as any normal unencrypted file system. When that happens, you can use filesystem repair tools supplied with your operating system to fix it. In Windows, it is the 'chkdsk' tool. VeraCrypt provides an easy way to use this tool on a VeraCrypt volume: Right-click the mounted volume in the main VeraCrypt window (in the drive list) and from the context menu select 'Repair Filesystem'.

We use VeraCrypt in a corporate/enterprise environment. Is there a way for an administrator to reset a volume password or pre-boot authentication password when a user forgets it (or loses a keyfile)?

Yes. Note that there is no "backdoor" implemented in VeraCrypt. However, there is *a way to "reset" volume passwords/keyfiles and pre-boot authentication passwords. After you create a volume, back up its header to a file (select* Tools > Backup Volume Header) *before you allow a non-admin user to use the volume. Note that the volume header (which is encrypted with a header key derived from a password/keyfile) contains the master key with which the volume is encrypted. Then ask the user to choose a password, and set it for him/her (*Volumes > Change Volume Password*); or generate   a user keyfile for him/her. Then you can allow the user to use the volume and to change the password/keyfiles without your assistance/permission. In case he/she forgets his/her password or loses his/her keyfile, you can "reset" the volume password/keyfiles to your original admin password/keyfiles by restoring the volume header from the backup file (*Tools > Restore Volume   Header*).*

*Similarly, you can reset a pre-boot authentication password. To create a backup of the master key data (that will be stored on a VeraCrypt Rescue Disk and encrypted with your administrator password), select '*System*' > '*Create Rescue Disk*'. To set a user pre-boot authentication password, select '*System*' > '*Change Password*'. To restore your administrator password, boot the   VeraCrypt Rescue Disk, select '*Repair Options*' > '*Restore key data*', and enter your administrator   password. Note: It is not required to burn each VeraCrypt Rescue Disk ISO image to a CD/DVD. You can   maintain a central repository of ISO images for all workstations (rather than a repository of CDs/DVDs). For   more information, see the section* Command Line Usage *(option /noisocheck).*

Can our commercial company use VeraCrypt free of charge?

Provided that you comply with the terms and conditions of the VeraCrypt License*, you can install and run VeraCrypt free of charge on an arbitrary number of your computers.*

We share a volume over a network. Is there a way to have the network share automatically restored when the system is restarted?

Please see the chapter Sharing over Network.

It is possible to access a single VeraCrypt volume simultaneously from multiple operating systems (for example, a volume shared over a network)?

Please see the chapter Sharing over Network.

Can a user access his or her VeraCrypt volume via a network?

Please see the chapter Sharing over Network.

I encrypted a non-system partition, but its original drive letter is still visible in the 'My Computer' list. When I double click this drive letter, Windows asks if I want to format the drive. Is there a way to hide or free this drive letter?

Yes, to free the drive letter follow these steps:

1. *Right-click the 'Computer' (or 'My Computer') icon on your desktop or in the Start Menu and select* Manage. *The 'Computer Management' window should appear.*
2. *From the list on the left, select 'Disk Management' (within the* Storage *sub-tree).*
3. *Right-click the encrypted partition/device and select 'Change Drive Letter and Paths'.*
4. *Click* Remove.
5. *If Windows prompts you to confirm the action, click* Yes.

When I plug in my encrypted USB flash drive, Windows asks me if I want to format it. Is there a way to prevent that?

Yes, but you will need to remove the drive letter assigned to the device. For information on how to do so, see the question 'I encrypted a non-system partition, but its original drive letter is still visible in the 'My Computer' list.'

How do I remove or undo encryption if I do not need it anymore? How do I permanently decrypt a volume?

Please see the section How to Remove Encryption.

What will change when I enable the option 'Mount volumes as removable media'?

Please see the section Volume Mounted as Removable Medium.

Do I have to "wipe" free space and/or files on a VeraCrypt volume?

Remark: to "wipe" = to securely erase; to overwrite sensitive data in order to render them unrecoverable.

If you believe that an adversary will be able to decrypt the volume (for example that he will make you reveal the password), then the answer is yes. Otherwise, it is not necessary, because the volume is entirely encrypted.

How does VeraCrypt know which encryption algorithm my VeraCrypt volume has been encrypted with?

Please see the section Encryption Scheme *(chapter* Technical Details*).*

How can I perform a Windows built-in backup on a VeraCrypt volume? The VeraCrypt volume doesn't show up in the list of available backup paths.

Windows built-in backup utility looks only for physical driver, that's why it doesn't display the VeraCrypt volume. Nevertheless, you can still backup on a VeraCrypt volume by using a trick: activate sharing on the VeraCrypt volume through Explorer interface (of course, you have to put the correct permission to avoid unauthorized access) and then choose the option "Remote shared folder" (it is not remote of course but Windows needs a network path). There you can type the path of the shared drive (for example \\ServerName\sharename) and the backup will be configured correctly.

Is the encryption used by VeraCrypt vulnerable to Quantum attacks?

VeraCrypt uses block ciphers (AES, Serpent, Twofish) for its encryption. Quantum attacks against these block ciphers are just a faster brute-force since the best know attack against these algorithms

is exhaustive search (related keys attacks are irrelevant to our case because all keys are random and independent from each other). Since VeraCrypt always uses 256-bit random and independent keys, we are assured of a 128-bit security level against quantum algorithms which makes VeraCrypt encryption immune to such attacks.

How to make a VeraCrypt volume available for Windows Search indexing?

In order to be able to index a VeraCrypt volume through Windows Search, the volume must be mounted at boot time (System Favorite) or the Windows Search services must be restart after the volume is mounted. This is needed because Windows Search can only index drives that are available when it starts.

Technical Details

Notation

C	Ciphertext block
$D_K()$	Decryption algorithm using encryption/decryption key K
$E_K()$	Encryption algorithm using encryption/decryption key K
$H()$	Hash function
i	Block index for n-bit blocks; n is context-dependent
K	Cryptographic key
P	Plaintext block
^	Bitwise exclusive-OR operation (XOR)
EB	Modulo 2^n addition, where n is the bit size of the left-most operand and of the resultant value (e.g., if the left operand is a 1-bit value, and the right operand is a 2-bit value, then: 1 EB 0 = 1; 1 EB 1 = 0; 1 EB 2 = 1; 1 EB 3 = 0; 0 EB 0 = 0; 0 EB 1 = 1; 0 EB 2 = 0; 0 EB 3 = 1)
	Modular multiplication of two polynomials over the binary field GF(2) modulo $x^{128}+x^7+x^2+x+1$ (GF stands for Galois Field)
||	Concatenation

Encryption Scheme

When mounting a VeraCrypt volume (assume there are no cached passwords/keyfiles) or when performing pre-boot authentication, the following steps are performed:

1. The first 512 bytes of the volume (i.e., the standard volume header) are read into RAM, out of which the first 64 bytes are the salt (see *VeraCrypt Volume Format Specification*). For system encryption (see the chapter *System Encryption*), the last 512 bytes of the first logical drive track are read into RAM (the VeraCrypt Boot Loader is stored in the first track of the system drive and/or on the VeraCrypt Rescue Disk).

2. Bytes 65536–66047 of the volume are read into RAM (see the section *VeraCrypt Volume Format Specification*). For system encryption, bytes 65536–66047 of the first partition located behind the active partition[*] are read (see the section *Hidden Operating System*). If there is a hidden volume within this volume (or within the partition behind the boot partition), we have read its header at this point; otherwise, we have just read random data (whether or not there is a hidden volume within it has to be determined by attempting to decrypt this data; for more information see the section *Hidden Volume*).

3. Now VeraCrypt attempts to decrypt the standard volume header read in (1). All data used and generated in the course of the process of decryption are kept in RAM (VeraCrypt never saves them to disk). The following parameters are unknown[†] and have to be determined through the process of trial and error (i.e., by testing all possible combinations of the following):

   a. PRF used by the header key derivation function (as specified in PKCS #5 v2.0; see the section *Header Key Derivation, Salt, and Iteration Count*), which can be one of the following:
   HMAC-SHA-512, HMAC-SHA-256, HMAC-RIPEMD-160, HMAC-Whirlpool. If a PRF is explicitly specified by the user, it will be used directly without trying the other possibilities.
   A password entered by the user (to which one or more keyfiles may have been applied – see the section *Keyfiles*), a PIM value (if specified) and the salt read in (1) are passed to the header key derivation function, which produces a sequence of values (see the section *Header Key Derivation, Salt, and Iteration Count*) from which the header encryption key and secondary header key (XTS mode) are formed. (These keys are used to decrypt the volume header.)

   b. Encryption algorithm: AES-256, Serpent, Twofish, AES-Serpent, AES-Twofish-Serpent, etc.

   c. Mode of operation: only XTS is supported.

   d. Key size(s)

---

[*] If the size of the active partition is less than 256 MB, then the data is read from the *second* partition behind the active one (Windows 7 and later, by default, do not boot from the partition on which they are installed).
[†] These parameters are kept secret *not* in order to increase the complexity of an attack, but primarily to make VeraCrypt volumes unidentifiable (indistinguishable from random data), which would be difficult to achieve if these parameters were stored unencrypted within the volume header. Also note that if a non-cascaded encryption algorithm is used for system encryption, the algorithm *is* known (it can be determined by analyzing the contents of the unencrypted VeraCrypt Boot Loader stored in the first logical drive track or on the VeraCrypt Rescue Disk).

4. Decryption is considered successful if the first 4 bytes of the decrypted data contain the ASCII string "VERA", and if the CRC-32 checksum of the last 256 bytes of the decrypted data (volume header) matches the value located at byte #8 of the decrypted data (this value is unknown to an adversary because it is encrypted – see the section *VeraCrypt Volume Format Specification*). If these conditions are not met, the process continues from (3) again, but this time, instead of the data read in (1), the data read in (2) are used (i.e., possible hidden volume header). If the conditions are not met again, mounting is terminated (wrong password, corrupted volume, or not a VeraCrypt volume).

5. Now we know (or assume with very high probability) that we have the correct password, the correct encryption algorithm, mode, key size, and the correct header key derivation algorithm. If we successfully decrypted the data read in (2), we also know that we are mounting a hidden volume and its size is retrieved from data read in (2) decrypted in (3).

6. The encryption routine is reinitialized with the primary master key[*] and the secondary master key (XTS mode – see the section *Modes of Operation*), which are retrieved from the decrypted volume header (see the section *VeraCrypt Volume Format Specification*). These keys can be used to decrypt any sector of the volume, except the volume header area (or the key data area, for system encryption), which has been encrypted using the header keys. The volume is mounted.

See also section *Modes of Operation* and section *Header Key Derivation, Salt, and Iteration Count* and also the chapter *Security Model*.

---

[*] The master keys were generated during the volume creation and cannot be changed later. Volume password change is accomplished by re-encrypting the volume header using a new header key (derived from a new password).

Modes of Operation

The mode of operation used by VeraCrypt for encrypted partitions, drives, and virtual volumes is XTS.

XTS mode is in fact XEX mode [12], which was designed by Phillip Rogaway in 2003, with a minor modification (XEX mode uses a single key for two different purposes, whereas XTS mode uses two independent keys).

In 2010, XTS mode was approved by NIST for protecting the confidentiality of data on storage devices [24]. In 2007, it was also approved by the IEEE for cryptographic protection of data on block-oriented storage devices (IEEE 1619).

Description of XTS mode:

$$C_i = E_{K1} (P_i \wedge (E_{K2} (n) \quad \alpha^i)) \wedge (E_{K2} (n) \quad \alpha^i)$$

Where:

denotes multiplication of two polynomials over the binary field GF(2) modulo $x^{128} + x^7 + x^2 + x + 1$ $K1$ is the encryption key (256-bit for each supported cipher; i.e., AES, Serpent, and Twofish)

$K2$ is the secondary key (256-bit for each supported cipher; i.e., AES, Serpent, and Twofish)

i is the cipher block index within a data unit; for the first cipher block within a data unit, $i = 0$

n is the data unit index within the scope of $K1$; for the first data unit, $n = 0$

α is a primitive element of Galois Field (2^{128}) that corresponds to polynomial x (i.e., 2)

The size of each data unit is always 512 bytes (regardless of the sector size).

For further information pertaining to XTS mode, see e.g. [12] and [24].

Header Key Derivation, Salt, and Iteration Count

Header key is used to encrypt and decrypt the encrypted area of the VeraCrypt volume header (for system encryption, of the key data area), which contains the master key and other data (see the sections *Encryption Scheme* and *VeraCrypt Volume Format Specification*). In volumes created by VeraCrypt (and for system encryption), the area is encrypted in XTS mode (see the   section *Modes of Operation*). The method that VeraCrypt uses to generate the header key and the   secondary header key (XTS mode) is PBKDF2, specified in PKCS #5 v2.0; see References.

512-bit salt is used, which means there are 2^{512} keys for each password. This significantly decreases vulnerability to 'off-line' dictionary/'rainbow table' attacks (pre-computing all the keys for a dictionary of passwords is very difficult when a salt is used) [7]. The salt consists of random values generated by the VeraCrypt random number generator during the volume creation process. The header key derivation function is based on HMAC-SHA-512, HMAC-SHA-256, HMAC-RIPEMD-160, or HMAC- Whirlpool (see [8, 9, 20, 22]) – the user selects which. The length of the derived key does not   depend on the size of the output of the underlying hash function. For example, a header key for the AES-256 cipher is always 256 bits long even if HMAC-RIPEMD-160 is used (in XTS mode, an additional 256-bit secondary header key is used; hence, two 256-bit keys are used for AES-256 in   total). For more information, refer to [7]. A large number of iterations of the key derivation function have to be performed to derive a header key, which increases the time necessary to perform an exhaustive search for passwords (i.e., brute force attack) [7].

Prior to version 1.12, VeraCrypt always used a fixed number of iterations depending on the volume type and the derivation algorithm used:
- For system partition encryption (boot encryption), **200000** iterations are used for the HMAC-SHA-256 derivation function and **327661** iterations are used for HMAC-RIPEMD-160.
- For standard containers and other partitions, **655331** iterations are used for HMAC-RIPEMD-160 and **500000** iterations are used for HMAC-SHA-512, HMAC-SHA-256 and HMAC-Whirlpool.

Starting from version 1.12, the PIM field (Personal Iterations Multiplier) enables users to have more control over the number of iterations used by the key derivation function.
When a PIM value is not specified or if it is equal to zero, VeraCrypt uses the default values expressed above.
When a PIM value is given by the user, the number of iterations of the key derivation function is calculated as follows:
- For system partition encryption (boot encryption): Iterations = **PIM x 2048**
- For standard containers and other partitions: Iterations = **15000 + (PIM x 1000)**

Header keys used by ciphers in a cascade are mutually independent, even though they are derived from a single password (to which keyfiles may have been applied). For example, for the AES-Twofish-Serpent cascade, the header key derivation function is instructed to derive a 768-bit encryption key from a given password (and, for XTS mode, in addition, a 768-bit *secondary* header key from the given password). The generated 768-bit header key is then split into three 256-bit keys (for XTS mode, the *secondary* header key is split into three 256-bit keys too, so the cascade actually uses six 256-bit keys in total), out of which the first key is used by Serpent, the second key is used by Twofish, and the third by AES (in addition, for XTS mode, the first secondary key is used by Serpent, the second secondary key is used by Twofish, and the third secondary key by AES). Hence, even when an adversary has one of the keys, he cannot use it to derive the other keys, as there is no feasible method to determine the password from which the key was derived (except for brute force attack mounted on a weak password).

Random Number Generator

The VeraCrypt random number generator (RNG) is used to generate the master encryption key, the secondary key (XTS mode), salt, and keyfiles. It creates a pool of random values in RAM (memory). The pool, which is 320 bytes long, is filled with data from the following sources:

- Mouse movements
- Keystrokes
- *Mac OS X and Linux*: Values generated by the built-in RNG (both */dev/random* and */dev/urandom*)
- *MS Windows only*: MS Windows CryptoAPI (collected regularly at 500-ms interval)
- *MS Windows only*: Network interface statistics (NETAPI32)
- *MS Windows only*: Various Win32 handles, time variables, and counters (collected regularly at 500-ms interval)

Before a value obtained from any of the above-mentioned sources is written to the pool, it is divided into individual bytes (e.g., a 32-bit number is divided into four bytes). These bytes are then individually written to the pool with the modulo 2^8 addition operation (not by replacing the old values in the pool) at the position of the pool cursor. After a byte is written, the pool cursor position is advanced by one byte. When the cursor reaches the end of the pool, its position is set to the beginning of the pool. After every 16th byte written to the pool, the pool mixing function is automatically applied to the entire pool (see below).

Pool Mixing Function

The purpose of this function is to perform diffusion [2]. Diffusion spreads the influence of individual "raw" input bits over as much of the pool state as possible, which also hides statistical relationships. After every 16th byte written to the pool, this function is applied to the entire pool.

Description of the pool mixing function:
1. Let R be the randomness pool.
2. Let H be the hash function selected by the user (SHA-512, RIPEMD-160, or Whirlpool).
3. l = byte size of the output of the hash function H (i.e., if H is RIPEMD-160, then $l = 20$; if H is SHA-512, $l = 64$)
4. z = byte size of the randomness pool R (320 bytes)
5. $q = z / l - 1$ (e.g., if H is Whirlpool, then $q = 4$)
6. R is divided into l-byte blocks $B_0...B_q$.

   For $0 :. i :. q$ (i.e., for each block B) the following steps are performed:
   - a. $M = H (B_0 || B_1 || ... || B_q)$ [i.e., the randomness pool is hashed using the hash function H, which produces a hash M]
   - b. $B_i = B_i \wedge M$
7. $R = B_0 || B_1 || ... || B_q$

   For example, if $q = 1$, the randomness pool would be mixed as follows:
   1. $(B_0 || B_1) = R$
   2. $B_0 = B_0 \wedge H(B_0 || B_1)$
   3. $B_1 = B_1 \wedge H(B_0 || B_1)$
   4. $R = B_0 || B_1$

Generated Values

The content of the RNG pool is never directly exported (even when VeraCrypt instructs the RNG to generate and export a value). Thus, even if the attacker obtains a value generated by the RNG, it is infeasible for him to determine or predict (using the obtained value) any other values generated by the RNG during the session (it is infeasible to determine the content of the pool from a value generated by the RNG).

The RNG ensures this by performing the following steps whenever VeraCrypt instructs it to generate and export a value:

1. Data obtained from the sources listed above is added to the pool as described above.

2. The requested number of bytes is copied from the pool to the output buffer (the copying starts from the position of the pool cursor; when the end of the pool is reached, the copying continues from the beginning of the pool; if the requested number of bytes is greater than the size of the pool, no value is generated and an error is returned).

3. The state of each bit in the pool is inverted (i.e., 0 is changed to 1, and 1 is changed to 0).

4. Data obtained from some of the sources listed above is added to the pool as described above.

5. The content of the pool is transformed using the pool mixing function. Note: The function uses a cryptographically secure one-way hash function selected by the user (for more information, see the section *Pool Mixing Function* above).

6. The transformed content of the pool is XORed into the output buffer as follows:

    a. The output buffer write cursor is set to 0 (the first byte of the buffer).

    b. The byte at the position of the pool cursor is read from the pool and XORed into the byte in the output buffer at the position of the output buffer write cursor.

    c. The pool cursor position is advanced by one byte. If the end of the pool is reached, the cursor position is set to 0 (the first byte of the pool).

    d. The position of the output buffer write cursor is advanced by one byte.

    e. Steps b–d are repeated for each remaining byte of the output buffer (whose length is equal to the requested number of bytes).

7. The content of the output buffer, which is the final value generated by the RNG, is exported.

Design Origins

The design and implementation of the random number generator are based on the following works:
- *Software Generation of Practically Strong Random Numbers* by Peter Gutmann [10]
- *Cryptographic Random Numbers* by Carl Ellison [11]

Keyfiles

VeraCrypt keyfile is a file whose content is combined with a password. The user can use any kind of file as a VeraCrypt keyfile. The user can also generate a keyfile using the built-in keyfile generator, which utilizes the VeraCrypt RNG to generate a file with random content (for more information, see the section *Random Number Generator*).

The maximum size of a keyfile is not limited; however, only its first 1,048,576 bytes (1 MB) are processed (all remaining bytes are ignored due to performance issues connected with processing extremely large files). The user can supply one or more keyfiles (the number of keyfiles is not limited).

Keyfiles can be stored on PKCS-11-compliant [23] security tokens and smart cards protected by multiple PIN codes (which can be entered either using a hardware PIN pad or via the VeraCrypt GUI).

Keyfiles are processed and applied to a password using the following method:

1. Let P be a VeraCrypt volume password supplied by user (may be empty)
2. Let KP be the keyfile pool
3. Let kpl be the size of the keyfile pool KP, in bytes (64, i.e., 512 bits);
   kpl must be a multiple of the output size of a hash function H
4. Let pl be the length of the password P, in bytes (in the current version: 0 :. pl :. 64)
5. if $kpl > pl$, append $(kpl - pl)$ zero bytes to the password P (thus $pl = kpl$)
6. Fill the keyfile pool KP with kpl zero bytes.
7. For each keyfile perform the following steps:
   a. Set the position of the keyfile pool cursor to the beginning of the pool
   b. Initialize the hash function H
   c. Load all bytes of the keyfile one by one, and for each loaded byte perform the following steps:
      i. Hash the loaded byte using the hash function H without initializing the hash, to obtain an intermediate hash (state) M. Do not finalize the hash (the state is retained for next round).
      ii. Divide the state M into individual bytes.
          For example, if the hash output size is 4 bytes, $(T_0 \| T_1 \| T_2 \| T_3) = M$
      iii. Write these bytes (obtained in step 7.c.ii) individually to the keyfile pool with the modulo 2^8 addition operation (not by replacing the old values in the pool) at the position of the pool cursor. After a byte is written, the pool cursor position is advanced by one byte. When the cursor reaches the end of the pool, its position is set to the beginning of the pool.
8. Apply the content of the keyfile pool to the password P using the following method:
   a. Divide the password P into individual bytes $B_0...B_{pl-1}$.
      Note that if the password was shorter than the keyfile pool, then the password was padded with zero bytes to the length of the pool in Step 5 (hence, at this point the length of the password is always greater than or equal to the length of the keyfile pool).
   b. Divide the keyfile pool KP into individual bytes $G_0...G_{kpl-1}$
   c. For 0 :. $i < kpl$ perform: $B_i = B_i$ EB G_i
   d. $P = B_0 \| B_1 \| ... \| B_{pl-2} \| B_{pl-1}$

9. The password *P* (after the keyfile pool content has been applied to it) is now passed to the header key derivation function PBKDF2 (PKCS #5 v2), which processes it (along with salt and other data) using a cryptographically secure hash algorithm selected by the user (e.g., SHA-512). See the section *Header Key Derivation, Salt, and Iteration Count* for more information.

The role of the hash function *H* is merely to perform diffusion [2]. CRC-32 is used as the hash function *H*. Note that the output of CRC-32 is subsequently processed using a cryptographically secure hash algorithm: The keyfile pool content (in addition to being hashed using CRC-32) is applied to the password, which is then passed to the header key derivation function PBKDF2 (PKCS #5 v2), which processes it (along with salt and other data) using a cryptographically secure hash algorithm selected by the user (e.g., SHA-512). The resultant values are used to form the header key and the secondary header key (XTS mode).

PIM

PIM stands for "Personal Iterations Multiplier". It is a parameter that was introduced in VeraCrypt 1.12 and whose value controls the number of iterations used by the header key derivation function. This value can be specified through the password dialog or in the command line.

If no PIM value is specified, VeraCrypt will use the default number of iterations used in versions prior to 1.12 (see Header Key Derivation).

When a PIM value is specified, the number of iterations is calculated as follows:

- For system encryption: Iterations = **PIM x 2048**

- For non-system encryption and file containers: Iterations = **15000 + (PIM x 1000)**

Prior to version 1.12, the security of a VeraCrypt volume was only based on the password strength because VeraCrypt was using a fixed number of iterations.
With the introduction of PIM, VeraCrypt has a 2-dimensional security space for volumes based on the couple (Password, PIM). This provides more flexibility for adjusting the desired security level while also controlling the performance of the mount/boot operation.

PIM Usage

It is not mandatory to specify a PIM.

When creating a volume or when changing the password, the user has the possibility to specify a PIM value by checking the "Use PIM" checkbox which in turn will make a PIM field available in the GUI so a PIM value can be entered.

The PIM is treated like a secret value that must be entered by the user each time alongside the password. If the incorrect PIM value is specified, the mount/boot operation will fail.

Using high PIM values leads to better security thanks to the increased number of iterations but it comes with slower mounting/booting times.
With small PIM values, mounting/booting is quicker but this could decrease security if a weak password is used.

During the creation of a volume or the encryption of the system, VeraCrypt forces the PIM value to be greater than or equal to a certain minimal value when the password is less than 20 characters. This check is done in order to ensure that, for short passwords, the security level is at least equal to the default level provided by an empty PIM.
The PIM minimal value for short passwords is **98** for system encryption and **485** for non-system encryption and files containers. For password with 20 characters and more, the PIM minimal value is **1**. In all cases, leaving the PIM empty or setting its value to 0 will make VeraCrypt use the default high number of iterations as explained in section **Header Key Derivation**.

Motivations behind using a custom PIM value can be:

- ➢ Add an extra secret parameter (PIM) that an attacker will have to guess

- ➢ Increase security level by using large PIM values to thwart future development of brute force attacks.

➢ Speeding up booting or mounting through the use of a small PIM value (less than 98 for system encryption and less than 485 for the other cases)

The screenshots below show the step to mount a volume using a PIM equal to 231:

Enter password for \Device\Harddisk3\Partition1

Password: ●●●●●●●●●●●●●●●●●●●●●●●●●●●●   OK

PKCS-5 PRF: HMAC-Whirlpool ▼   ☐ TrueCrypt Mode   Cancel

☐ Use PIM

☐ Cache passwords and keyfiles in memory

☐ Display password

☐ Use keyfiles   Keyfiles...   Mount Options...

Enter password for \Device\Harddisk3\Partition1

Password: ●●●●●●●●●●●●●●●●●●●●●●●●●●●   OK

PKCS-5 PRF: HMAC-Whirlpool ▼   ☐ TrueCrypt Mode   Cancel

Volume PIM: 231   (Empty or 0 for default iterations)

☐ Cache passwords and keyfiles in memory

☐ Display password

☐ Use keyfiles   Keyfiles...   Mount Options...

Changing/clearing the PIM

The PIM of a volume or for system encryption can be changed or cleared using the change password functionality. The screenshots below shows an example of changing the PIM from the empty default value to a value equal to 3 (this is possible since the password has more than 20 characters). In order to do so, the user must first tick "Use PIM" checkbox in the "New" section to reveal the PIM field.

Normal volume case
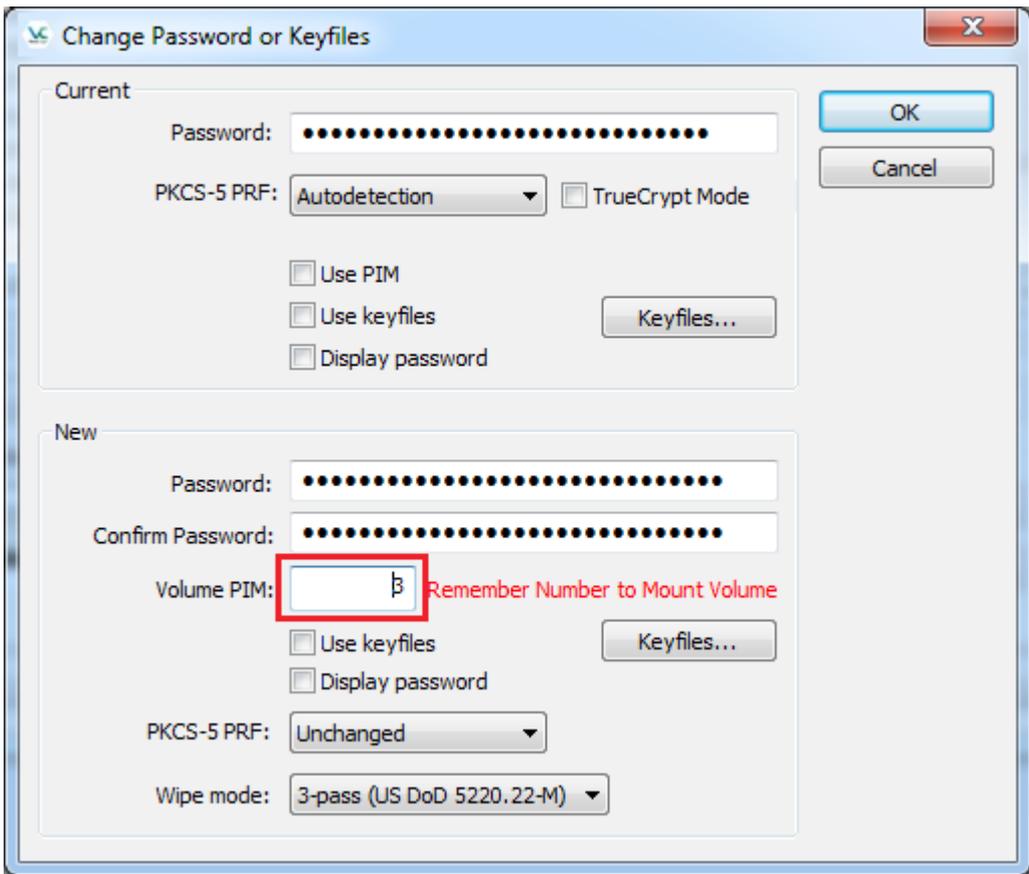
System encryption case
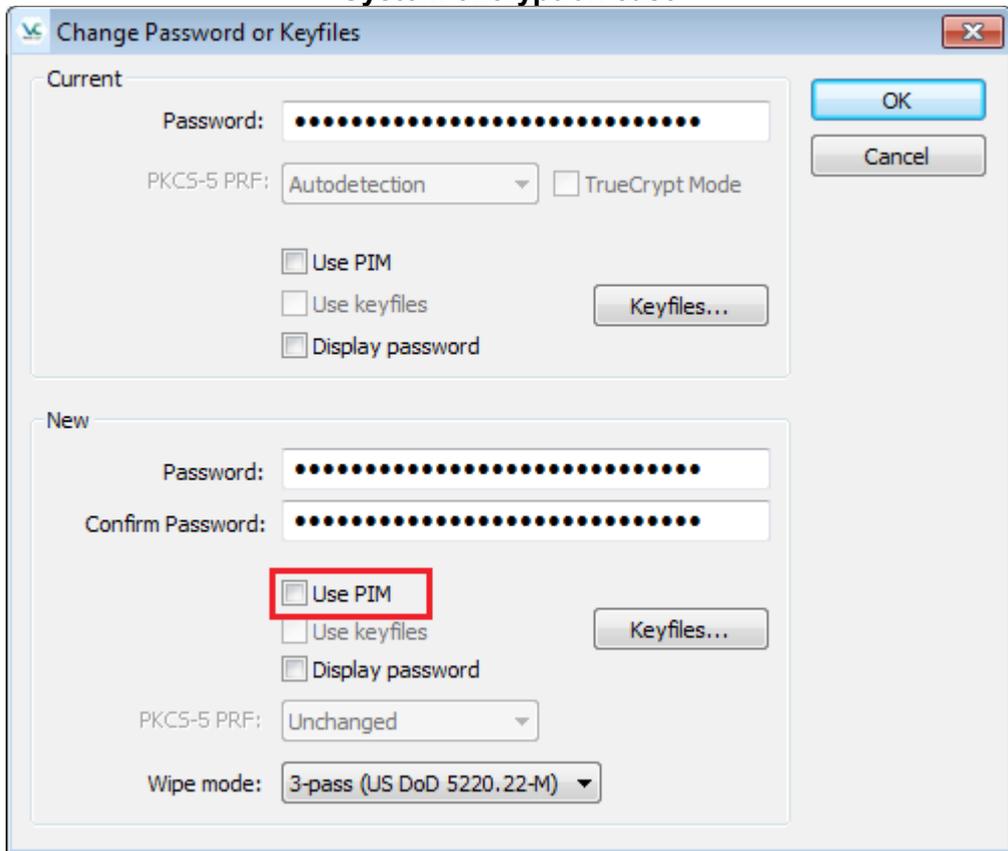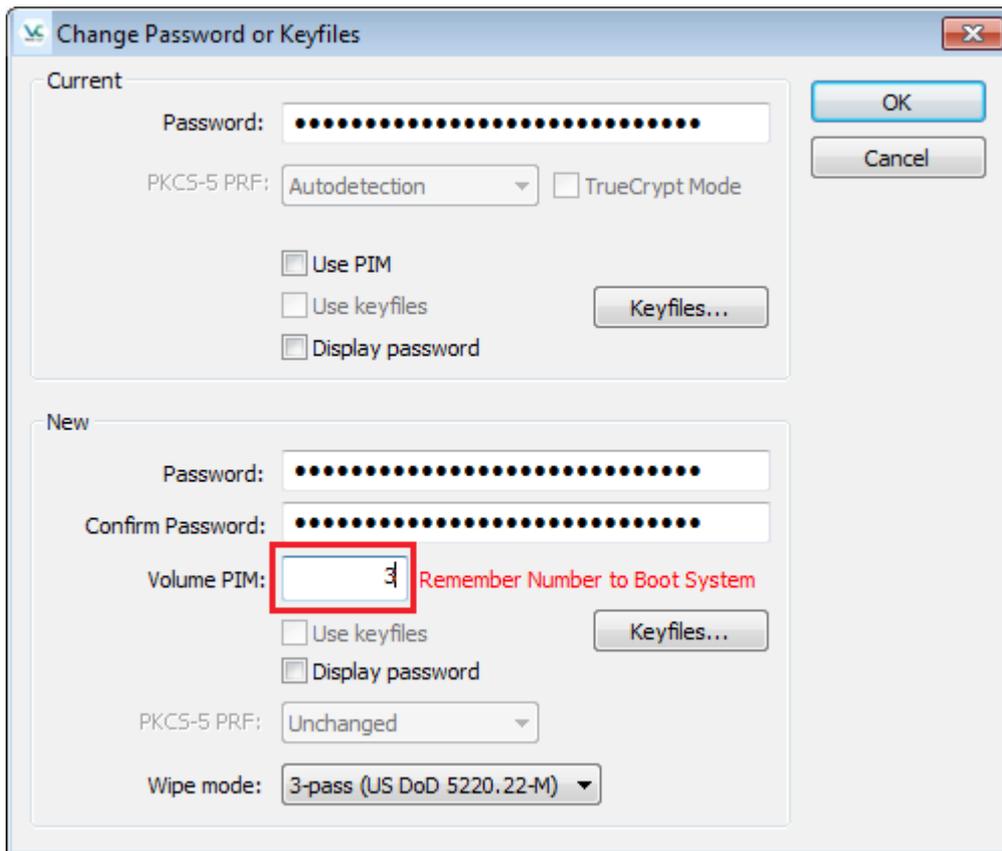
VeraCrypt Volume Format Specification

Offset (bytes)	Size (bytes)	Encryption Status[*]	Description
0	64	Unencrypted[‡]	Salt
64	4	Encrypted	ASCII string "VERA"
68	2	Encrypted	Volume header format version (2)
70	2	Encrypted	Minimum program version required to open the volume
72	4	Encrypted	CRC-32 checksum of the (decrypted) bytes 256–511
76	16	Encrypted	Reserved (must contain zeroes)
92	8	Encrypted	Size of hidden volume (set to zero in non-hidden
100	8	Encrypted	Size of volume
108	8	Encrypted	Byte offset of the start of the master key scope
116	8	Encrypted	Size of the encrypted area within the master key scope
124	4	Encrypted	Flag bits (bit 0 set: system encryption; bit 1 set: non-in-place-encrypted volume; bits 2-31 are reserved)
128	4	Encrypted	Sector size (in bytes)
132	120	Encrypted	Reserved (must contain zeroes)
252	4	Encrypted	CRC-32 checksum of the (decrypted) bytes 64–251
256	*Var.*	Encrypted	Concatenated primary and secondary master keys[§]
512	65024	Encrypted	Reserved (for system encryption, this item is omitted[††])
65536	65536	Encrypted / Unencrypted[‡]	Area for hidden volume header (if there is no hidden volume within the volume, this area contains random data[**]). For system encryption, this item is omitted.[††] See bytes 0–65535.
131072	*Var.*	Encrypted	Data area (master key scope). For system encryption, offset may be different (depending on offset of system partition).
S–131072[‡]	65536	Encrypted / Unencrypted[‡]	Backup header (encrypted with a different header key derived using a different salt). For system encryption, this item is omitted. [††] See bytes 0–65535.
S–65536	65536	Encrypted / Unencrypted[‡]	Backup header for hidden volume (encrypted with a different header key derived using a different salt). If there is no hidden volume within the volume, this area contains random data.[**] For system encryption, this item is omitted. [††] See bytes 0–65535.

[*] The encrypted areas of the volume header are encrypted in XTS mode using the primary and secondary header keys. For more information, see the section *Encryption Scheme* and the section *Header Key Derivation, Salt, and Iteration Count.*
[†] *S* denotes the size of the volume host (in bytes).
[‡] Note that the salt does not need to be encrypted, as it does not have to be kept secret [7] (salt is a sequence of random values).
[§] Multiple concatenated master keys are stored here when the volume is encrypted using a cascade of ciphers (secondary master keys are used for XTS mode).
[**] See below in this section for information on the method used to fill free volume space with random data when the volume is created.
[††] Here, the meaning of "system encryption" does not include a hidden volume containing a hidden operating system.

The format of file-hosted volumes is identical to the format of partition/device-hosted volumes (however, the "volume header", or key data, for a system partition/drive is stored in the last 512 bytes of the first logical drive track). VeraCrypt volumes have no "signature" or ID strings. Until decrypted, they appear to consist solely of random data.

Free space on each VeraCrypt volume is filled with random data when the volume is created.* The random data is generated as follows: Right before VeraCrypt volume formatting begins, a temporary encryption key and a temporary secondary key (XTS mode) are generated by the random number generator (see the section Random Number Generator). The encryption algorithm that the user selected is initialized with the temporary keys. The encryption algorithm is then used to encrypt plaintext blocks consisting of zeroes. The encryption algorithm operates in XTS mode (see the section Hidden Volume). The resulting ciphertext blocks are used to fill (overwrite) the free space on the volume. The temporary keys are stored in RAM and are erased after formatting finishes.

Note that this specification applies to volumes created by VeraCrypt 1.0b or later. The format of file-hosted volumes is identical to the format of partition/device-hosted volumes (however, the "volume header", or key data, for a system partition/drive is stored in the last 512 bytes of the first logical drive track). VeraCrypt volumes have no "signature" or ID strings. Until decrypted, they appear to consist solely of random data.

Free space on each VeraCrypt volume is filled with random data when the volume is created.[*] The random data is generated as follows: Right before VeraCrypt volume formatting begins, a temporary encryption key and a temporary secondary key (XTS mode) are generated by the random number generator (see the section *Random Number Generator*). The encryption algorithm that the user selected is initialized with the temporary keys. The encryption algorithm is then used to encrypt plaintext blocks consisting of zeroes. The encryption algorithm operates in XTS mode (see the section *Modes of Operation*). The resulting ciphertext blocks are used to fill (overwrite) the free space on the volume. The temporary keys are stored in RAM and are erased after formatting finishes.

The fields located at byte #0 (salt) and #256 (master keys) contain random values generated by the random number generator (see the section *Random Number Generator*) during the volume creation process. If a VeraCrypt volume hosts a hidden volume (within its free space), the header of the hidden volume is located at byte #65536 of the host volume (the header of the host/outer volume is located at byte #0 of the host volume – see the section *Hidden Volume*). If there is no hidden volume within a VeraCrypt volume, bytes 65536–131071 of the volume (i.e., the area where the header of a hidden volume can reside) contain random data (see above for information on the method used to fill free volume space with random data when the volume is created). The layout of the header of a hidden volume is the same as the one of a standard volume (bytes 0–65535).

The maximum possible VeraCrypt volume size is 2^{63} bytes (8,589,934,592 GB). However, due to security reasons (with respect to the 128-bit block size used by the encryption algorithms), the maximum allowed volume size is 1 PB (1,048,576 GB).

---

* Provided that the options *Quick Format* and *Dynamic* are disabled and provided that the volume does not contain a filesystem that has been encrypted in place (note that VeraCrypt does not allow the user to create a hidden volume within such a volume).

Embedded Backup Headers

Each VeraCrypt volume contains an embedded backup header, located at the end of the volume (see above). The header backup is *not* a copy of the volume header because it is encrypted with a different header key derived using a different salt (see the section *Header Key Derivation, Salt, and Iteration Count*).

When the volume password and/or PIM and/or keyfiles are changed, or when the header is restored from the embedded (or an external) header backup, both the volume header and the backup header (embedded in the volume) are re-encrypted with different header keys (derived using newly generated salts – the salt for the volume header is different from the salt for the backup header). Each salt is generated by the VeraCrypt random number generator (see the section *Random Number Generator*).

For more information about header backups, see the subsection *Tools > Restore Volume Header* in the chapter *Main Program Window*.

Compliance with Standards and Specifications

To our best knowledge, VeraCrypt complies with the following standards, specifications, and recommendations:

- ISO/IEC 10118-3:2004 [21]

- FIPS 197 [3]

- FIPS 198 [22]

- FIPS 180-2 [14]

- FIPS 140-2 (XTS-AES, SHA-256, SHA-512, HMAC) [25]

- NIST SP 800-38E [24]

- PKCS #5 v2.0 [7]

- PKCS #11 v2.20 [23]

The correctness of the implementations of the encryption algorithms can be verified using test vectors (select *Tools > Test Vectors*) or by examining the source code of VeraCrypt.

Source Code

VeraCrypt is open-source and free software. The complete source code of VeraCrypt (written in C, C++, and assembly) is freely available for peer review at:

https://veracrypt.codeplex.com/SourceControl/latest
https://sourceforge.net/p/veracrypt/code/ci/master/tree/
https://github.com/veracrypt/VeraCrypt
https://bitbucket.org/veracrypt/veracrypt/src

The source code of each release can be downloaded from the same location as the release binaries.

Future Development

For the list of features that are planned for a future release, please refer to:
https://veracrypt.codeplex.com/wikipage?title=Future%20Development

Contact

You can contact us by sending a message to veracrypt [at] idrix dot fr, which is associated with VeraCrypt Team PGP key.
You can also use the address veracrypt-contact [at] lists dot sourceforge.net.

To contact IDRIX directly, you can use our contact form.

Legal Information

License

The text of the license under which VeraCrypt is distributed is contained in the file *License.txt* that is included in the VeraCrypt binary and source code distribution packages.

More information on the license can be found at https://veracrypt.codeplex.com/wikipage?title=VeraCrypt%20License

Copyright Information

This software as a whole:
Copyright © 2016 IDRIX. All rights reserved.

Portions of this software:
Copyright © 2013-2016 IDRIX. All rights reserved.
Copyright © 2003-2012 TrueCrypt Developers Association. All rights reserved.
Copyright © 1998-2000 Paul Le Roux. All rights reserved.
Copyright © 1998-2008 Brian Gladman, Worcester, UK. All rights reserved.
Copyright © 1995-2013 Jean-loup Gailly and Mark Adler.
Copyright © 2016 Disk Cryptography Services for EFI (DCS), Alex Kolotnikov
Copyright © 1999-2014 Dieter Baron and Thomas Klausner.
Copyright © 2013, Alexey Degtyarev. All rights reserved.
Copyright © 1999-2013,2014,2015,2016 Jack Lloyd. All rights reserved.

For more information, please see the legal notices attached to parts of the source code.

Trademark Information

Any trademarks mentioned in this document are the sole property of their respective owners.

Version History

1.19-BETA3 (October 8th, 2016)

- All OSs:

  - Fix issues raised by Quarkslab audit:

    - Remove GOST89 encryption algorithm.

    - Make PBKDF2 and HMAC code clearer and easier to analyze.

    - Add test vectors for Kuznyechik.

    - Update documentation to warn about risks of using command line switch "token-pin".

  - Use SSE2 optimized Serpent algorithm implementation from Botan project (2.5 times faster on 64-bit platforms).

- Windows:

  - Fix keyboard issues in EFI Boot Loader.

  - Fix crash on 32-bit machines when creating a volume that uses Streebog as PRF.

  - Fix false positive detection of Evil-Maid attacks in some cases (e.g. hidden OS creation)

  - Fix failure to access EFS data on VeraCrypt volumes under Windows 10.

  - Fix wrong password error in the process of copying hidden OS.

  - Fix issues raised by Quarkslab audit:

    - Fix leak of password length in MBR bootloader inherited from TrueCrypt.

    - EFI bootloader: Fix various leaks and erase keyboard buffer after password is typed.

    - Use libzip library for handling zip Rescue Disk file instead of vulnerable XUnzip library.

  - EFI system encryption: perform shutdown instead of reboot during Pre-Test to detect incompatible motherboards.

- MacOSX:

  - Remove dependency to MacFUSE compatibility layer in OSXFuse.

1.18 (August 17th, 2016)

- Windows:

- Support of EFI system encryption (limitations: no hidden os, no boot custom message)

- Fix TrueCrypt vulnerability that enables detection of presence of hidden volumes (reported by Ivanov Aleksey Mikhailovich, alekc96 [at] mail dot ru)

- Add support for Japanese encryption standard Camellia, including for system encryption.

- Add support for Russian encryption and hash standards Kuznyechik, Magma and Streebog including for EFI system encryption.

- Add benchmarking of hash algorithms and PRF with PIM (including for pre-boot).

- Move build system to Visual C++ 2010 for better stability.

- Fix boot issues on some machines by increasing required memory by 1 KiB

- Workaround for AES-NI support under Hyper-V on Windows Server 2008 R2.

- Enhanced protection against dll hijacking attacks.

- Correctly remove driver file veracrypt.sys during uninstall on Windows 64-bit.

- Implement passing smart card PIN as command line argument (/tokenpin) when explicitly mounting a volume.

- When no drive letter specified, choose A: or B: only when no other free drive letter is available.

- Reduce CPU usage caused by the option to disable use of disconnected network drives.

- Add new volume ID mechanism to be used to identify disks/partitions instead of their device name.

- Add option to avoid PIM prompt in pre-boot authentication by storing PIM value unencrypted in MBR.

- Add option and command line switch to hide waiting dialog when performing operations.

- Add checkbox in "VeraCrypt Format" wizard GUI to skip Rescue Disk verification during system encryption procedure.

- Allow files drag-n-drop when VeraCrypt is running as elevated process.

- Minor GUI and translations fixes.

- Linux:

  - Fix mount issue on Fedora 23.

  - Fix mount failure when compiling source code using gcc 5.x.

- Adhere to XDG Desktop Specification by using XDG_CONFIG_HOME to determine location of configuration files.

- Mac OSX:

  - Solve compatibility issue with newer versions of OSXFuse.

1.17 (February 13th, 2016)

- All OSs:

  - Support UNICODE passwords: all characters are now accepted in passwords (except Windows system encryption)

  - Cut mount/boot time by half thanks to a clever optimization of key derivation (found by Xavier de Carné de Carnavalet)

  - Optimize Whirlpool code by using assembly (25% speed gain compared to previous code).

  - Add support for creating exFAT volumes.

  - Add GUI indicator for the amount of randomness gathered using mouse movement.

  - Include new icons and graphics contributed by Andreas Becker (http://www.andreasbecker.de)

- Windows:

  - Fix dll hijacking issue affecting installer that allows code execution with elevation of privilege (CVE-2016-1281). Reported by Stefan Kanthak (http://home.arcor.de/skanthak/)

  - Sign binaries using both SHA-1 and SHA-256 to follow new Microsoft recommendations.

  - Solve issues under Comodo/Kaspersky when running an application from a VeraCrypt volume (Reported and fixed by Robert Geisler)

  - Bootloader: Protect password/PIM length by filling the fields to maximum length with '*' after ENTER

  - Solve issue with system favorites not being able to be mounted to drive A:

  - Solve lost focus issues for after displaying the waiting dialog

  - Solve rare issue where some partitions where associated with wrong disk the "Select Device" dialog.

  - Implement PIM caching, for both system encryption and normal volumes. Add options to activate it.

- o Don't try mounting using cached passwords if password and/or keyfile are specified in the command line.

- o Internal rewrite to make VeraCrypt native UNICODE application.

- o Workaround to avoid false positive detection by some anti-virus software.

- o Hide disconnected network drives in the list of available drives. Add option to make them available for mounting.

- o Solve issue that caused in some cases configuration and history XML files to be updated even when not needed.

- o Fix leak of path of selected keyfiles in RAM.

- o Fix TB unit can't be deselected in VeraCryptExpander.

- o Add Alt+i keyboard shortcut for "Use PIM" checkbox.

- o Minor GUI and translations fixes.

- Linux/MacOSX:

  - o Fix issue of --stdin option not handling correctly passwords that contain a space character (reported and fixed by Codeplex user horsley1953).

  - o Fix issue creating volumes using command line with a filesystem other than FAT.

  - o Support K/M/G/T suffixes for --size switch to indicate unit to use for size value.

1.16 (October 7th, 2015)

- Windows:

  - o Modify patch for CVE-2015-7358 vulnerability to solve side effects on Windows mount manager while still making it very hard to abuse drive letter handling.

  - o Fix failure to restore volume header from an external file in some configurations.

  - o Add option to disable "Evil Maid" attack detection for those encountering false positive cases (e.g. FLEXnet/Adobe issue).

  - o By default, don't try to mount using empty password when default keyfile configured or keyfile specified in command line. Add option to restore the old behavior.

    - ▪ If mounting using empty password is needed, explicitly specify so in the command line using: /p ""

1.15 (September 26th, 2015)

- Windows:

- Fix two TrueCrypt vulnerabilities reported by James Forshaw (Google Project Zero)

    - CVE-2015-7358 (critical): Local Elevation of Privilege on Windows by abusing drive letter handling.

    - CVE-2015-7359: Local Elevation of Privilege on Windows caused by incorrect Impersonation Token Handling.

- Fix regression in mounting of favorite volumes at user logon.

- Fix display of some Unicode languages (e.g. Chinese) in formatting wizard.

- Set keyboard focus to PIM field when "Use PIM" is checked.

- Allow Application key to open context menu on drive letters list

- Support specifying volumes size in TB in the GUI (command line already supports this)

1.14 (September 16th, 2015)

- All Oss:

    - Mask and unmask PIM value in GUI and bootloader like the password.

- Windows:

    - Solve Rescue Disk damaged error when using cascade ciphers and SHA256 for system encryption.

    - Solve option "Cache password in drive memory" always disabled even if checked in preferences.

    - Solve UI language change not taken into account for new install unless a preference is changed.

    - Implement creating file containers using command line.

    - Driver: disable support of IOCTL_STORAGE_QUERY_PROPERTY by default and add option to enable it.

    - Driver: Support returning StorageDeviceProperty if IOCTL_STORAGE_QUERY_PROPERTY is supported.

    - Support setting volume label in Explorer through mount option or favorite label value.

    - Fix for Hot Keys assignment dialog issue where OEM-233 is always displayed and can't be changed.

- Always copy both 32-bit and 64-bit executable binaries during install and in Traveler Disk Setup.

    - Traveler Disk will again use 32-bit exe by default while also offering 64-bit exe.

    - On Windows 64-bit, 32-bit exe files are now available(e.g. if needed to use 32-bit PKCS#11 dll)

- Include Volume Expander in Traveler Disk Setup.

- Don't offer creating a restore point if it is disabled in Windows.

- Add possibility to verify a Rescue Disk ISO image file.

- Minors fixes in the installer, GUI and driver.

1.13 (August 9th, 2015)

- Windows:

    - Solve TOR crashing when run from a VeraCrypt volume.

1.12 (August 5th, 2015)

- All OSs:

    - Implement "Dynamic Mode" by supporting a Personal Iterations Multiplier (PIM).

- Windows:

    - Detect Boot Loader tampering ("Evil Maid" attacks) for system encryption and propose recovery options.

    - Detect Boot Loader tampering ("Evil Maid" attacks) for system encryption and propose recovery options.

    - Fix buffer overrun issue and other memory related bugs when parsing language XML files.

    - Fix wrongly reported bad sectors by chkdsk caused by a bug in IOCTL_DISK_VERIFY handling.

    - Fix privacy issue caused by configuration and history files being updated whenever VeraCrypt is used (reported by Liran Elharar)

    - Fix system favorites not always mounting after cold start.

    - Solve installer error when updating VeraCrypt on Windows 10.

- o Implement decryption of non-system partition/drive.

- o Include 64-bit exe files in the installer and deploy them on 64-bit machines for better performances.

- o Allow using drive letters A: and B: for mounting volumes

- o Make command line argument parsing more strict and robust (e.g. /lz rejected, must be /l z)

- o Add possibility to show system encryption password in Windows GUI and bootloader

- o Solve "Class Already exists" error that was happening for some users.

- o Solve some menu items and GUI fields not translatable

- o Make volumes correctly report Physical Sector size to Windows.

- o Correctly detect switch user/RDP disconnect operations for autodismount on session locked.

- o Add manual selection of partition when resuming in-place encryption.

- o Add command line option (/cache f) to temporarily cache password during favorites mounting.

- o Add waiting dialog for Auto-Mount Devices operations to avoid freezing GUI.

- o Add extra information to displayed error message in order to help analyze reported issues.

- o Disable menu entry for changing system encryption PRF since it's not yet implemented.

- o Fix failure to change password when UAC required (inherited from TrueCrypt)

- o Minor fixes and changes (see Git history for more details))

- Linux:

- o Solve installer issue under KDE when xterm not available

- o Fix warnings on about/LegalNotice dialogs when wxWidgets linked dynamically (N/A for official binary)

- o Support hash names with '-' in command line (sha-256, sha-512 and ripemd-160)

- o Remove "--current-hash" switch and add "--new-hash" to be more coherent with existing switches.

- o When only keyfile specified in command line, don't try to mount using empty password.

- If mounting using empty password is needed, explicitly specify so using: -p ""

For a list of changes in older versions, see: https://veracrypt.codeplex.com/wikipage?title=Release%20Notes

Acknowledgements

We would like to thank the following people:

The *TrueCrypt Developers* team who have done an amazing job over the course of 10 years. Without their hard work, VeraCrypt would not exist today.

Paul Le Roux for making his E4M source code available. TrueCrypt 1.0 was derived from E4M and some parts of the E4M source code are still incorporated in the latest version of the VeraCrypt source code.

Brian Gladman, who wrote the excellent AES, Twofish, and SHA-512 routines.

Peter Gutmann for his paper on random numbers, and for creating his cryptlib, which was the source of parts of the random number generator source code.

Wei Dai, who wrote the Serpent, RIPEMD-160 and Whirlpool routines.

Tom St Denis, the author of LibTomCrypt which includes compact SHA-256 routines.

Mark Adler and Jean-loup Gailly, who wrote the zlib library.

The designers of the encryption algorithms, hash algorithms, and the mode of operation:
Horst Feistel, Don Coppersmith, Walt Tuchmann, Lars Knudsen, Ross Anderson, Eli Biham, Bruce Schneier, David Wagner, John Kelsey, Niels Ferguson, Doug Whiting, Chris Hall, Joan Daemen, Vincent Rijmen, Carlisle Adams, Stafford Tavares, *Phillip Rogaway, Hans Dobbertin, Antoon Bosselaers*, *Bart Preneel, Paulo S. L. M. Barreto.*

Andreas Becker for designing VeraCrypt logo and icons.

Xavier de Carné de Carnavalet who proposed a speed optimization for PBKDF2 that reduced mount/boot time by half.

kerukuro for cppcrypto library (http://cppcrypto.sourceforge.net/) from which Kuznyechik cipher implementation was taken.

Dieter Baron and Thomas Klausner who wrote the libzip library.

Jack Lloyd who wrote the SIMD optimized Serpent implementation.

All the others who have made this project possible, all who have morally supported us, and all who sent us bug reports or suggestions for improvements.

Thank you very much.

References

[1] U.S. Committee on National Security Systems (CNSS), *National Policy on the Use of the Advanced Encryption Standard (AES) to Protect National Security Systems and National Security Information*, CNSS Policy No. 15, Fact Sheet No. 1, June 2003, available at http://csrc.nist.gov/groups/STM/cmvp/documents/CNSS15FS.pdf.

[2] C. E. Shannon, *Communication Theory of Secrecy Systems*, Bell System Technical Journal, v. 28, n. 4, 1949

[3] NIST, *Advanced Encryption Standard (AES)*, Federal Information Processing Standards Publication 197, November 26, 2001, available at http://csrc.nist.gov/publications/fips/fips197/fips-197.pdf.

[4] J. Nechvatal, E. Barker, L. Bassham, W. Burr, M. Dworkin, J. Foti, E. Roback, NIST, *Report on the Development of the Advanced Encryption Standard (AES)*, October 2, 2000, Journal of Research of the National Institute of Standards and Technology, Vol. 106, No. 3, May-June 2001, available at http://nvl.nist.gov/pub/nistpubs/jres/106/3/j63nec.pdf.

[5] B. Schneier, J. Kelsey, D. Whiting, D. Wagner, C. Hall, N. Ferguson, T. Kohno, M. Stay, *The Twofish Team's Final Comments on AES Selection,* May 15, 2000, available at http://csrc.nist.gov/archive/aes/round2/comments/20000515-bschneier.pdf.

[6] Bruce Schneier, *Beyond Fear: Thinking Sensibly About Security in an Uncertain World*, Springer, 2003

[7] RSA Laboratories, PKCS #5 v2.0: Password-Based Cryptography Standard, *RSA Data Security, Inc. Public-Key Cryptography Standards (PKCS), March 25, 1999, available at http://www.emc.com/emc-plus/rsa-labs/standards-initiatives/pkcs-5-password-based-cryptography-standard.htm.*

[8] H. Krawczyk, M. Bellare, R. Canetti, *HMAC: Keyed-Hashing for Message Authentication*, RFC 2104, February 1997, available at http://www.ietf.org/rfc/rfc2104.txt.

[9] M. Nystrom, RSA Security, *Identifiers and Test Vectors for HMAC-SHA-224, HMAC-SHA-256, HMAC-SHA-384, and HMAC-SHA-512*, RFC 4231, December 2005, available at http://www.ietf.org/rfc/rfc4231.txt.

[10] Peter Gutmann, *Software Generation of Practically Strong Random Numbers*, presented at the 1998 Usenix Security Symposium, available at http://www.cs.auckland.ac.nz/~pgut001/pubs/usenix98.pdf.

[11] Carl Ellison, *Cryptographic Random Numbers*, originally an appendix to the P1363 standard, available at http://world.std.com/~cme/P1363/ranno.html.

[12] P. Rogaway, *Efficient Instantiations of Tweakable Blockciphers and Refinements to Modes OCB and PMAC*, Asiacrypt 2004. LNCS vol. 3329. Springer, 2004. Also available at: http://www.cs.ucdavis.edu/~rogaway/papers/offsets.pdf.

[13] J. Kelsey, *Twofish Technical Report #7: Key Separation in Twofish*, AES Round 2 public comment, April 7, 2000

[14] NIST, *Secure Hash Standard*, FIPS 180-2, August 1, 2002, available at http://csrc.nist.gov/publications/fips/fips180-2/fips180-2.pdf.

[15] U. Maurer, J. Massey, *Cascade Ciphers: The Importance of Being First*, Journal of Cryptology, v. 6, n. 1, 1993

[16] Bruce Schneier, *Applied Cryptography*, Second Edition, John Wiley & Sons, 1996

[17] Peter Gutmann, *Secure Deletion of Data from Magnetic and Solid-State Memory*, first published in the Sixth USENIX Security Symposium Proceedings, San Jose, California, July 22-25, 1996, available at http://www.cs.auckland.ac.nz/~pgut001/pubs/secure_del.html

[18] Serpent home page: http://www.cl.cam.ac.uk/~rja14/serpent.html.

[19] M. E. Smid, *AES Issues*, AES Round 2 Comments, May 22, 2000, available at http://csrc.nist.gov/archive/aes/round2/comments/20000523-msmid-2.pdf.

[20] A. Menezes, P. van Oorschot, S. Vanstone, *Handbook of Applied Cryptography*, CRC Press, October 1996

[21] International Organization for Standardization (ISO), *Information technology – Security techniques – Hash-functions – Part 3: Dedicated hash-functions*, ISO/IEC 10118-3:2004, February 24, 2004

[22] NIST, *The Keyed-Hash Message Authentication Code (HMAC)*, Federal Information Processing Standards Publication 198, March 6, 2002, available at http://csrc.nist.gov/publications/fips/fips198/fips-198a.pdf.

[23] RSA Laboratories, *PKCS #11 v2.20: Cryptographic Token Interface Standard*, RSA Security, Inc. Public-Key Cryptography Standards (PKCS), June 28, 2004, available at http://www.emc.com/emc-plus/rsa-labs/standards-initiatives/pkcs-11-cryptographic-token-interface-standard.htm. PDF available at http://www.cryptsoft.com/pkcs11doc/STANDARD/pkcs-11v2-20.pdf

[24] Morris Dworkin, *Recommendation for Block Cipher Modes of Operation: The XTS-AES Mode for Confidentiality on Storage Devices*, NIST Special Publication 800-3E, January 2010, available at http://csrc.nist.gov/publications/nistpubs/800-38E/nist-sp-800-38E.pdf.

[25] NIST, Approved Security Functions for FIPS PUB 140-2, Security Requirements for Cryptographic Modules, October 8, 2010, available at http://csrc.nist.gov/publications/fips/fips140-2/fips1402annexa.pdf

[25] TC 26, Approved Security Functions for FIPS PUB 140-2, Security Requirements for Cryptographic Modules, October 8, 2010, available at