Eraser Help Index

Advanced Topics

Support

Overview

Eraser is an advanced security tool, which allows you to completely remove sensitive data from your hard disk by overwriting it several times with carefully selected patterns.

You can drag and drop files and folders to the on-demand eraser, use the convenient Explorer shell extension or use the integrated scheduler to program overwriting of unused disk space or, for example, browser cache files to happen regularly, at night, during your lunch break, at weekends or whenever you like.

The patterns used for overwriting are based on Peter Gutmann's paper "Secure Deletion of Data from Magnetic and Solid-State Memory" and they are selected to effectively remove the magnetic remnants from the hard disk making it impossible to recover the data.

Other methods include the one defined in the National Industrial Security Program Operating Manual of the US Department of Defense and overwriting with pseudorandom data.

Why to Use It?

Most people have some data that they would rather not share with others - passwords, personal information, classified documents from work, financial records, self-written poems, the list can be continued forever. Perhaps you have saved some of this information on your computer where it is conveniently at your reach, but when the time comes to remove the data from your hard disk, things get a bit more complicated and maintaining your privacy is not as simple as it may have seemed at first.

Normal file deletion is insecure

Your first thought may be that when you delete a file, the data is gone. Not quite, when you delete a file, the operating system does not really remove the file from the disk; it only removes the reference of the file from the file system table. The file remains on the disk as long as another file is created over it, and even after that, it might be possible to recover data by studying the magnetic fields on the disk platter surface. Before the file is overwritten, anyone can easily retrieve it with a disk maintenance or an undelete utility.

For example, imagine that you have been surfing on the web for a while and afterwards wish to clear any traces revealing what sites you visited. You go to your browser’s preferences and select to clear the cache and the history file, the information is now gone you think to yourself - well think again. The browser cache files can easily be restored with an undelete utility and your privacy is once again compromised.

To be sure that a file is gone, its contents must be properly overwritten before deleting. As simple as it sounds, there are several problems in secure file removal, mostly caused by the construction of a hard disk and the use of data encoding. These problems have been taken into consideration when Eraser was designed and because this intuitive design you can safely and easily erase private data from your disk.

Deleted data can be easily recovered

You have most likely already insecurely deleted countless amount of files from your drive and every now and then applications create (and insecurely delete) temporary files on your drive containing some possibly sensitive data that you would rather not share with other people. This data remains on your drive until it gets overwritten and can be viewed with simple disk utility.

This is where the erasing of unused disk space comes in handy. The erasing of unused disk space means that all space available on your drive will be overwritten so that data previously saved on it cannot be restored. Eraser provides you a convenient way to erase the unused disk space regularly in order to remove the remains of temporary files and other sensitive information you possibly have had on your hard disk.

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System Requirements

This version of Eraser runs on Windows 95, 98, ME, NT 4.0, 2000 and later. If you can run Windows on your computer, your hardware is adequate for running Eraser.

If you are using Windows 95 or NT 4.0 and do not have Internet Explorer 4.01 or later installed, you will need to download an update for the Windows Common Control Library, which is available at Eraser home page.

Installed Components

Eraser consists of the following components.

File	Description
`eraser.exe`	Eraser – the main application
`eraserl.exe`	Eraser Launcher – for using Eraser from the Windows command prompt.
`eraserd.exe`	Eraser for DOS – command line tool.
`verify.exe`	Verify – used for verifying that overwriting works.
`erasext.dll`	Explorer shell extension
`eraser.dll`	Eraser Library – contains all overwriting functionality.
`eraser.cnt`	Help contents
`eraser.hlp`	Help file
`uninstall.dat`	Information used by uninstaller
`stuninstall.exe`	Uninstaller (in C:\Windows\System)

Using Eraser Step-by-Step

This section teaches you how to use Eraser as a part of your everyday work. After you have learned the basics, it is recommend you read the rest of the help file to really understand how things work.

Step 1: Choose User Interface

Soon after starting Eraser you will find out that it is divided into four interfaces available to the user, each having its own special purpose. You should choose which one to use depending on what you want to do.

We will discuss only the three most commonly used interfaces here leaving the usage instructions of the more rarely used fourth user interface for later sections.

So, before actually starting, you must make a fundamental choice of which user interface to use. The three choices are the standard On-Demand eraser, the Scheduler and the Explorer shell extension.

On-Demand

This is a basic user interface for a file erasing program. It is not a separate utility, but the **first part** of the two integrated to the main Eraser application, which you can start, by running `eraser.exe`. After starting the program you may choose which view you want to use from the selection bar on the left side of the main window.

This user interface consists of **a list of data** to erase. In the next step you will find out that there are several ways to enter data to the list including dragging and dropping, and pasting from Explorer.

Scheduler

Scheduler is the second **part of the main application** and looks the same as the On-Demand view. With Scheduler you can program the erasing of various data to happen regularly and automatically whenever you like. Scheduler also has a large list for viewing data and you can start it by running `eraser.exe`. Scheduler lives **on the taskbar** as a tray application and is therefore available to you all the time.

Shell Extension

Unlike the previous two user interfaces, the shell extension uses Windows Explorer as its main window so you can erase files conveniently **within the Explorer**. In the next step you will see that if you can use Windows, you can already use this user interface too. You can also use the Shell Extension with the Eraser Explorer on the main application.

Just for a note, the fourth user interface mentioned earlier is called Eraser Launcher and it allows one to use all Eraser functions with a single command from the command prompt. When you start the Launcher application, `eraserl.exe`, without any command line parameters, you will receive a dialog box giving you a quick usage reference. If you need to use Eraser capabilities from the command prompt, you should read the further sections for instructions on how to use the Launcher.

Step 2: Select Data

In the previous step you chose the user interface, now you will see how to select data that you want to erase.

On-Demand

There are three ways to enter data into the list view of the On-Demand eraser. You can either select files and folders within the Windows (or Eraser) Explorer and **drag and drop** them to the list, **copy them to the clipboard** in the Explorer and then use paste to add them to the list or use **the New Task** command in the File menu. If you choose to use the latter, a window will appear allowing you to select [unused space on] a drive, a folder or a file to be erased. After you have added the data you wish to erase to the list, you are ready to move to the next step.

Scheduler

When using the Scheduler, in addition to selecting the data, you must decide when the data should be erased. You can do all this by selecting **the New Task** item from the File menu. A window with two pages will appear allowing you to you to select [unused space on] a drive, a folder or a file to be erased on the first page and the schedule on the second page. You can choose the data can be erased daily or weekly. After you have added all the data you want to schedule to be erased to the list, you are ready to move to the next step.

Shell Extension

Using the shell extension is as easy as using Explorer. When you open the Explorer, you can select the files or folders (or both at once) to be erased or a drive whose unused space you want to overwrite just like you do when normally deleting the data, but instead of selecting Delete from **the popup menu** that appears when you right click the selection, select “Erase” (or “Erase unused disk space”). If you have selected valid data, a window will appear asking for you confirmation and you are ready to move to the next step. You can also use the Shell Extension from Eraser Explorer.

Step 3: Choose Method

Now that you have selected the user interface and the data, there is one more thing you must consider before actually starting to erase – how to erase.

You can choose from three different built-in methods, these descriptions apply to all user interfaces.

The Default Method – Gutmann

Based on Peter Gutmann's paper "Secure Deletion of Data from Magnetic and Solid-State Memory", this method provides **the best security**. Data will be written 35 times with carefully selected patterns, which makes it unrecoverable. For more thorough description, see the Advanced Topics.

This method is used as the default for overwriting files, but has been proven to be very slow when erasing unused space on a hard disk (could be several gigabytes).

A Faster Method – US DoD 5220-22.M

Two methods based on United States Department of Defense recommendation 5220-22.M from January 1995. The data will be overwritten seven times making this method significantly faster than the default, but also less secure when it comes to hardware recovery. For a more thorough description, see the Advanced Topics.

Pseudorandom Data

All passes will be random data, which is highly incompressible. Therefore, this is the only method that should be used when erasing unused space or data on a compressed drive. The number of passes is user selectable from one to 65535. For a more thorough description, see the Advanced Topics.

Being the fastest method, this one is used as default for erasing unused disk space (one pass).

Based on the descriptions above you can choose the method most suitable for your purposes. If you really do not know what you are doing, **settling for the default** is your best choice. You can change the used method from the Erasing Preferences window, which can be opened differently depending on the user interface. As you may notice, you can use different methods for erasing files and unused disk space. You can also define your own, custom, overwriting methods.

On-Demand and Scheduler

To change the erasing method, open the preferences window by selecting Erasing from the Edit – Preferences submenu.

Shell Extension

To change the erasing methods, open the preferences window by clicking the Options button on the confirmation dialog box.

Notice that you do not need to select the method every time, it is usually enough to set the methods once and change them only in special cases. If you want to learn more about these special cases where only specific method should be used, you should read the instructions further.

Now that you have chosen the methods, you are finally ready to move to the final step and start erasing.

Step 4: Confirm and Erase

Now that you have gone through the previous steps and selected the user interface, the data to erase and the method to use, it is time to start the erasing.

But wait, before starting, Eraser wants your confirmation. **This is your last chance to prevent data from being erased accidentally**. Make sure you have selected only data that you really wish to erase; after Eraser has finished there is no way to recover what you erased. Now that you are standing on your toes, lets continue.

On-Demand

To start erasing data, select the items you wish to erase from the list and select “Run” from the Process menu. After answering “Yes” when you are asked for a confirmation, a progress window will appear showing you what is happening and how much time will it take. After the operation is finished, a window will appear telling you if the erasing was successful, giving you also some vital statistics.

Scheduler

Unlike the other two user interfaces, **Scheduler will *not* ask for your confirmation before erasing**, so be careful. When the scheduled time comes, Scheduler will start erasing. Multiple tasks can be processed at a time, but unless you have a fast SCSI drive, you may want to schedule tasks so that only one is running at a time (or use the “Queue Overlapping Tasks” option available on the General Preferences window) to prevent the disk activity from slowing down the system too much. Scheduler will not inform you about the success after erasing, but you can set it to log possible errors to be viewed later. You can also view statistics for a task by opening the task property window.

If your computer is not on, or you have set the Scheduler to disabled state, when the time comes to run a task, Scheduler will happily skip the run and try again next time.

Shell Extension

After your confirmation, the shell extension will start erasing and shows you a progress window similar to the one in On-Demand eraser during the process. However, there is a check box on the bottom of the progress window, which allows you to choose whether you wish to view the Erasing Report after erasing, or not. Shell extension will remember this setting the next time you use it. The setting can also be altered from the General Preferences window of the main Eraser application.

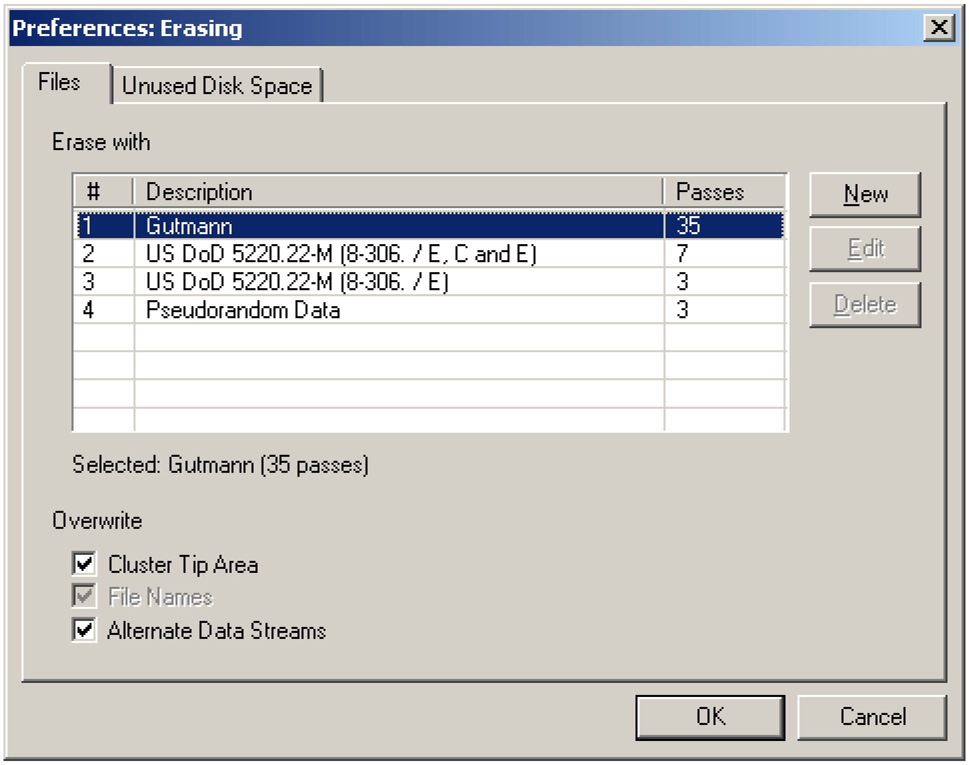
Now that you have erased some data and have gotten hooked on it (?), you may want to learn how to use Eraser more efficiently. You can find lots of information, little helpful details and even answers for the most frequently asked questions by reading the rest of this help file.

Configuration: Erasing

You can change the used erasing methods from the Erasing Preferences window. You can access this window through all user interfaces and the defined settings are common for all applications using the Eraser library.

The preferences dialog box is divided into **two pages** allowing you to use separate settings for erasing files and folders, and unused disk space.

On the first page you may choose one of the three built-in overwriting methods or one of your own, custom methods, to be used when overwriting files and folders. The default is to use the 35-pass Gutmann method.



Erase with

#	Description	Passes
1	Gutmann	35
2	US DoD 5220.22-M (8-306. / E, C and E)	7
3	US DoD 5220.22-M (8-306. / E)	3
4	Pseudorandom Data	3

Selected: Gutmann (35 passes)

Overwrite

☑ Cluster Tip Area
☑ File Names
☑ Alternate Data Streams

The first two built-in methods have a fixed amount of overwriting passes, but if you choose to overwrite only with pseudorandom data, you may set the number of passes, 65535 being the maximum, by pushing the **“Edit”** button. The number of passes for the pseudorandom data method can be set separately for both erasing files and unused disk space.

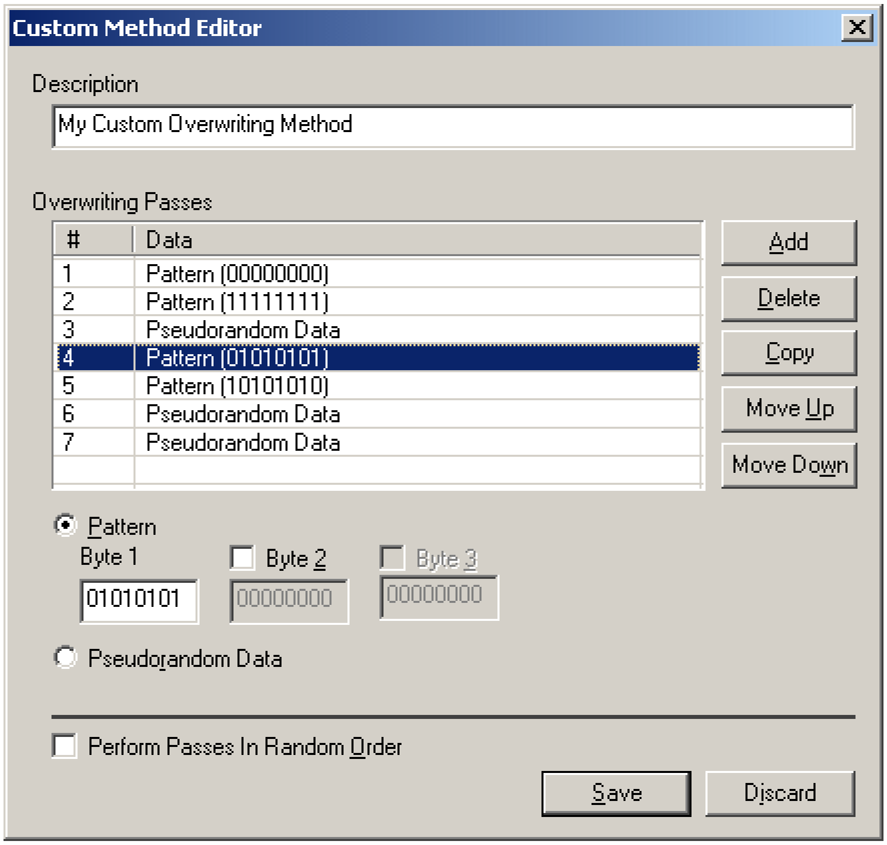
If you want to create a new custom overwriting method, press the **“New”** button. You can edit the properties of the new method using the Custom Method Editor window – you can open this window later by pressing the **“Edit”** button. To delete a custom method from the list, press **“Delete”**.

On the bottom of the window you can choose which parts of files will be overwritten in addition to the actual content. By default, all options are enabled.

If you select **“Cluster Tip Area”**, the unused space at the end of the last cluster allocated for the file will be erased.

If you select **“File Names”**, the name of the file will be overwritten. This option cannot be deselected on Windows NT/2000 where file names will be overwriting always when erasing files.

If you select **"Alternate Data Streams"**, Eraser will also find and overwrite possible unnamed data streams associated with the file. This option is available only on Windows NT/2000, alternate data streams are supported only on NTFS file system.



Description
My Custom Overwriting Method

Overwriting Passes

#	Data
1	Pattern (00000000)
2	Pattern (11111111)
3	Pseudorandom Data
4	Pattern (01010101)
5	Pattern (10101010)
6	Pseudorandom Data
7	Pseudorandom Data

● Pattern
Byte 1: 01010101
□ Byte 2: 00000000
□ Byte 3: 00000000

○ Pseudorandom Data

□ Perform Passes In Random Order

Write a short description of your method to the **"Description"** field. This text will be displayed on the method list.

To add new overwriting pass to the list, press **"Add"**. To remove the selected pass, press **"Delete"**. To create a duplicate of the selected pass, press **"Copy"**. You can move the selected pass up and down the list using the **"Move up"** and **"Move down"** buttons.

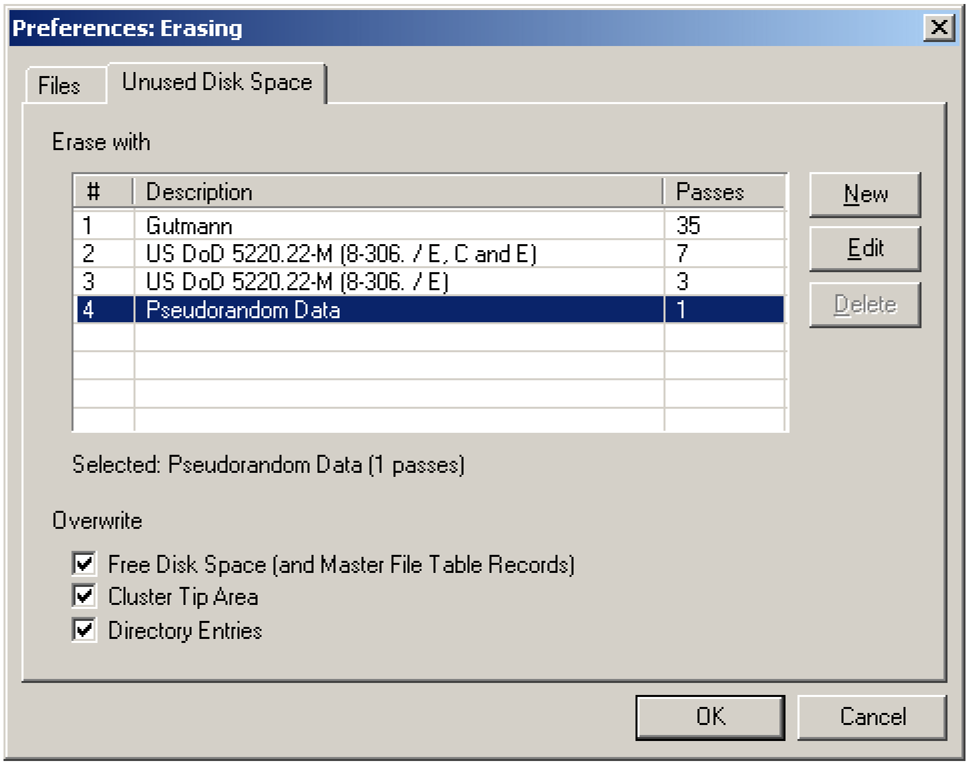
An overwriting pass contains maximum of three adjacent bytes (enter binary representation to the byte fields), or pseudorandom data. As you edit the pass data, the list constantly updates showing you the pattern that will be written to the disk.

If you select **"Perform passes in random order"**, Eraser will shuffle the passes using cryptographically strong random numbers before overwriting – otherwise the passes are written in the order they appear on the list.

To save the method, press **"Save"**. To discard the changes you made, press **"Discard"**. Please notice that the changes you made will be final only after you dismiss the preferences window by pressing **"OK"**. Pressing **"Cancel"** will not save the changes.

The custom method now appears on both pages of the preferences window – it can be used for overwriting files and unused disk space.

On the second page you may set the preferences for overwriting unused disk space. The default setting is to use one pass of pseudorandom data for overwriting, which was chosen speed in mind. You should increase the number of passes or choose another method if you need better security.



Erase with

#	Description	Passes
1	Gutmann	35
2	US DoD 5220.22-M (8-306. / E, C and E)	7
3	US DoD 5220.22-M (8-306. / E)	3
4	Pseudorandom Data	1

Selected: Pseudorandom Data (1 passes)

Overwrite

☑ Free Disk Space (and Master File Table Records)
☑ Cluster Tip Area
☑ Directory Entries

Detailed descriptions of the overwriting methods and the reason why one should include the cluster tip area when erasing unused disk space can be found from the Advanced Topics. You may want to learn more about the available methods before using a setting other than the default.

On the bottom of the window you can choose which parts of the unused disk space will be overwritten. By default, all options are enabled.

If you select **"Free Disk Space"**, all available, or free, disk space will be overwritten. On Windows NT and 2000, the unused space on the Master File Table records will be cleared as well.

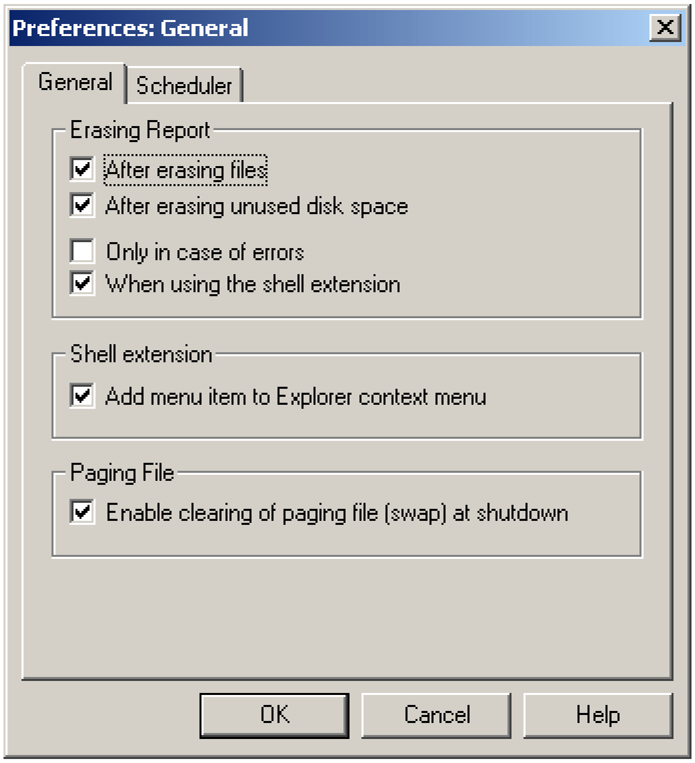
If you select **"Cluster Tip Area"**, the cluster tips of each file on the drive will be erased. You should not use this option for drives compressed with external software – cluster tip area of compressed NTFS drives can be erased.

If you select **"Directory Entries"**, names of all previously deleted files will be cleared from the file system table.

Configuration: General

You may change the settings of the main Eraser application using the General Preferences window. You can access this window only from the main application.

As the Erasing Preferences window, this dialog box is also divided into **two pages** of which the first is for more general settings and the second is reserved solely for Scheduler preferences.



Erasing Report

☑ After erasing files

☑ After erasing unused disk space

☐ Only in case of errors

☑ When using the shell extension

Shell extension

☑ Add menu item to Explorer context menu

Paging File

☑ Enable clearing of paging file (swap) at shutdown

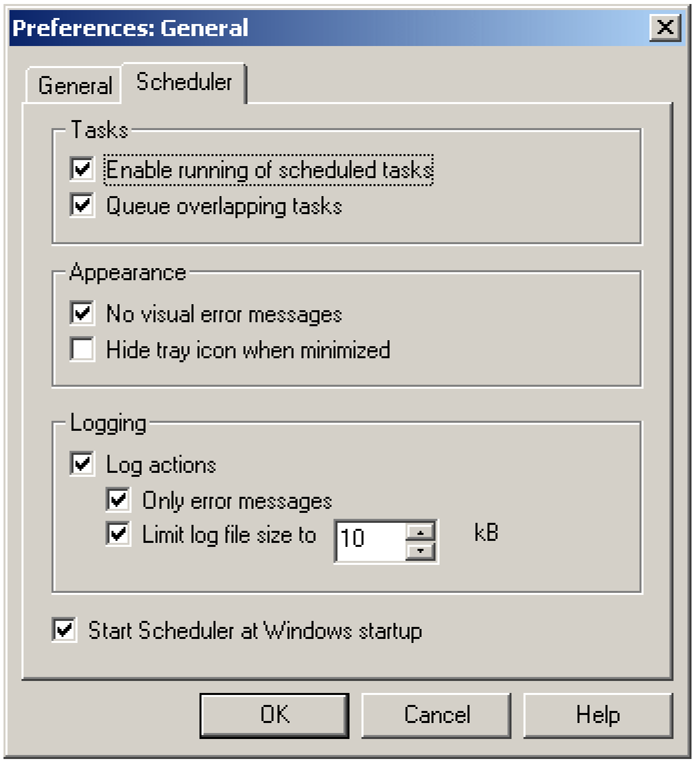
You can select whether you want Eraser to display the erasing report **after erasing files (and folders)** or **erasing unused disk space** on a drive, or both. If you deselect both of these options, the Erasing Report will not be shown. If you want the Erasing Report to be shown only if errors have occurred (or the operation was terminated by the user), select the corresponding option. You can also disable the Erasing Report for the shell extension by deselecting **"Erasing Report ... When Using the Shell Extension"**.

If you have entered both files (and folders) and unused space on one or more drives to the On-Demand list, the results shown in the Erasing Report are the combination of the selected items. For example, if you have only files on the list and have **Erasing Report ... After Erasing Unused Disk Space"** selected, you will get no Erasing Report window after the operation.

Eraser Launcher ignores the Erasing Report settings – it will show the results only if you specify the **"-results"** command line parameter.

If you are using Windows NT and 2000, you can **enable the clearing of the paging (swap) file** at shutdown (this change does not take effect until you restart the computer and requires Administrator privileges to set). This is a Windows NT security feature and the overwriting is performed by the operating system, not by Eraser. Clearing the paging file means that after closing all applications and after writing unused data to the disk, Windows overwrites all available space on the paging file with zeros. Since the overwriting is done at shutdown, all possible sensitive data should be overwritten and the small number of areas that are still inaccessible at the moment are used only by the operating system. This option is not available when running on Windows 95, 98 or ME and is disabled if the user does not Administrator privileges on the system.

On the second page you may set the preferences for the Scheduler user interface. These settings apply only for the Scheduler.



Tasks

☑ Enable running of scheduled tasks

☑ Queue overlapping tasks

Appearance

☑ No visual error messages

□ Hide tray icon when minimized

Logging

☑ Log actions

☑ Only error messages

☑ Limit log file size to 10 kB

☑ Start Scheduler at Windows startup

You can set the Scheduler (and therefore, the whole main application) to start automatically as a taskbar tray application every time you start Windows by selecting the **“Start Scheduler at Windows startup”** option. If you do not want to add another icon to your taskbar tray, select **“No taskbar tray icon”** option. If you would still like to move Eraser to the background by minimizing the window, select **“Hide main window on minimize”**. To restore the hidden instance of the application, start another copy of the program and the background process will take over.

Scheduler also includes an option to **log the occurred events** into a file. This is useful for studying the success of operations afterwards. You can also set Scheduler to log only error messages and limit the size of the log file if you wish.

Scheduler can run multiple tasks at a time – you can start several tasks and they will all be processed simultaneously. However, processing multiple tasks requires lots of system resources and the excessive disk activity can slow down the system considerable amount. If you select **“Queue Overlapping Tasks”** option, Scheduler will not run multiple tasks, but will instead queue new tasks to be processed one at a time after the process currently being run has finished. When this option is selected and a task is being processed, the **“Run”** menu command will add the selected task to the queue and **“Stop”** will remove a task from the queue.

All **visual error messages** (dialog boxes) shown during the Scheduler operation will be dismissed in 15 seconds if no user intervention occurs, so you can safely leave the visual error messages enabled even when Scheduler is running for long times without supervision. However, the option to disable visual errors can be useful if you are an administrator of one or more computers with multiple users and do not want to confuse other users with possible error messages that may show up unexpectedly.

User Interfaces

The main design principle used in Eraser is modularity. When an application is divided into components that contain common code used by several other components, it results in smaller code requiring less space on your drive and less resources from your computer.

The current version of Eraser is implemented as four separate components, three of which contain the total amount of four user interfaces and one, the Eraser library, contains all the overwriting functionality and other code common to the user interfaces.

Each included user interface offers a different way of using the overwriting capabilities of the Eraser library and each one has distinctive features that make it the choice for the job it was designed to do.

On-Demand and Scheduler

The main application, `eraser.exe`, contains two user interfaces, the On-Demand eraser and the Scheduler. The integration of these two previously separate programs not only saves you time when you only have to learn one program, but it also allows the user interfaces to benefit greatly from each other.

The Scheduler is the choice of user interface when you need to schedule erasing of data to happen regularly. It could be used for clearing the web browser cache or history files, the remains of temporary files by overwriting unused disk space on a drive or anything you like and whenever you like.

The On-Demand eraser replaces the clumsy and extremely simple utility that once came with Eraser 2.1. The integration with Scheduler in the main application makes it available to you at all times. Since the Scheduler lives as a taskbar tray application most of the time and usually is set to run at Windows startup, you can also access the On-Demand eraser by double-clicking the tray icon.

The On-Demand eraser is designed to serve you as the main user interface which you can use in your everyday work to destroy sensitive documents and to act like a standard wipe utility like you may have ran across sometimes. You can easily copy data from the Windows Explorer and paste it into the On-Demand view, or drag and drop files and folders into the list.

The main application also contains the Eraser Explorer that is not really an user interface for the erasing library, but instead provides a convenient way to erase data using the Shell Extension or drag items to the On-Demand eraser without opening the Windows Explorer.

Shell Extension

As the name says, the Shell Extension is a convenient extension to the Windows shell, the Explorer. You can use it while browsing through your drive without needing to start a separate application or having to enter data into one, it is enough to just select the data on the Explorer and choose “Erase” from the pop-up menu. Because it is always simply at reach and is easy to use, the Shell Extension may just become your choice for everyday file erasing. Obeying the modular design principle, the Shell Extension code is in a separate component, `erasext.dll`.

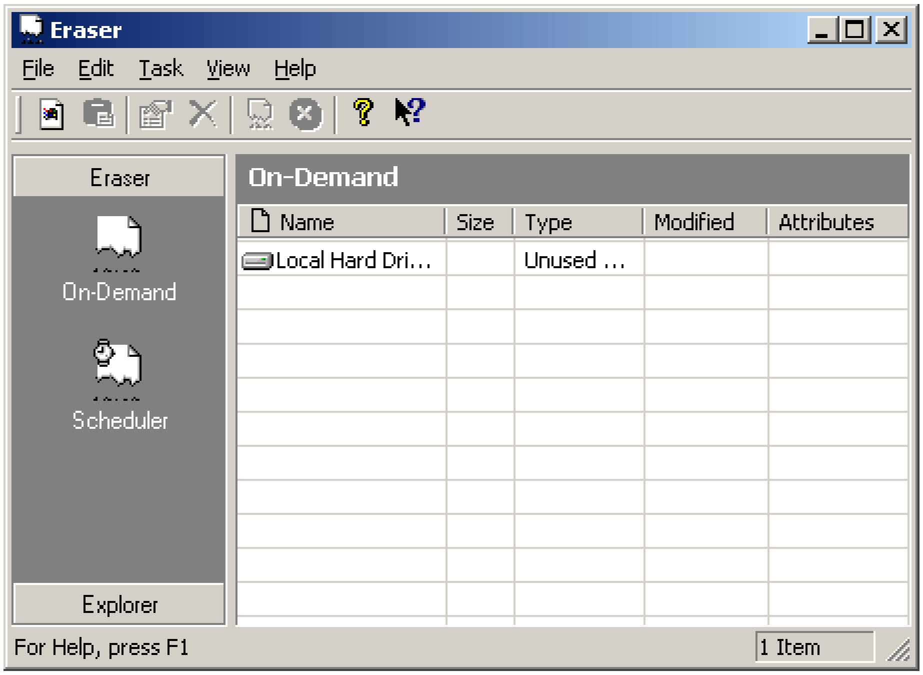
Launcher

If you would rather prefer using Eraser from the command line, or would like to erase some data from within a batch file, the Eraser Launcher is your choice. Allowing you to control the full power of Eraser with just a single command makes the Launcher not only the most simple, but also the most dangerous user interface that must be used with extra caution. Launcher also takes care of erasing data on Windows Recycle Bin.

The following pages in this section will give you detailed instructions on how to use these four user interfaces included in three separate components in the most efficient way.

Eraser: Basics

The main application consists of two user interfaces, the On-Demand eraser and the Scheduler. On the left side of the main window you can find a bar from which you may select which user interface is to be shown. In addition to the user interfaces, the main application also includes the Eraser Explorer that can be opened by clicking the “Explorer” text on the folder bar.



Name	Size	Type	Modified	Attributes
Local Hard Dri...		Unused ...		

For Help, press F1

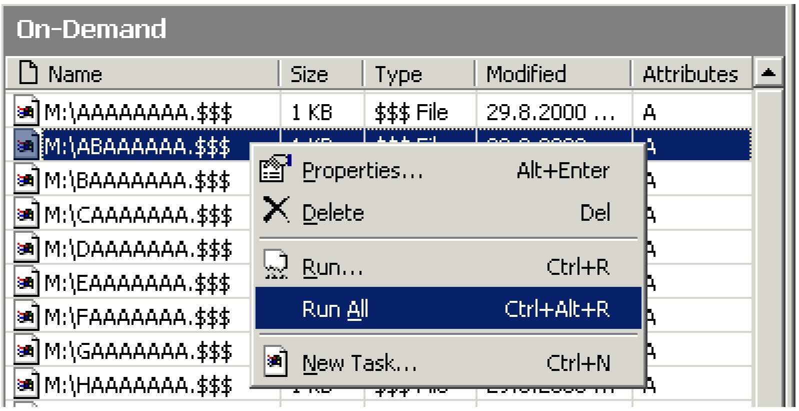
Notice that even when you have the On-Demand view active, the Scheduler still runs on the background and performs the scheduled tasks normally. You can set the initial view which is shown when starting the application from the General Preferences window.

In addition to the Eraser bar, the main window provides two other ways for you to control the program execution, the main menu and the toolbar.

You can find a detailed description of the menu items from the Menu Reference subsection or by using the context-sensitive help system to view help for the selected user interface component. The status bar on the bottom of the main window shows you a brief description of the menu item as you browse through them.

On-Demand: Basics

The On-Demand window consists of a list of data, which is to be erased. In the next section you will learn how to add data to the list.



On-Demand

Name	Size	Type	Modified	Attributes
M:\AAAAAAAA.$$$	1 KB	$$$ File	29.8.2000 ...	A
M:\ABAAAAAA.$$$				A
M:\BAAAAAAA.$$$				A
M:\CAAAAAAA.$$$				A
M:\DAAAAAAA.$$$				A
M:\EAAAAAAA.$$$				A
M:\FAAAAAAA.$$$				A
M:\GAAAAAAA.$$$				A
M:\HAAAAAAA.$$$				A

The list has **five columns** showing you the name, size, type, the last modified date and the attributes associated with the data on a row.

The **name** column shows you the name and full path of a file or folder to erase or the name and letter of the drive whose unused space is to be erased.

The **size** column shows you the size of a file or if the data is a drive, the amount of free disk space. If a file is compressed, the compressed size (the actual space required on the disk) is shown.

The **type** column shows the name of the type associated with a file extension, or the type of data to be erased.

The **last modified date** column shows you when the selected file or folder has been last edited.

The **attributes** column shows the attribute flags associated with a file or a folder. The following letters are used to mark different flags set for the item:
R (read-only), H (hidden), S (system), A (archive), C (compressed), E (encrypted), T (temporary)

The compressed and encrypted flags are set only if the file or the folder is compressed or encrypted in the file system level. This of course requires a file system that supports these functions. If the data is a drive or the file or the folder has the normal attributes flag set, no letters will be shown.

You can refresh the list contents by selecting the Refresh command from the Edit menu or by pressing F5.

The pop-up menu shown above can be opened by right-clicking (or clicking with the secondary mouse button) the list. It contains some of the most used commands that are briefly discussed below.

The **Properties** menu item (keyboard shortcut Alt+Enter) opens the task property window allowing you to edit the selected task.

The **Delete** menu item (keyboard shortcut Del) removes the selected task from the list.

The **Run** menu item (keyboard shortcut Ctrl+R) starts erasing tasks you have selected on the list after your confirmation.

The **Run All** menu item (keyboard shortcut Ctrl+Alt+R) starts erasing all tasks on the list after your confirmation.

The **New Task** menu item (keyboard shortcut Ctrl+N) opens the task property window allowing you to enter a new task to the list.

You can get a detailed description of the menu items on the Menu Reference section or by using the context-sensitive help; click the help button on the toolbar and select the menu item whose help section you wish to open.

On-Demand: Entering Data

There are three ways to enter data to the On-Demand list; drag and drop, pasting from the Explorer and the New Task command.

Drag and drop

Select the files and folders you wish to add to the list on the Windows Explorer, press the left mouse button over the selection and keep it down while dragging the files over the list. When releasing the mouse button, dragged data will be added to the list. You cannot add drives to the list using drag and drop.

You can also use the Eraser Explorer to drag and drop items to the On-Demand eraser window without needing to open the Windows Explorer.

Pasting from the Explorer

Select the files and folders just like when using drag and drop, but instead of using the mouse, press Ctrl+C to copy the filenames to the clipboard. To add the files to the list, select Paste from the Eraser menu or press Ctrl+V. You cannot copy and paste drives to the list.

New Task command

Select the New Task command from the File menu or press Ctrl+N to open the task properties window. After selecting the data to be erased, click OK to save the task.

To keep the data on the On-Demand list even after erasing, select “Keep Task on List” option on the task properties window.

On-Demand: Erasing

After you have entered the data to be erased to the list using methods described in the previous section, select the items you wish to erase and start the erasing with the Run command. Eraser will ask for your confirmation before starting the procedure.

- After your confirmation, a progress window will be shown during erasing. After the operation is completed, you will receive a summary of results in the Erasing Report window.

On-Demand: Step-by-Step

These three simple steps will give you a quick start into using the On-Demand eraser.

Step 1: Entering Data

Select the New Task command from the File menu. From the appearing task properties window select the data to be erased. Keep adding files, folders or drives until the list contains all data you want to erase.

Step 2: Confirm and Erase

After selecting the items on the list that you wish to erase, select Run from the Process menu, Eraser will ask for your confirmation. This is your last chance to prevent data from being accidentally erased, so make sure you have selected only the items you really want to destroy.

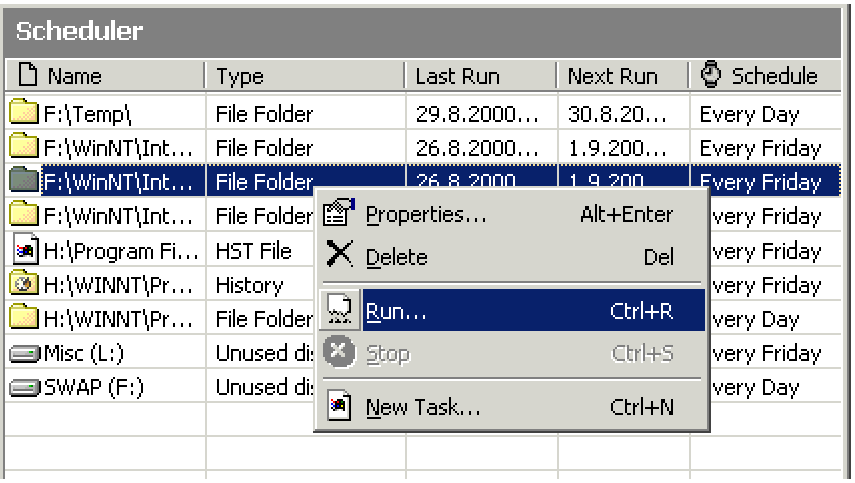
After you have given your approval for erasing, you will be shown a progress window during the operation. You can stop erasing any time by pressing the Stop button on the bottom of the dialog box.

Step 3: Results

When done erasing, a summary of results will be shown in the Erasing Report window.

Scheduler: Basics

The Scheduler window consists of a list very similar to the one in On-Demand view containing the scheduled tasks. In the next section you will learn how to schedule tasks and add them to the list.



Name	Type	Last Run	Next Run	Schedule
F:\Temp\	File Folder	29.8.2000...	30.8.20...	Every Day
F:\WinNT\Int...	File Folder	26.8.2000...	1.9.200...	Every Friday
F:\WinNT\Int...	File Folder	26.8.2000	1.9.200	Every Friday
F:\WinNT\Int...	File Folder			very Friday
H:\Program Fi...	HST File			very Friday
H:\WINNT\Pr...	History			very Friday
H:\WINNT\Pr...	File Folder			very Day
Misc (L:)	Unused di:			very Friday
SWAP (F:)	Unused di:			very Day

The list has **five columns** showing you the name, type, last run time, next run time and schedule associated with the data on a row.

The **name** column shows you the name and full path of a file or folder scheduled to be erased or the letter of the drive whose unused disk space is to be erased.

The **type** column shows the name of the type associated with a file extension, or the type of data to be erased.

The **last run** column shows you the time when the task was last completed.

The **next run** column shows you when the task is scheduled to run next.

The **schedule** column shows you whether the task is scheduled to be run daily or weekly (and what day of the week).

You can refresh the list contents by selecting the Refresh command from the Edit menu or by pressing F5.

The pop-up menu shown above can be opened by right-clicking (or clicking with the secondary mouse button) the list. It contains some of the most used commands that are briefly discussed below.

The **Properties** menu item (keyboard shortcut Alt+Enter) opens the task property window allowing you to edit the selected task.

The **Delete** menu item (keyboard shortcut Del) removes the selected task from the list.

The **Run** menu item (keyboard shortcut Ctrl+R) starts processing the selected task (without confirmation).

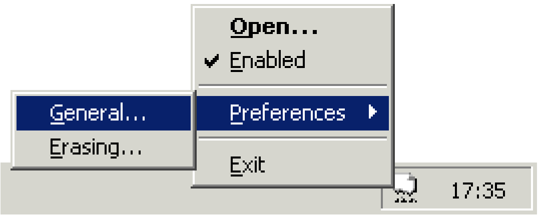
The **Run All** menu item (keyboard shortcut Ctrl+Alt+R) starts processing all items on the list. This is again done without asking for your confirmation; **use this action with caution!**

The **Stop** menu item (keyboard shortcut Ctrl+S) stops processing the selected task or if the task is queued, removes it from the queue.

The **New Task** menu item (keyboard shortcut Ctrl+N) opens the task property window allowing you to enter a new task to the list.

You can get a detailed description of the menu items on the Menu Reference section or by using the context-sensitive help; click the help button on the toolbar and select the menu item whose help section you wish to open.

From the Scheduler page of the General Preferences window you can change several settings for the Scheduler. As default the Scheduler is set to run at Windows startup and the next time you start Windows, you will indeed notice a new **icon on the taskbar tray area**.



You can open the main window by double-clicking the icon or open a pop-up menu by right clicking it.

The menu contains items allowing you to open the main window, change the Scheduler state, edit preferences and quit the application.

If you deselect the “Enabled” option on the tray menu, it will set the Scheduler to a disabled state meaning that it ignores all scheduled tasks until you enable it again. This is useful if you are working on something and do not want erasing to slow down the system during that time.

The tray icon will change to signal when the Scheduler is disabled and also when it is running one or more tasks. The icon tool tip will tell you when the next task is scheduled to run.

Scheduler: Entering Data

You can use the New Task command (Ctrl+N) from the File menu to add new scheduled tasks to the list. On the first page of the appearing task properties window you can set the data and on the second page, the schedule.

Notice that once a task is scheduled, the Scheduler will not require confirmation before running. So use caution when scheduling data to be erased.

You can edit the properties of an existing task by using the Properties command (Alt+Enter). The same task properties window used for creating a task will be shown allowing you to change all task properties.

You can also edit the list when the Scheduler is processing some of the tasks. If you edit properties for a task that is running, it must be stopped in order to save the changes. You can also delete a running task and it will be terminated normally.

Scheduler: Running Tasks

The Scheduler will automatically run scheduled tasks at the time shown by the next run column – without your confirmation. However, if you do not want to wait for a task to be processed, you can start it any time using the Run command (Ctrl+R) from the Process menu.

You can stop a running task, scheduled or not any time by selecting it from the list and using the Stop command (Ctrl+S) from the Process menu.

Even though the Scheduler can run multiple tasks at the same time, unless you have a fast SCSI hard disk, you may want to schedule tasks to be run one at the time to make sure excessive disk usage does not slow down your computer too much. Or you can set the “Queue Overlapping Tasks” option from the General Preferences window to set scheduled tasks to be run one at the time.

Scheduler: Viewing Results

The Scheduler does not show a summary of results in a window after operation like the other user interfaces, but it has other powerful features that allow you to monitor the success of the operations.

Logging

On the second page of the General Preferences window you can set the Scheduler to log actions into a file called `schedlog.txt`, which will be located on the same directory as the executable. You can also choose to log only errors and limit the size of the log file.

You can use the log file to determine whether the scheduled tasks have been processed successfully and what errors may have occurred. A log file could look like this:

```
11:43:11: Scheduler starting.
20:33:39: Running assignment (H:\WINNT\Profiles\Administrator\Recent\).
20:33:58: Assignment finished (H:\WINNT\Profiles\Administrator\Recent\).
5.5.1999 2:00:00: Running assignment (F:\Temp\).
5.5.1999 2:00:06: Assignment finished (F:\Temp\).
5.5.1999 2:30:00: Running assignment (F:\).
5.5.1999 2:32:56: Possible operation failure running assignment (F:\).
5.5.1999 2:32:56: Failed to wipe unused space on F:\Explorer\Content.IE5\index.dat.
5.5.1999 2:32:56: Failed to wipe unused space on F:\pagefile.sys.
5.5.1999 3:00:00: Running assignment (H:\Temp\).
5.5.1999 3:00:37: Assignment finished (H:\Temp\).
5.5.1999 3:15:00: Running assignment (H:\WINNT\Profiles\Administrator\Recent\).
5.5.1999 3:15:14: Assignment finished (H:\WINNT\Profiles\Administrator\Recent\).
5.5.1999 16:23:12: Scheduler quitting.
```

If you set the Scheduler to log only error messages, only the lines marked with red would have been logged. You can open the log file with an associated viewer using the View Log command on the File menu.

Statistics

The third page of the task properties window shows you various statistical figures for the selected task. The statistics will be reset every time you change the data for the task.

Scheduler: Step-by-Step

These three simple steps will give you a quick start into using the Scheduler.

Step 1: Entering Data

Select the New Task command from the File menu. From the appearing task properties window select the data to be erased and from the next page when it should be erased.

Step 2: Running Task

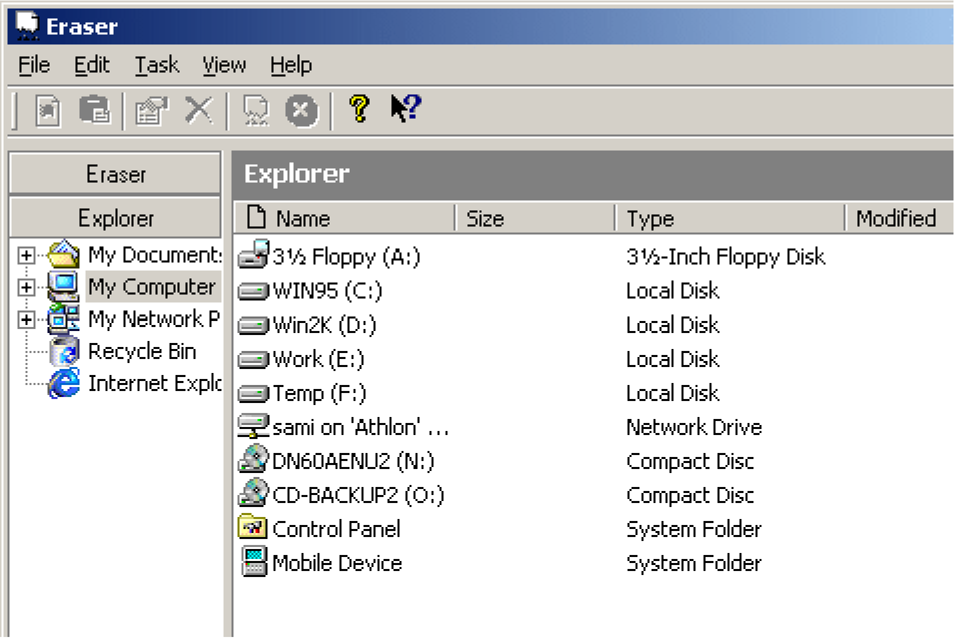
After saving the scheduled task, it will be run automatically without your confirmation. If you do not want to wait for a task to be processed, you can run the selected task any time using the Run command. You can stop a running task, scheduled or not using the Stop command.

Step 3: Viewing Results

After the operation you can view statistics on the third page of the task property window and if you have enabled logging, see possible errors using the View Log command.

Explorer: Basics

In addition to the two user interfaces for the Eraser library introduced before, the main application also provides you a convenient way to use Windows Explorer capabilities within Eraser.

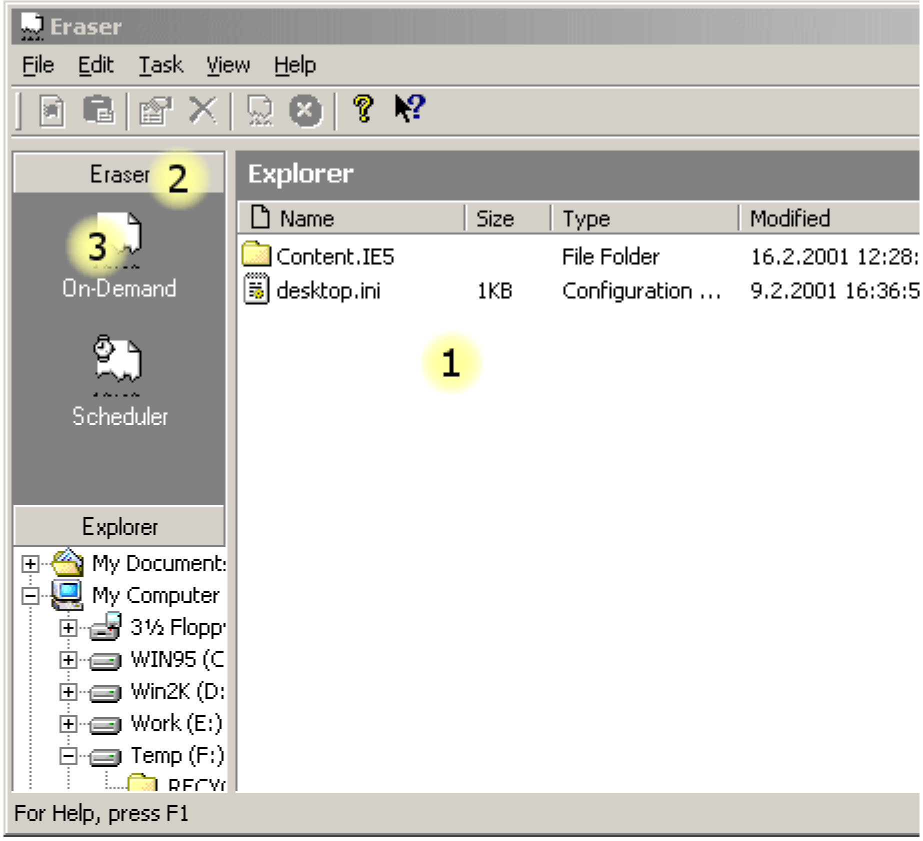


Name	Size	Type	Modified
3½ Floppy (A:)		3½-Inch Floppy Disk	
WIN95 (C:)		Local Disk	
Win2K (D:)		Local Disk	
Work (E:)		Local Disk	
Temp (F:)		Local Disk	
sami on 'Athlon' ...		Network Drive	
DN60AENU2 (N:)		Compact Disc	
CD-BACKUP2 (O:)		Compact Disc	
Control Panel		System Folder	
Mobile Device		System Folder	

The Eraser Explorer allows you to browse through your computer, drag and drop files to the On-Demand eraser and even use the Shell Extension to erase data. Please notice that items in the Task menu are not available when using Eraser Explorer.

Explorer: Drag and Drop

Follow these three steps to easily drag and drop files and folders from Eraser Explorer to the On-Demand eraser.



Name	Size	Type	Modified
Content.IE5		File Folder	16.2.2001 12:28:
desktop.ini	1KB	Configuration ...	9.2.2001 16:36:5

1 Select the files on the Explorer view (right pane) and press down the default (usually left) mouse button.

2 While keeping the mouse button down move (drag) the pointer over the “Eraser” text on the folder bar. Hold the mouse over the folder for a while until it opens.

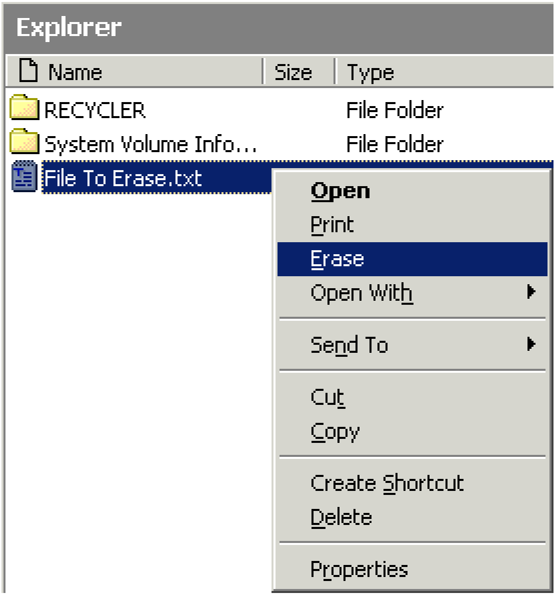
3 If you did not have the On-Demand view open the last time you used the Eraser user interfaces, after opening the Eraser folder (on the bar), move the pointer over the On-Demand icon to open it. When the On-Demand view is visible, move the pointer over it (right pane) and release the mouse button (drop).

You can drag folders from the right pane of the Eraser Explorer the same way described above. Please notice that if you drag a drive from the right pane to the On-Demand view, it will be treated as a folder meaning that all data on the drive will be erased if you continue to process the list.

You cannot drag and drop data to the Scheduler view – to enter scheduled tasks, use the “New Task” menu option.

Explorer: Shell Extension

In addition to erasing data with the On-Demand eraser, the Eraser Explorer also allows you to use the Shell Extension to erase data just as if you were using the Windows Explorer.



Name	Size	Type
RECYCLER		File Folder
System Volume Info...		File Folder
File To Erase.txt		

For more information on how to use the Shell Extension, see the following chapters.

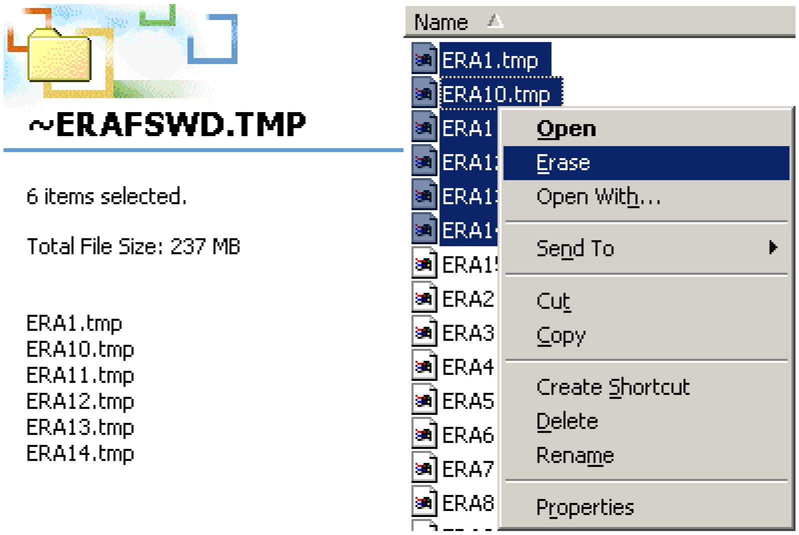
Shell Extension: Basics

The Shell Extension allows you to erase data directly from the Windows Explorer without starting extra applications or having to specify the data any other way than normally selecting it on the Explorer window.

You can also use the Shell Extension with the Eraser Explorer on the main application in a similar way, but without needing to start the Windows Explorer.

Shell Extension: Entering Data

After selecting the data on the Explorer window, you can erase it by selecting the proper option from the pop-up menu.



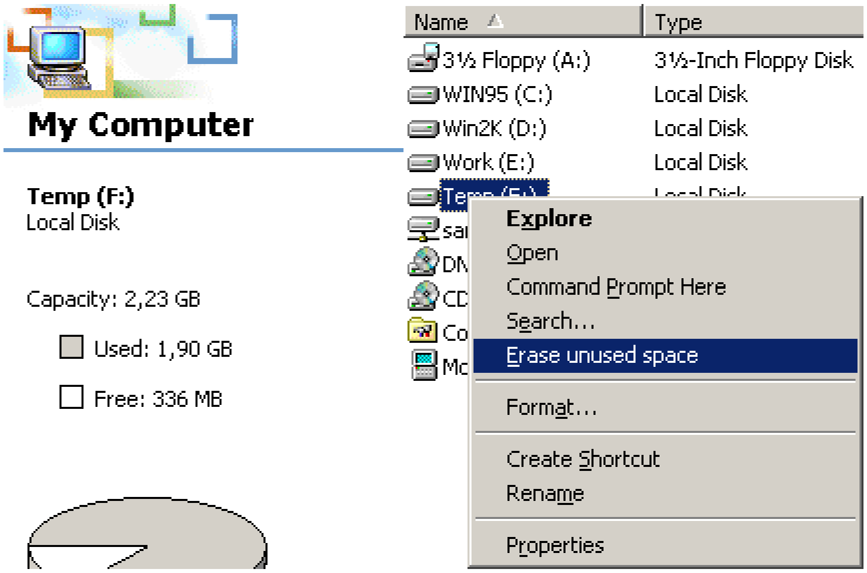
~ERAFSWD.TMP

6 items selected.

Total File Size: 237 MB

ERA1.tmp
ERA10.tmp
ERA11.tmp
ERA12.tmp
ERA13.tmp
ERA14.tmp

To erase files or folders, select them on the Explorer, right-click on the selection and choose “Erase” from the pop-up menu.



My Computer

Temp (F:)
Local Disk

Capacity: 2,23 GB

Used: 1,90 GB

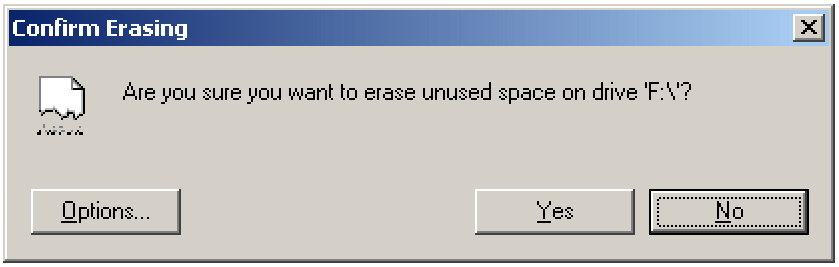
Free: 336 MB

Name	Type
3½ Floppy (A:)	3½-Inch Floppy Disk
WIN95 (C:)	Local Disk
Win2K (D:)	Local Disk
Work (E:)	Local Disk
Temp (F:)	Local Disk

To erase unused space on one or multiple drives, select them on the Explorer, right-click over the selection and choose “Erase unused space” from the pop-up menu.

Shell Extension: Erasing

After selecting the data, the Shell Extension will ask for your a confirmation before erasing.



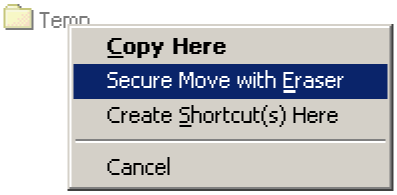
Are you sure you want to erase unused space on drive 'F:\'?

You can change the erasing method at this point by opening the Erasing Preferences window using the “Options” button. If you have selected multiple drives to be erased, the Yes to all option is also available.

After receiving your confirmation a progress window will be shown during the operation. If you have selected the “Show results” option on the bottom of the progress window (or you can use the General Preferences window to set it), a summary of results will be shown in the Erasing Report window.

Shell Extension: Secure Move

When moving files or folders across drives, the operating system is forced to delete insecurely the source files after copying them to the new location. The Shell Extension allows you to securely move files, erasing the source files after copying them.



To use the Secure Move option, select source files normally on the Explorer and drag them to the destination keeping the secondary (usually right) mouse button down. When over the destination, release the mouse button and select “Secure Move with Eraser” from the appearing pop-up menu.

You will be asked for a confirmation before the files are copied. If the destination already contains files or folders with the same name, you will be asked if you want to replace them with the source files – if you decide not to, the corresponding source file will not be erased.

If the files were copied successfully, the Shell Extension will continue with erasing of the source files. You can stop the erasing any time by pressing “Stop” on the progress window. Erasing Report will be shown after moving if you have set it to be shown when otherwise working with the Shell Extension. If the copying failed, the source files will not be erased.

This feature is available only on Windows Explorer.

Shell Extension: Step-by-Step

These three simple steps will give you a quick start into using the Shell Extension.

Step 1: Select Data

Open the Windows Explorer or the Eraser Explorer, browse to the data to be erased and select it, right-click over the selection and select Erase from the pop-up menu (or Erase unused space if the data is a drive).

Step 2: Confirm and Erase

After your confirmation, a progress window will be shown during erasing.

Step 3: Results

If you have selected the Show results option on the bottom of the progress window, a summary of results will be shown in the Erasing Report window.

Launcher: Basics

The Eraser Launcher allows you to use erase data from the command prompt. You can get a brief usage description by starting “eraserl.exe” without any command line parameters.

Launcher: Erasing

The valid command line parameters for the Eraser Launcher are listed below. The Launcher does not ask for a confirmation before erasing the given data, use caution when using it.

```
eraserl [Data] [Method] [-silent | -results | -resultsonerror ] [-queue] [-options]
```

Data:

```
-file                  data [-subfolders]
-folder                data [-subfolders] [-keepfolder]
-disk                  drive: | all
-recycled
```

Method:

```
-method                Gutmann | DoD | DoD_E | Random passes | Library
```

Parameters:

-file	The data to erase is a file (wildcards may be used)
-subfolders	Include subfolders
-folder	The data to erase is files on a folder
-subfolders	Include subfolders
-keepfolder	Do not delete the folder
-disk	The data to erase in unused space on a drive or all local hard drives (all)
-recycled	Erase all data on the Recycle Bin
-silent	Do not show any windows
-results	Show Erasing Report
-resultsonerror	Show Erasing Report only in case of error
-queue	Wait until previous instances have finished
-options	Ignore all other valid parameters and show Erasing Preferences window

Examples

Erase all files in the directory “C:\Windows\Temp” leaving subfolders untouched

```
  eraserl -file C:\Windows\Temp\*
```

If you want to remove the folder as well (will not be deleted if subfolders exist)

```
  eraserl –folder C:\Windows\Temp\
```

Erase all files in folder “H:\Some Folder” and its subfolders, remove them afterwards and show the Erasing Report window (notice the quotation marks around the folder name; they are required when the path contains spaces)

```
  eraserl -folder “H:\Some Folder” –subfolders –results
```

Erase unused disk space on drive L without showing any windows, using three passes of pseudorandom data

```
  eraserl -disk L:\ -silent –method Random 3
```

Erase all data deleted to the Windows Recycle Bin and show the Erasing Report window afterwards. Unlike when using other parameters, this one asks for your confirmation before erasing unless “-silent” is specified

```
  eraserl -recycled -results
```

Show the Erasing Preferences dialog

```
eraserl —options
```

Launcher: Step-by-Step

These three simple steps will give you a quick start into using the Eraser Launcher.

Step 1: Open Command Prompt

The Launcher get its instructions only as command line parameters so you need to use it from a command prompt, or from the run dialog box available at Windows Start menu.

Step 2: Erasing

You can get a brief usage description by running `eraserl.exe` without any command line parameters. For example, to clear all files from the temporary folder, `C:\Temp`, without touching the subfolders or deleting the folder, use the following command

```
eraserl -file C:\Temp\*
```

Be careful when using the Launcher, it **will not ask for your confirmation** before erasing.

Step 3: Results

A summary of the results will be shown in the Erasing Report window if you have specified the `–results` command line parameter.

Tips and Tricks

Some tips that make using Eraser more convenient or help you to maintain your privacy better are discussed on this section.

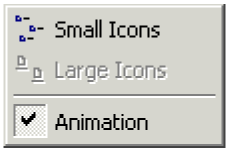
Reading tasks from a different file

If you want Eraser to read initial tasks from a file different from the `default.ers` located in the application folder, you can specify the initial file on the command line – `eraser.exe alternative.ers` for example. The file specified on the command line will be used only to read the tasks, when leaving the program, tasks will be saved to the `default.ers` file.

Shortcuts

Most Eraser windows contain keyboard shortcuts allowing you to use them without needing to grab the mouse. The shortcut keys for different commands can be found from the menus.

Animated icons



Do you find the animated icons on the folder bar distracting or perhaps annoying? If so, you can turn off the animation by right clicking the folder bar and deselecting the “Animation” option.

Erasing Browser Cache and Email

Occasionally you may want to clear any traces that you may have left on the computer while surfing the web. To do this, you must know what to erase. In general, the web browser stores information on three places; the cache, the history and the cookies file.

Mozilla / Netscape 6.x

Mozilla stores the saved files to folders “Cache” and “NewCache”, which you can find under the user specific folder (“Profiles”). You can safely erase both of these folders.

You will also need to erase the history file called `history.dat`, which can be found from the user specific folder. The cookie file may also reveal information so the `cookies.txt`, which is in the same place as the history file should be erased as well.

The URLs shown on the location can be cleared from browser preferences.

Netscape Navigator 4.7

Netscape stores the saved files in its cache folder the location of which can be found from the advanced section of the browser preferences dialog. You can safely erase the contents if this folder including the `fat.db` file which contains information about the files in cache.

You will also need to erase the history file called `netscape.hst`, which can be found from the user specific folder. The cookie file may also reveal information so the `cookies.txt`, which is in the same place as the history file should be erased as well.

The URLs shown on the location bar are stored on Windows registry. The later versions of Navigator allow you to clear the location bar from within the preferences window. If you are using a version that does not allow clearing of the location bar, you will have to edit the registry manually to remove the entries; doing this is not recommend for other than advanced users.

Microsoft Internet Explorer

Microsoft Internet Explorer stores its information in several folders that are usually located under the Windows folder. The cache files are in the `Temporary Internet Files` folder and they can be erased normally. To remove the cookies possibly stored on the computer, you should erase the contents of the `Cookies` folder.

The `History` folder contains information about the sites where you have visited. You can safely erase the folder, it will be recreated when you start the Internet Explorer.

Please notice that what you see in Windows Explorer when viewing the `Temporary Internet Files` or `History` folders is not the actual directory contents, but an image built from `index.dat` database file, which is kept locked by Windows shell and cannot be erased.

In other words, even if you have erased all files from `Temporary Internet Files` folder, Explorer **will still show you names and locations of web sites you have visited**. To complete cleaning, you need to clear the contents of `index.dat`:

Open `Control Panel` / `Internet Options` and press `Delete Files…` and `Clear History` to clear the `index.dat` files. You may also want to visit the `Content` page to clear AutoComplete entries (if you have turned it on) – press `AutoComplete…` and then `Clear Forms` and `Clear Passwords`.

If you are really worried about your privacy, you may also want to erase unused space on the drive where the history files and the cache are stored – and recompress registry.

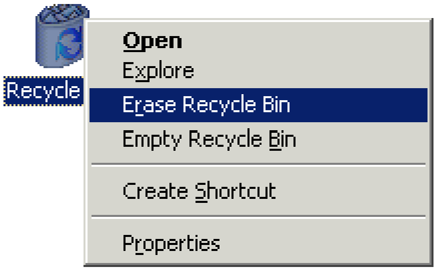
Erasing email also depends on the program you are using; in some programs erasing individual messages may not be possible at all.

Outlook Express

Outlook Express stored your mail folders in separate files, which can easily be erased. After moving the messages you want to delete to `Deleted Items` folder in OE, close the program without emptying the deleted items. Find the folder where OE stores your mail, and erase `Deleted Items.dbx`. You may also need to erase the unused disk space on the drive (and possibly the mail folder where the deleted message was before) to be sure deleted email is really gone.

Erasing Recycle Bin

You can erase the contents of the Windows Recycle Bin using Eraser Launcher with `-recycled` command line parameter. For your convenience, “Erase Recycle Bin” command is added to the context menu of the Recycle Bin.



You will be asked for a confirmation before erasing the Recycle Bin contents. On older systems, the Recycle Bin may show wrong icon after erasing until the next time you open it or delete a file.

You should empty (or erase) the Recycle Bin before erasing unused disk space.

Erasing Paging (Swap) File

See also section Common Security Problems.

Windows NT and 2000

Windows NT (and 2000) has a security feature that will overwrite the paging file at shutdown. The overwriting is done by the operating system after all applications are closed so most data will be overwritten. There are small areas that cannot be accessed because they are allocated by the operating system components that are still active. You may enable this feature from the General Preferences window of Eraser.

Windows 9x and ME

The overwriting of the paging file on Windows 9x is a more complicated task and should only be done by those who know what they are doing.

If you want to do the erasing from Windows, you will need to disable the virtual memory from the Control Panel and then use Eraser to overwrite the unused space on the drive where the paging file was. Disabling virtual memory may cause your computer to run out of memory and possibly stop responding, so you should not run any other applications before enabling the virtual memory again.

A better method is to set the paging file to a fixed size from Control Panel and use a command line file erasing utility to overwrite the swap file from DOS. You can find a suitable DOS file wiper, `eraserd.exe`, from the directory where you have Eraser installed.

Just boot to DOS mode (this means shutting down Windows), or boot your computer from a floppy disk, and move to the directory where you have `eraserd.exe` (usually `C:\Program Files\Eraser`), and run the following command

```
eraserd –file C:\win386.swp –passes 3
```

If you swap file is not located in the root directory, use the correct path to swap file instead. You can increase or decrease the number of overwriting passes if you want.

Erasing All Data on Drive

Sometimes one needs to clear all data on a drive, for example, when selling the drive or when throwing it away. On this chapter you can find step-by-step instructions on how to erase all data on a drive.

First, to overwrite completely all data on a drive, it may be required to install the drive on another system because the operating system files cannot be accessed while it is running (this is not of course needed if the operating system if not installed on the drive).

To start clearing the drive, the first thing to do is to delete all files (no overwriting at this point). After deleting the files, it is time to overwrite the unused disk space. The default method for erasing unused disk space is one pass of pseudorandom data, but you may want to change this to increase security – be aware that overwriting unused space on a large drive using multiple overwriting passes may take several hours.

After all data on the drive is overwritten, you should finally use the standard format to clear possible data remaining on the file system table.

With these security cautions, you can be sure that nobody gets their hand on your data by accident. However, if you are disposing the hard drive (i.e. have no plans for it to be used again) and the drive contains really sensitive data, you may want to consider physically destroying the disk platters after overwriting.

If you don't have access to another system, you need to use a file wiper that can be used from a bootable floppy disk. I recommend using GNU/Linux and the `dd` command, there are also some DOS applications available for the task.

Eraser for DOS

If you need to erase all files and free disk space from your old personal computer you are planning to donate or recycle, and your computer runs DOS, any version of 16-bit Windows or an early version of Windows 95, you can use the DOS file wiper included with Eraser, `eraserd.exe`.

Note! EraserD is designed to be compatible even with older DOS version, which introduces some limitations. The program only supports files that are smaller than 2GB and cannot overwrite free space on partitions that are larger than 2GB.

After you have created a bootable floppy disk and copied `eraserd.exe` from Eraser directory to the floppy, boot the computer from the floppy disk and run the following commands to erase all files from your drive and overwrite remaining free space:

```
A:\eraserd -allfiles C: -passes 3
A:\eraserd -disk C: -passes 1
```

You can change the number of overwriting passes to use – the commands above define three overwriting passes for files and one pass for free space, which should be fine for most people.

Repeat the procedure for other partitions you have on the drive. You should also reformat partitions after erasing to remove possibly remaining entries from the file system tables.

What Does It Do: When Erasing Files

By now you must be wondering what exactly does this program do to my computer when erasing files. You have come to the right place, the procedures gone through when erasing files are explained here.

After determining the file type (files compressed or encrypted at the file system level are supported on Windows NT and 2000, but Administrator privileges are required for low-level disk access), Eraser needs to determine the size of the file. When calculating the size, the cluster tip area is included so the data stored on it will be erased too (see Overwriting Properly at Advanced Topics), unless you have deselected this option.

Once the size is calculated, the file will be overwritten with the selected method (see detailed descriptions of the available methods at Advanced Topics). Eraser takes care of flushing write buffers to make sure that the data really gets written to the disk and is not only saved in a buffer somewhere. If the overwriting was successful, the final step is to properly delete the file.

Before removing the reference of the file from the file system (standard delete), the file will be truncated to zero length to clear traces of the allocated clusters, the filename will be overwritten (if selected) and finally file dates (creation, access, modified) will be scrambled to complete the file erasing.

What Does It Do: When Erasing Unused Disk Space

But what is it that Eraser does to clear unused space on your disk? And where this unused space can be found?

> If you have not disabled the option to erase cluster tip area (generally, there is no reason why you should disable this option unless the drive uses FAT file system and is compressed; see Overwriting Properly), Eraser will start by clearing this unused space from each file on the selected drive.
>
> When a file is loaded in memory by some application or by the operating system (or opened without file sharing), its cluster tip area cannot be overwritten and you will receive an error because of this. To reduce the amount of locked files into a minimum, you should close as many applications as possible before erasing unused disk space and even then the files locked by the operating system cannot be accessed.
>
> After taking care of the cluster tips, it is time to overwrite the free space on the drive. If your drive is equipped with a file system that supports quota and the space available to you is limited (i.e. the space available to you is smaller than the free space on the drive), you cannot erase unused space on that drive and should ask the administrator to do it instead.
>
> To overwrite the free space, Eraser creates a temporary directory, which it fills with files (these are deleted after the erasing is finished). Multiple files are used because it is faster than creating one huge file. Data will be written until there is no more space available on the drive. This procedure may take a long time if the free area is large and it may slow down your computer substantially; especially if the paging file (swap) is located on the selected drive. This is another reason why you should close all applications before erasing unused space.
>
> If you are running Windows NT or 2000 and the file system on the drive is NTFS, Eraser will next overwrite the free space on the Master File Table (MFT). The reason why this is done is that on NTFS file system, clusters are not necessarily allocated for files smaller than the size of a MFT record, but the file is stored completely in the MFT (the file is then said to be resident). If you have insecurely deleted such a small file, the free space on the MFT still may contain the file body and therefore, it must be erased as well. Windows 9x does not support NTFS file system so this step will be skipped.
>
> Finally, the names of all previously deleted (or erased) files will be overwritten. On FAT{12,16,32} partitions this is done by going through all directory entries and overwriting deleted file entries. On NTFS partitions (Windows NT and 2000 only), Eraser creates maximum length files until the unused entries in the Master File Table are overwritten.

In addition to erasing unused disk space, you can also set the paging (swap) file to be overwritten on Windows NT and 2000. Using the General Preferences window you can enable this Windows NT security feature that overwrites all unused portions of the paging file when shutting down.

When to Use It?

You should use overwriting every time when removing data from your drive. You do not need to overwrite data, which you do not think is secret, or sensitive, but there is no harm in overwriting everything.

However, there are some special cases when overwriting may not be suitable, or may have side effects. These cases are discussed in the next chapter.

You may also want to erase the unused disk space on your drive regularly to get rid of the remains of temporary files created by applications and other information that may have been stored on your disk. You can use the Scheduler to conveniently set this procedure to happen when you are not using the computer, at nights for example.

Special Cases

The special cases when erasing data by overwriting may not be desirable – when alternative methods should be used or when there are important matters that need to be considered first – are discussed here.

Compressed Files

You can safely erase files compressed at the file system level (file compression requires a file system that supports it, such as NTFS). When erasing compressed files on Windows NT or 2000, Administrator privileges are required for low-level disk access.

Files compressed with an external application, such as ZIP files, can naturally be erased.

If you are erasing files from a partition compressed with external compression software (such as DriveSpace), use only **pseudorandom data** for overwriting.

Compressed Drives

Files and unused space on a compressed NTFS partition can be erased normally.

However, **if your partition is compressed with external compression software (such as DriveSpace)**, the following details should be considered. In general, one should avoid storing sensitive data on a partition compressed with external software.

Turn off cluster tip erasing for partitions that are compressed with external software, erasing cluster tips will confuse the application that handles the compressing and may result to dramatic loss of disk space. If you erased cluster tips on a compressed drive and lost significant amount of disk space, you must recompress the drive to restore the lost space.

You should **use only pseudorandom data** when overwriting unused space on a partition compressed with external software, the other methods include passes that are of highly compressible data and should not be used. Your computer may slow down and even stop responding because the written data is being compressed.

Files saved on the compressed drive can also be overwritten taking the aforementioned matters into consideration.

Encrypted Files

You can safely erase files encrypted at the file system level (file compression requires a file system that supports it). Files encrypted with an external application, such as Pretty Good Privacy (PGP), can be erased as well.

As the data is already stored in unreadable format, erasing is not required, but usually increases security.

Encrypted Drives

In general, one should **not** erase the unused disk space on an encrypted drive (the same applies to encrypted virtual drives, such as the ones created by PGPDisk, ScramDisk or E4M).

The erasing will be useless because the data saved on the drive is encrypted into unreadable format, erasing may slow down your computer and it may even stop responding, depending on the driver that handles encryption.

Files on the encrypted drives can be overwritten, but this should be avoided because of the reasons mentioned above.

Network Drives

You should **never** erase data from a drive over the network. It will not work as expected and your network administrator will hate you for jamming the network.

Floppy Disks

You can erase data on a floppy disk just if you were erasing a hard disk. However, if you have stored sensitive data on a floppy disk, you may want to consider **physically destroying** the disk using another method, such as burning it.

CD-RW, DVD-RAM, DVD-RW, …

You should **not** use multiple overwriting passes to erase data on a CD-RW or DVD-RAM disk (or another rewritable optical media). These are not magnetic media and overwriting multiple times would have no meaning, if you want to erase a single file, one overwriting pass is enough. Use the CD-writing software to format the disk when you want to clear its contents; or if the disk contains sensitive data, you may want to consider **physically destroying** it by possibly shredding or burning the disk.

Common Security Problems

Some of the most commonly overlooked security holes are discussed below.

Paging (Swap) File

The virtual memory storage of the Windows operating system is called the paging file (or the swap file). The operating system may store any information from the memory to the disk whenever it wants. This means that the paging file may contain passwords, pieces of documents and other sensitive information.

Since the operating system locks the paging file while it is running, the file cannot be accessed using standard file operations. There are applications that claim to overwrite the paging file by allocating huge amounts of memory, but this method may freeze your computer and even then the space allocated by applications cannot be accessed and not all the available space on the paging file is necessarily overwritten.

For information on how to erase the paging file, see Erasing Paging (Swap) File.

Filenames

Unless you name your files with arbitrary names, the name of a file can reveal information about the file contents. Eraser will overwrite the filename when erasing the rest of the file.

Names of the files you have previously deleted may also still be stored in the file system table; Eraser will overwrite them when you erase unused disk space.

Locked Files

An executable file cannot be accessed when it is running, the same goes for shared dynamic link libraries and all files that are opened without file sharing allowed. The cluster tip area of these files may contain sensitive data the same way as the unused area in any other file, but it cannot be overwritten because the file is locked.

To reduce the amount of these locked files into a minimum, you should close as many applications as possible before erasing the unused disk space. Closing the applications will also free memory allowing the operating system to reduce the size of the paging file making more free space available for overwriting.

The files loaded in memory by the operating system, such as the system libraries, cannot be accessed at all while the computer is running. The cluster tip area of these files may contain sensitive information, but it is not very probable because these files are locked all the time.

Bad Sectors

When an area on the disk gets damaged for some reason, the disk electronics mark this area to contain only bad sectors. These bad sectors cannot be accessed so the data still stored in them cannot be erased either. Peter Gutmann has discussed this subject further in chapter “Further Problems with Magnetic Media“ of his paper “Secure Deletion of Data from Magnetic and Solid-State Memory“.

Advanced Topics

If you are interested in the theory behind the operation, or are looking for more detailed information about file erasing, this section should give you all the answers you need.

The Advanced Topics start by explaining some of the terms most commonly used and continues by explaining why and where to overwrite and what kind of data to use. The discussion is continued with a detailed description of the overwriting methods used in Eraser and finished off with the complete paper “Secure Deletion of Data from Magnetic and Solid-State Memory” by Peter Gutmann.

Terms Used

Here you can find a brief description of some of the most commonly used terms in these instructions.

Cluster

To be able to keep track of the data on a partition, the file system divides each partition into small blocks called clusters. A cluster is the smallest area, which can be allocated from the disk and its size depends on the file system and on the size of the partition.

Cluster tip

The unused area at the end of the last cluster allocated by a file is called the cluster tip (or the slack space). This unused area is present in most files because space can be allocated only as cluster sized blocks and the contents of the file rarely completely fill all allocated clusters.

File system

The operating system uses the file system as a database to control the allocation status of a partition. The file system, such as FAT (File Allocation Table) and all its variants (FAT12, FAT16, FAT32) and NTFS (New Technology File System), keeps track of the data on a partition; filenames, dates, size and the physical location on the disk.

Partition

A hard disk can be divided into several logical drives called partitions. The size of the partition and the file system used determine the cluster size. Usually it is desirable to keep the cluster size small to reduce the amount of wasted (or slack) space on the partition.

Pass, overwriting

The number of overwriting passes determines how many times an area on the disk is to be overwritten.

Period length, of PRNG

The length of a pseudorandom sequence; the amount of numbers that can be generated with a PRNG before the sequence starts from the beginning.

Pseudorandom number generator, PRNG

An algorithm that provides a sequence of numbers that appears to be random. All “random” data created by arithmetical means is called pseudorandom.

“Any one who considers arithmetical means of producing random digits is, of course, in a state of sin” – John Von Neumann (1951)

Unused disk space

The space on a partition not used for storing data. Consists of cluster tip areas of the files on the partition and the available free space.

Deleting Files

An operating system, such as MS-DOS and Windows, uses a file system to keep track of the data on the hard disk: directories, files, their location, size, dates etc. Using a file system is noticeably faster than parsing the information directly from the disk, but also causes problems when the user wants to securely remove a file.

Normally, when you delete a file, the operating system does not actually erase the file; it only removes the reference of the file from the file system table and marks the area occupied by the file unused. Therefore anyone can recover the file using any disk maintenance utility capable of reading the disk directly. The data will not be destroyed until a program writes over the deleted file, and even after that it may be possible to recover some or all of the data by studying the disk with specialized equipment.

To some people this is enough, but if you want to ensure that your confidential data will not end up in wrong hands, you should properly overwrite a file before removing its reference from the file system table.

Overwriting Properly

The Media

A hard disk consists of one or several disk platters, which have been plated, with a very thin (a few millionths of an inch thick) layer of magnetic substance. One read/write head is being used to both read and write data from the platter. The head is positioned very close to the platter, only a few millionths of an inch away. The surface of the disk platter can be seen to consist of magnetic domains acting like small magnets, having both positive and negative poles. The data is saved to the disk in binary form - as ones and zeros - and millions of magnetic domains are used to save one bit. When writing new data to the disk, the read/write head reverses the magnetic pole direction if necessary.

When the read/write head reverses the polarity of a region of domains (presenting one bit of data), the polarity of most domains reverses, but small portions remain in their original state. The electronics of the drive ignore these small inaccuracies, but when studying the platter surface with a sophisticated electronic microscope it may be possible to recover data even if it has been overwritten.

Overwriting

The main purpose of overwriting is to alter the magnetic polarity of each domain on the disk platter as much as possible so it will be extremely hard to determine their previous state.

If the data was written directly to the disk, files could simply be overwritten with patterns consisting only of ones or zeros. However, various run-length limited encoding algorithms are used in hard disks to prevent read/write head from losing its position and therefore, only limited amount of adjacent ones or zeros will be written to the disk. This is why different encoding schemes must be taken into account when selecting overwriting patterns.

In his paper Secure Deletion of Data from Magnetic and Solid-State Memory, Peter Gutmann has discussed the subject further. In chapter Erasure of Data stored on Magnetic Media he suggests a 35 pass overwriting method which should erase the data despite the drive encoding and this method is used as the default overwriting method for Eraser.

Where to Overwrite

After determining the proper pattern to be used, there remains a question where to write the data. When the objective is to overwrite all data that is stored in a file, the obvious destination would be from the beginning of the file to the end. However, not all people know that because of the file system design, the space allocated by a file can be larger than the file itself.

To be able to keep record of the drive contents, the file system divides each partition on the drive into small blocks called clusters. A cluster is the smallest data block, which can be allocated from a partition. The size and the number of clusters on a partition depend on the file system and the size of the partition.

It is relatively rare for the size of a file to be divisible by the partition cluster size, i.e., for the file to use completely all clusters it has allocated. Therefore, usually only a part of the last allocated cluster is used and the unused part of the last cluster (the cluster tip, or slack space) contains old and possibly secret data, which cannot be overwritten before the file that allocated the cluster has been removed.

This problem is not only present when overwriting single files, but it also opens a potential security problem when overwriting unused disk space. If one overwrites only the free space available on a drive, the cluster tip area still remains untouched – this is why Eraser overwrites also cluster tips when overwriting unused disk space or single files.

One more thing you can do to improve security is to close as many applications as possible before erasing unused disk space. This should be done to reduce the number of locked files so as much of the unused space as possible can be overwritten.

When a file is opened using exclusive access (e.g. when a program file is loaded into memory by the operating system), it will be locked to prevent other applications and the user from touching it. Because the file is locked, its cluster tip cannot be overwritten. Therefore, by closing applications you assure that all possible unused space can be accessed, but remember that even then the files locked by the operating system cannot be accessed.

References:

Quantum Storage Resources
IBM Storage
Peter Gutmann, Secure Deletion of Data from Magnetic and Solid-State Memory

Government Regulations (for Secure Data Removal)

Governments often have a need to destroy classified information, so several regulations concerning the subject have been made. To mislead opponents, publicly available regulations may intentionally underrate the data destruction methods, while the real regulations remain classified. Many of the available regulations are also quite old.

> Eraser offers two overwriting methods that are based on the clearing and sanitization matrix in the National Industrial Security Program Operating Manual (NISPOM also known as US DoD 5220.22-M) of the US Department of Defense.
>
> According to this manual, overwriting is not approved for sanitizing media that contains TOP SECRET data. This would require degaussing or physically destroying the disk by disintegrating, incinerating, pulverizing, shredding, or melting it.

Gutmann – The Default Method

This method is based on Peter Gutmann’s paper “Secure Deletion of Data from Magnetic and Solid-State Memory”. In chapter “Erasure of Data from Magnetic Media” he represents 27 deterministic passes that should overwrite the data despite drive encoding.

Pass	**Pattern** (binary, hex)
1	01010101 01010101 01010101, 0x55
2	10101010 10101010 10101010, 0xAA
3	10010010 01001001 00100100, 0x92 0x49 0x24
4	01001001 00100100 10010010, 0x49 0x24 0x92
5	00100100 10010010 01001001, 0x24 0x92 0x49
6	00000000 00000000 00000000, 0x00
7	00010001 00010001 00010001, 0x11
8	00100010 00100010 00100010, 0x22
9	00110011 00110011 00110011, 0x33
10	01000100 01000100 01000100, 0x44
11	01010101 01010101 01010101, 0x55
12	01100110 01100110 01100110, 0x66
13	01110111 01110111 01110111, 0x77
14	10001000 10001000 10001000, 0x88
15	10011001 10011001 10011001, 0x99
16	10101010 10101010 10101010, 0xAA
17	10111011 10111011 10111011, 0xBB
18	11001100 11001100 11001100, 0xCC
19	11011101 11011101 11011101, 0xDD
20	11101110 11101110 11101110, 0xEE
21	11111111 11111111 11111111, 0xFF
22	10010010 01001001 00100100, 0x92 0x49 0x24
23	01001001 00100100 10010010, 0x49 0x24 0x92
24	00100100 10010010 01001001, 0x24 0x92 0x49
25	01101101 10110110 11011011, 0x6D 0xB6 0xDB
26	10110110 11011011 01101101, 0xB6 0xDB 0x6D
27	11011011 01101101 10110110, 0xDB 0x6D 0xB6

These deterministic passes should be committed in random order to make it more difficult for an opponent to recover the data. Permutation should be done with cryptographically strong random number generator.

> Eraser shuffles the pass array using its own cryptographically strong random number generator based on the one described in Dr. Gutmann’s paper “Software Generation of Practically Strong Random Numbers”. Tiger hash function by Ross Anderson and Eli Biham is used for mixing the entropy pool.

It is also stated that the overwriting sequence can be slightly improved by performing random passes before and after the deterministic passes above.

> Eraser writes four passes containing random data before and after writing the deterministic passes in random order, therefore ending up with total 35 passes. The data used in the random passes is created using the ISAAC pseudorandom number generator.

This method is **not suitable for erasing data on compressed drives**, because some of the passes contain highly compressible data.

References:

Peter Gutmann, Secure Deletion of Data from Magnetic and Solid-State Memory
Tiger: A Fast New Hash Function

US DoD 5220-22.M

These two methods are based on “National Industrial Security Program Operating Manual”, NISPOM (also known as US DoD 5220.22-M), of United States Department of Defense from January 1995 (chapter 8, section 3, 8-306. Maintenance).

The first alternative consists of parts E (which is D without verifying), C and E (once more) of the clearing and sanitization matrix.

Pass	Matrix	Pattern
1	E [1]	Random character X
2	E [2]	Bit-wise complement of X
3	E [3]	Random data
4	C	Random character Y
5	E [1]	Random character Z
6	E [2]	Bit-wise complement of Z
7	E [3]	Random data
		X, Y, Z = [0,255]

The latter version includes only part E of the matrix, and the first two passes consist of constants instead of random characters.

Pass	Matrix	Pattern
1	E [1]	`00000000`, 0x00
2	E [2]	`11111111`, 0xFF
3	E [3]	Random data

All random data is created with the ISAAC pseudorandom number generator.

Even though these overwriting methods are faster than the Gutmann method, they are less secure, especially when there is a chance that someone will try to use hardware recovery methods in attempt to restore the previous data.

These methods are **not suitable for erasing data on compressed drives**, because some of the passes contain compressible data.

References:

National Industrial Security Program Operating Manual (NISPOM)

Pseudorandom Data

Cryptographically strong pseudorandom data used for overwriting is created using the ISAAC (Indirection, Shift, Accumulate, Add and Count) algorithm by Bob Jenkins. The ISAAC generator is reseeded before each task using Eraser's own multi-source polling random number generator.

The random data generated using ISAAC is guaranteed to have a period length of 2^40 numbers, and the average cycle is 2^8295 32-bit (4-byte) numbers. Therefore, the average amount of data provided by the generator before the sequence starts from the beginning is 4.12e2488 gigabytes (and is at least 4096 gigabytes), which is more than enough for overwriting even the largest hard drives.

The number of overwriting passes for this method is user selectable, the maximum being ((2^16) - 1) = 65535 passes.

For more information, see the source code.

Because the random data is highly incompressible, this is the only method that **should be used on compressed drives**.

References:

ISAAC: a fast cryptographic random number generator

Donald Ervin Knuth, The Art of Computer Programming: Seminumerical Algorithms, Volume 2, 3rd Edition

Secure Deletion of Data from Magnetic and Solid-State Memory

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Abstract

With the use of increasingly sophisticated encryption systems, an attacker wishing to gain access to sensitive data is forced to look elsewhere for information. One avenue of attack is the recovery of supposedly erased data from magnetic media or random-access memory. This paper covers some of the methods available to recover erased data and presents schemes to make this recovery significantly more difficult.

Secure Deletion of Data from Magnetic and Solid-State Memory

Introduction

Much research has gone into the design of highly secure encryption systems intended to protect sensitive information. However work on methods of securing (or at least safely deleting) the original plaintext form of the encrypted data against sophisticated new analysis techniques seems difficult to find. In the 1980's some work was done on the recovery of erased data from magnetic media [1] [2] [3], but to date the main source of information is government standards covering the destruction of data. There are two main problems with these official guidelines for sanitizing media. The first is that they are often somewhat old and may predate newer techniques for both recording data on the media and for recovering the recorded data. For example most of the current guidelines on sanitizing magnetic media predate the early-90's jump in recording densities, the adoption of sophisticated channel coding techniques such as PRML, the use of magnetic force microscopy for the analysis of magnetic media, and recent studies of certain properties of magnetic media recording such as the behaviour of erase bands. The second problem with official data destruction standards is that the information in them may be partially inaccurate in an attempt to fool opposing intelligence agencies (which is probably why a great many guidelines on sanitizing media are classified). By deliberately under-stating the requirements for media sanitization in publicly-available guides, intelligence agencies can preserve their information-gathering capabilities while at the same time protecting their own data using classified techniques.

This paper represents an attempt to analyse the problems inherent in trying to erase data from magnetic disk media and random-access memory without access to specialised equipment, and suggests methods for ensuring that the recovery of data from these media can be made as difficult as possible for an attacker.

Secure Deletion of Data from Magnetic and Solid-State Memory

Methods of Recovery for Data stored on Magnetic Media

Magnetic force microscopy (MFM) is a recent technique for imaging magnetization patterns with high resolution and minimal sample preparation. The technique is derived from scanning probe microscopy (SPM) and uses a sharp magnetic tip attached to a flexible cantilever placed close to the surface to be analysed, where it interacts with the stray field emanating from the sample. An image of the field at the surface is formed by moving the tip across the surface and measuring the force (or force gradient) as a function of position. The strength of the interaction is measured by monitoring the position of the cantilever using an optical interferometer or tunnelling sensor.

Magnetic force scanning tunneling microscopy (STM) is a more recent variant of this technique which uses a probe tip typically made by plating pure nickel onto a prepatterned surface, peeling the resulting thin film from the substrate it was plated onto and plating it with a thin layer of gold to minimise corrosion, and mounting it in a probe where it is placed at some small bias potential (typically a few tenths of a nanoamp at a few volts DC) so that electrons from the surface under test can tunnel across the gap to the probe tip (or vice versa). The probe is scanned across the surface to be analysed as a feedback system continuously adjusts the vertical position to maintain a constant current. The image is then generated in the same way as for MFM [4] [5]. Other techniques which have been used in the past to analyse magnetic media are the use of ferrofluid in combination with optical microscopes (which, with gigabit/square inch recording density is no longer feasible as the magnetic features are smaller than the wavelength of visible light) and a number of exotic techniques which require significant sample preparation and expensive equipment. In comparison, MFM can be performed through the protective overcoat applied to magnetic media, requires little or no sample preparation, and can produce results in a very short time.

Even for a relatively inexperienced user the time to start getting images of the data on a drive platter is about 5 minutes. To start getting useful images of a particular track requires more than a passing knowledge of disk formats, but these are well-documented, and once the correct location on the platter is found a single image would take approximately 2-10 minutes depending on the skill of the operator and the resolution required. With one of the more expensive MFM's it is possible to automate a collection sequence and theoretically possible to collect an image of the entire disk by changing the MFM controller software.

There are, from manufacturers sales figures, several thousand SPM's in use in the field today, some of which have special features for analysing disk drive platters, such as the vacuum chucks for standard disk drive platters along with specialised modes of operation for magnetic media analysis. These SPM's can be used with sophisticated programmable controllers and analysis software to allow automation of the data recovery process. If commercially-available SPM's are considered too expensive, it is possible to build a reasonably capable SPM for about US$1400, using a PC as a controller [6].

Faced with techniques such as MFM, truly deleting data from magnetic media is very difficult. The problem lies in the fact that when data is written to the medium, the write head sets the polarity of most, but not all, of the magnetic domains. This is partially due to the inability of the writing device to write in exactly the same location each time, and partially due to the variations in media sensitivity and field strength over time and among devices.

In conventional terms, when a one is written to disk the media records a one, and when a zero is written the media records a zero. However the actual effect is closer to obtaining a 0.95 when a zero is overwritten with a one, and a 1.05 when a one is overwritten with a one. Normal disk circuitry is set up so that both these values are read as ones, but using specialised circuitry it is possible to work out what previous "layers" contained. The recovery of at least one or two layers of overwritten data isn't too hard to perform by reading the signal from the analog head electronics with a high-quality digital sampling oscilloscope, downloading the sampled waveform to a PC, and analysing it in software to recover the previously recorded signal. What the software does is generate an "ideal" read signal and subtract it from what was actually read, leaving as the difference the remnant of the previous signal. Since the analog circuitry in a commercial hard drive is nowhere near the quality of the circuitry in the oscilloscope used to sample the signal, the ability exists to recover a lot of extra information which isn't exploited by the hard drive electronics (although with newer channel coding techniques such as PRML (explained further on) which require extensive amounts of signal processing, the use of simple tools such as an oscilloscope to directly recover the data is no longer possible).

Using MFM, we can go even further than this. During normal readback, a conventional head averages the signal over the track, and any remnant magnetization at the track edges simply contributes a small percentage of noise to the total signal. The sampling region is too broad to distinctly detect the remnant magnetization at the track edges, so that the overwritten data which is still present beside the new data cannot be recovered without the use of specialised techniques such as MFM or STM (in fact one of the "official" uses of MFM or STM is to evaluate the effectiveness of disk drive servo-positioning mechanisms) [7]. Most drives are capable of microstepping the heads for internal diagnostic and error recovery purposes (typical error recovery strategies consist of rereading tracks with slightly changed data threshold and window offsets and varying the head positioning by a few percent to either side of the track), but writing to the media while the head is off-track in order to erase the remnant signal carries too much risk of making neighbouring tracks unreadable to be useful (for this reason the microstepping capability is made very difficult to access by external means).

These specialised techniques also allow data to be recovered from magnetic media long after the read/write head of the drive is incapable of reading anything useful. For example one experiment in AC erasure involved driving the write head with a 40 MHz square wave with an initial current of 12 mA which was dropped in 2 mA steps to a final level of 2 mA in successive passes, an order of magnitude more than the usual write current which ranges from high microamps to low milliamps. Any remnant bit patterns left by this erasing process were far too faint to be detected by the read head, but could still be observed using MFM [8].

Even with a DC erasure process, traces of the previously recorded signal may persist until the applied DC field is several times the media coercivity [9].

Deviations in the position of the drive head from the original track may leave significant portions of the previous data along the track edge relatively untouched. Newly written data, present as wide alternating light and dark bands in MFM and STM images, are often superimposed over previously recorded data which persists at the track edges. Regions where the old and new data coincide create continuous magnetization between the two. However, if the new transition is out of phase with the previous one, a few microns of erase band with no definite magnetization are created at the juncture of the old and new tracks. The write field in the erase band is above the coercivity of the media and would change the magnetization in these areas, but its magnitude is not high enough to create new well- defined transitions. One experiment involved writing a fixed pattern of all 1's with a bit interval of 2.5 µm, moving the write head off-track by approximately half a track width, and then writing the pattern again with a frequency slightly higher than that of the previously recorded track for a bit interval of 2.45 µm to create all possible phase differences between the transitions in the old and new tracks. Using a 4.2 µm wide head produced an erase band of approximately 1 µm in width when the old and new tracks were 180° out of phase, dropping to almost nothing when the two tracks were in-phase. Writing data at a higher frequency with the original tracks bit interval at 0.5 µm and the new tracks bit interval at 0.49 µm allows a single MFM image to contain all possible phase differences, showing a dramatic increase in the width of the erase band as the two tracks move from in-phase to 180° out of phase [10].

In addition, the new track width can exhibit modulation which depends on the phase relationship between the old and new patterns, allowing the previous data to be recovered even if the old data patterns themselves are no longer distinct. The overwrite performance also depends on the position of the write head relative to the originally written track. If the head is directly aligned with the track, overwrite performance is relatively good; as the head moves offtrack, the performance drops markedly as the remnant components of the original data are read back along with the newly-written signal. This effect is less noticeable as the write frequency increases due to the greater attenuation of the field with distance [11].

When all the above factors are combined it turns out that each track contains an image of everything ever written to it, but that the contribution from each "layer" gets progressively smaller the further back it was made. Intelligence organisations have a lot of expertise in recovering these palimpsestuous images.

Secure Deletion of Data from Magnetic and Solid-State Memory

Erasure of Data stored on Magnetic Media

The general concept behind an overwriting scheme is to flip each magnetic domain on the disk back and forth as much as possible (this is the basic idea behind degaussing) without writing the same pattern twice in a row. If the data was encoded directly, we could simply choose the desired overwrite pattern of ones and zeroes and write it repeatedly. However, disks generally use some form of run-length limited (RLL) encoding, so that the adjacent ones won't be written. This encoding is used to ensure that transitions aren't placed too closely together, or too far apart, which would mean the drive would lose track of where it was in the data.

To erase magnetic media, we need to overwrite it many times with alternating patterns in order to expose it to a magnetic field oscillating fast enough that it does the desired flipping of the magnetic domains in a reasonable amount of time. Unfortunately, there is a complication in that we need to saturate the disk surface to the greatest depth possible, and very high frequency signals only "scratch the surface" of the magnetic medium. Disk drive manufacturers, in trying to achieve ever-higher densities, use the highest possible frequencies, whereas we really require the lowest frequency a disk drive can produce. Even this is still rather high. The best we can do is to use the lowest frequency possible for overwrites, to penetrate as deeply as possible into the recording medium.

The write frequency also determines how effectively previous data can be overwritten due to the dependence of the field needed to cause magnetic switching on the length of time the field is applied. Tests on a number of typical disk drive heads have shown a difference of up to 20 dB in overwrite performance when data recorded at 40 kFCI (flux changes per inch), typical of recent disk drives, is overwritten with a signal varying from 0 to 100 kFCI. The best average performance for the various heads appears to be with an overwrite signal of around 10 kFCI, with the worst performance being at 100 kFCI [12]. The track write width is also affected by the write frequency - as the frequency increases, the write width decreases for both MR and TFI heads. In [13] there was a decrease in write width of around 20% as the write frequency was increased from 1 to 40 kFCI, with the decrease being most marked at the high end of the frequency range. However, the decrease in write width is balanced by a corresponding increase in the two side- erase bands so that the sum of the two remains nearly constant with frequency and equal to the DC erase width for the head. The media coercivity also affects the width of the write and erase bands, with their width dropping as the coercivity increases (this is one of the explanations for the ever-increasing coercivity of newer, higher-density drives).

To try to write the lowest possible frequency we must determine what decoded data to write to produce a low-frequency encoded signal.

In order to understand the theory behind the choice of data patterns to write, it is necessary to take a brief look at the recording methods used in disk drives. The main limit on recording density is that as the bit density is increased, the peaks in the analog signal recorded on the media are read at a rate which may cause them to appear to overlap, creating intersymbol interference which leads to data errors. Traditional peak detector read channels try to reduce the possibility of intersymbol interference by coding data in such a way that the analog signal peaks are separated as far as possible. The read circuitry can then accurately detect the peaks (actually the head itself only detects transitions in magnetisation, so the simplest recording code uses a transition to encode a 1 and the absence of a transition to encode a 0. The transition causes a positive/negative peak in the head output voltage (thus the name "peak detector read channel"). To recover the data, we differentiate the output and look for the zero crossings). Since a long string of 0's will make clocking difficult, we need to set a limit on the maximum consecutive number of 0's. The separation of peaks is implemented as some form of run-length-limited, or RLL, coding.

The RLL encoding used in most current drives is described by pairs of run-length limits (*d, k*), where *d* is the minimum number of 0 symbols which must occur between each 1 symbol in the encoded data, and *k* is the maximum. The parameters (*d, k*) are chosen to place adjacent 1's far enough apart to avoid problems with intersymbol interference, but not so far apart that we lose synchronisation.

The grandfather of all RLL codes was FM, which wrote one user data bit followed by one clock bit, so that a 1 bit was encoded as two transitions (1 wavelength) while a 0 bit was encoded as one transition (« wavelength). A different approach was taken in modified FM (MFM), which suppresses the clock bit except between adjacent 0's (the ambiguity in the use of the term MFM is unfortunate. From here on it will be used to refer to modified FM rather than magnetic force microscopy). Taking three example sequences 0000, 1111, and 1010, these will be encoded as 0(1)0(1)0(1)0, 1(0)1(0)1(0)1, and 1(0)0(0)1(0)0 (where the ()s are the clock bits inserted by the encoding process). The maximum time between 1 bits is now three 0 bits (so that the peaks are no more than four encoded time periods apart), and there is always at least one 0 bit (so that the peaks in the analog signal are at least two encoded time periods apart), resulting in a (1,3) RLL code. (1,3) RLL/MFM is the oldest code still in general use today, but is only really used in floppy drives which need to remain backwards-compatible.

These constraints help avoid intersymbol interference, but the need to separate the peaks reduces the recording density and therefore the amount of data which can be stored on a disk. To increase the recording density, MFM was gradually replaced by (2,7) RLL (the original "RLL" format), and that in turn by (1,7) RLL, each of which placed less constraints on the recorded signal.

Using our knowledge of how the data is encoded, we can now choose which decoded data patterns to write in order to obtain the desired encoded signal. The three encoding methods described above cover the vast majority of magnetic disk drives. However, each of these has several possible variants. With MFM, only one is used with any frequency, but the newest (1,7) RLL code has at least half a dozen variants in use. For MFM with at most four bit times between transitions, the lowest write frequency possible is attained by writing the repeating decoded data patterns 1010 and 0101. These have a 1 bit every other "data" bit, and the intervening "clock" bits are all 0. We would also like patterns with every other clock bit set to 1 and all others set to 0, but these are not possible in the MFM encoding (such "violations" are used to generate special marks on the disk to identify sector boundaries). The best we can do here is three bit times between transitions, which is generated by repeating the decoded patterns 100100, 010010 and 001001. We should use several passes with these patterns, as MFM drives are the oldest, lowest-density drives around (this is especially true for the very-low-density floppy drives). As such, they are the easiest to recover data from with modern equipment and we need to take the most care with them.

From MFM we jump to the next simplest case, which is (1,7) RLL. Although there can be as many as 8 bit times between transitions, the lowest sustained frequency we can have in practice is 6 bit times between transitions. This is a desirable property from the point of view of the clock-recovery circuitry, and all (1,7) RLL codes seem to have this property. We now need to find a way to write the desired pattern without knowing the particular (1,7) RLL code used. We can do this by looking at the way the drives error-correction system works. The error- correction is applied to the decoded data, even though errors generally occur in the encoded data. In order to make this work well, the data encoding should have limited error amplification, so that an erroneous encoded bit should affect only a small, finite number of decoded bits.

Decoded bits therefore depend only on nearby encoded bits, so that a repeating pattern of encoded bits will correspond to a repeating pattern of decoded bits. The repeating pattern of encoded bits is 6 bits long. Since the rate of the code is 2/3, this corresponds to a repeating pattern of 4 decoded bits. There are only 16 possibilities for this pattern, making it feasible to write all of them during the erase process. So to achieve good overwriting of (1,7) RLL disks, we write the patterns 0000, 0001, 0010, 0011, 0100, 0101, 0110, 0111, 1000, 1001, 1010, 1011, 1100, 1101, 1110, and 1111. These patterns also conveniently cover two of the ones needed for MFM overwrites, although we should add a few more iterations of the MFM-specific patterns for the reasons given above.

Finally, we have (2,7) RLL drives. These are similar to MFM in that an eight-bit-time signal can be written in some phases, but not all. A six-bit-time signal will fill in the remaining cracks. Using a « encoding rate, an eight-bit-time signal corresponds to a repeating pattern of 4 data bits. The most common (2,7) RLL code is shown below:

The most common (2,7) RLL Code

Decoded Data	(2,7) RLL Encoded Data
00	1000
01	0100
100	001000
101	100100
111	000100
1100	00001000
1101	00100100

The second most common (2,7) RLL code is the same but with the "decoded data" complemented, which doesn't alter these patterns. Writing the required encoded data can be achieved for every other phase using patterns of 0x33, 0x66, 0xCC and 0x99, which are already written for (1,7) RLL drives.

Six-bit-time patterns can be written using 3-bit repeating patterns. The all-zero and all-one patterns overlap with the (1,7) RLL patterns, leaving six others:

```
001001001001001001001001
   2   4   9   2   4   9
```

in binary or 0x24 0x92 0x49, 0x92 0x49 0x24 and 0x49 0x24 0x92 in hex, and

```
011011011011011011011011
   6   D   B   6   D   B
```

in binary or 0x6D 0xB6 0xDB, 0xB6 0xDB 0x6D and 0xDB 0x6D 0xB6 in hex. The first three are the same as the MFM patterns, so we need only three extra patterns to cover (2,7) RLL drives.

Although (1,7) is more popular in recent (post-1990) drives, some older hard drives do still use (2,7) RLL, and with the ever-increasing reliability of newer drives it is likely that they will remain in use for some time to come, often being passed down from one machine to another. The above three patterns also cover any problems with endianness issues, which weren't a concern in the previous two cases, but would be in this case (actually, thanks to the strong influence of IBM mainframe drives, everything seems to be uniformly big-endian within bytes, with the most significant bit being written to the disk first).

The latest high-density drives use methods like Partial-Response Maximum-Likelihood (PRML) encoding, which may be roughly equated to the trellis encoding done by V.32 modems in that it is effective but computationally expensive. PRML codes are still RLL codes, but with somewhat different constraints. A typical code might have (0,4,4) constraints in which the 0 means that 1's in a data stream can occur right next to 0's (so that peaks in the analog readback signal are not separated), the first 4 means that there can be no more than four 0's between 1's in a data stream, and the second 4 specifies the maximum number of 0's between 1's in certain symbol subsequences. PRML codes avoid intersymbol influence errors by using digital filtering techniques to shape the read signal to exhibit desired frequency and timing characteristics (this is the "partial response" part of PRML) followed by maximum- likelihood digital data detection to determine the most likely sequence of data bits that was written to the disk (this is the "maximum likelihood" part of PRML). PRML channels achieve the same low bit error rate as standard peak-detection methods, but with much higher recording densities, while using the same heads and media. Several manufacturers are currently engaged in moving their peak-detection-based product lines across to PRML, giving a 30-40% density increase over standard RLL channels [14].

Since PRML codes don't try to separate peaks in the same way that non-PRML RLL codes do, all we can do is to write a variety of random patterns because the processing inside the drive is too complex to second- guess. Fortunately, these drives push the limits of the magnetic media much more than older drives ever did by encoding data with much smaller magnetic domains, closer to the physical capacity of the magnetic media (the current state of the art in PRML drives has a track density of around 6700 TPI (tracks per inch) and a data recording density of 170 kFCI, nearly double that of the nearest (1,7) RLL equivalent. A convenient side-effect of these very high recording densities is that a written transition may experience the write field cycles for successive transitions, especially at the track edges where the field distribution is much broader [15]. Since this is also where remnant data is most likely to be found, this can only help in reducing the recoverability of the data). If these drives require sophisticated signal processing just to read the most recently written data, reading overwritten layers is also correspondingly more difficult. A good scrubbing with random data will do about as well as can be expected.

We now have a set of 22 overwrite patterns which should erase everything, regardless of the raw encoding. The basic disk eraser can be improved slightly by adding random passes before and after the erase process, and by performing the deterministic passes in random order to make it more difficult to guess which of the known data passes were made at which point. To deal with all this in the overwrite process, we use the sequence of 35 consecutive writes shown below:

Overwrite Data

Pass No.	Data Written	Encoding Scheme Targeted		
1	Random			
2	Random			
3	Random			
4	Random			
5	01010101 01010101 01010101 0x55	(1,7) RLL		MFM
6	10101010 10101010 10101010 0xAA	(1,7) RLL		MFM
7	10010010 01001001 00100100 0x92 0x49 0x24		(2,7) RLL	MFM
8	01001001 00100100 10010010 0x49 0x24 0x92		(2,7) RLL	MFM
9	00100100 10010010 01001001 0x24 0x92 0x49		(2,7) RLL	MFM
10	00000000 00000000 00000000 0x00	(1,7) RLL	(2,7) RLL	
11	00010001 00010001 00010001 0x11	(1,7) RLL		
12	00100010 00100010 00100010 0x22	(1,7) RLL		
13	00110011 00110011 00110011 0x33	(1,7) RLL	(2,7) RLL	
14	01000100 01000100 01000100 0x44	(1,7) RLL		
15	01010101 01010101 01010101 0x55	(1,7) RLL		MFM
16	01100110 01100110 01100110 0x66	(1,7) RLL	(2,7) RLL	
17	01110111 01110111 01110111 0x77	(1,7) RLL		
18	10001000 10001000 10001000 0x88	(1,7) RLL		
19	10011001 10011001 10011001 0x99	(1,7) RLL	(2,7) RLL	
20	10101010 10101010 10101010 0xAA	(1,7) RLL		MFM
21	10111011 10111011 10111011 0xBB	(1,7) RLL		
22	11001100 11001100 11001100 0xCC	(1,7) RLL	(2,7) RLL	
23	11011101 11011101 11011101 0xDD	(1,7) RLL		
24	11101110 11101110 11101110 0xEE	(1,7) RLL		
25	11111111 11111111 11111111 0xFF	(1,7) RLL	(2,7) RLL	
26	10010010 01001001 00100100 0x92 0x49 0x24		(2,7) RLL	MFM
27	01001001 00100100 10010010 0x49 0x24 0x92		(2,7) RLL	MFM
28	00100100 10010010 01001001 0x24 0x92 0x49		(2,7) RLL	MFM
29	01101101 10110110 11011011 0x6D 0xB6 0xDB		(2,7) RLL	

30	`10110110 11011011 01101101 0xB6 0xDB 0x6D`	(2,7) RLL
31	`11011011 01101101 10110110 0xDB 0x6D 0xB6`	(2,7) RLL
32	Random	
33	Random	
34	Random	
35	Random	

The MFM-specific patterns are repeated twice because MFM drives have the lowest density and are thus particularly easy to examine. The deterministic patterns between the random writes are permuted before the write is performed, to make it more difficult for an opponent to use knowledge of the erasure data written to attempt to recover overwritten data (in fact we need to use a cryptographically strong random number generator to perform the permutations to avoid the problem of an opponent who can read the last overwrite pass being able to predict the previous passes and "echo cancel" passes by subtracting the known overwrite data).

If the device being written to supports caching or buffering of data, this should be disabled to ensure that physical disk writes are performed for each pass instead of everything but the last pass being lost in the buffering. For example physical disk access can be forced during SCSI-2 Group 1 write commands by setting the Force Unit Access bit in the SCSI command block (although at least one popular drive has a bug which causes all writes to be ignored when this bit is set - remember to test your overwrite scheme before you deploy it). Another consideration which needs to be taken into account when trying to erase data through software is that drives conforming to some of the higher-level protocols such as the various SCSI standards are relatively free to interpret commands sent to them in whichever way they choose (as long as they still conform to the SCSI specification). Thus some drives, if sent a FORMAT UNIT command may return immediately without performing any action, may simply perform a read test on the entire disk (the most common option), or may actually write data to the disk (the SCSI- 2 standard includes an initialization pattern (IP) option for the FORMAT UNIT command, however this is not necessarily supported by existing drives).

If the data is very sensitive and is stored on floppy disk, it can best be destroyed by removing the media from the disk liner and burning it, or by burning the entire disk, liner and all (most floppy disks burn remarkably well - albeit with quantities of oily smoke - and leave very little residue).

Other Methods of Erasing Magnetic Media

The previous section has concentrated on erasure methods which require no specialised equipment to perform the erasure. Alternative means of erasing media which do require specialised equipment are degaussing (a process in which the recording media is returned to its initial state) and physical destruction. Degaussing is a reasonably effective means of purging data from magnetic disk media, and will even work through most drive cases (research has shown that the aluminium housings of most disk drives attenuate the degaussing field by only about 2 dB [16]).

The switching of a single-domain magnetic particle from one magnetization direction to another requires the overcoming of an energy barrier, with an external magnetic field helping to lower this barrier. The switching depends not only on the magnitude of the external field, but also on the length of time for which it is applied. For typical disk drive media, the short-term field needed to flip enough of the magnetic domains to be useful in recording a signal is about 1/3 higher than the coercivity of the media (the exact figure varies with different media types) [17].

However, to effectively erase a medium to the extent that recovery of data from it becomes uneconomical requires a magnetic force of about five times the coercivity of the medium [18], although even small external magnetic fields are sufficient to upset the normal operation of a hard disk (typically a few gauss at DC, dropping to a few milligauss at 1 MHz). Coercivity (measured in Oersteds, Oe) is a property of magnetic material and is defined as the amount of magnetic field necessary to reduce the magnetic induction in the material to zero - the higher the coercivity, the harder it is to erase data from a medium. Typical figures for various types of magnetic media are given below:

Typical Media Coercivity Figures

Medium	Coercivity
5.25" 360K floppy disk	300 Oe
5.25" 1.2M floppy disk	675 Oe
3.5" 720K floppy disk	300 Oe
3.5" 1.44M floppy disk	700 Oe
3.5" 2.88M floppy disk	750 Oe
3.5" 21M floptical disk	750 Oe
Older (1980's) hard disks	900-1400 Oe
Newer (1990's) hard disks	1400-2200 Oe
1/2" magnetic tape	300 Oe
1/4" QIC tape	550 Oe
8 mm metallic particle tape	1500 Oe
DAT metallic particle tape	1500 Oe

US Government guidelines class tapes of 350 Oe coercivity or less as low-energy or Class I tapes and tapes of 350-750 Oe coercivity as high-energy or Class II tapes. Degaussers are available for both types of tapes. Tapes of over 750 Oe coercivity are referred to as Class III, with no known degaussers capable of fully erasing them being known [19], since even the most powerful commercial AC degausser cannot generate the recommended 7,500 Oe needed for full erasure of a typical DAT tape currently used for data backups.

Degaussing of disk media is somewhat more difficult - even older hard disks generally have a coercivity equivalent to Class III tapes, making them fairly difficult to erase at the outset. Since manufacturers rate their degaussers in peak gauss and measure the field at a certain orientation which may not be correct for the type of medium being erased, and since degaussers tend to be rated by whether they erase sufficiently for clean rerecording rather than whether they make the information impossible to recover, it may be necessary to resort to physical destruction of the media to completely sanitise it (in fact since degaussing destroys the sync bytes, ID fields, error correction information, and other paraphernalia needed to identify sectors on the media, thus rendering the drive unusable, it makes the degaussing process mostly equivalent to physical destruction). In addition, like physical destruction, it requires highly specialised equipment which is expensive and difficult to obtain (one example of an adequate degausser was the 2.5 MW Navy research magnet used by a former Pentagon site manager to degauss a 14" hard drive for 1« minutes. It bent the platters on the drive and probably succeeded in erasing it beyond the capabilities of any data recovery attempts [20]).

Secure Deletion of Data from Magnetic and Solid-State Memory

Further Problems with Magnetic Media

A major issue which cannot be easily addressed using any standard software-based overwrite technique is the problem of defective sector handling. When the drive is manufactured, the surface is scanned for defects which are added to a defect list or flaw map. If further defects, called grown defects, occur during the life of the drive, they are added to the defect list by the drive or by drive management software. There are several techniques which are used to mask the defects in the defect list. The first, alternate tracks, moves data from tracks with defects to known good tracks. This scheme is the simplest, but carries a high access cost, as each read from a track with defects requires seeking to the alternate track and a rotational latency delay while waiting for the data location to appear under the head, performing the read or write, and, if the transfer is to continue onto a neighbouring track, seeking back to the original position. Alternate tracks may be interspersed among data tracks to minimise the seek time to access them.

A second technique, alternate sectors, allocates alternate sectors at the end of the track to minimise seeks caused by defective sectors. This eliminates the seek delay, but still carries some overhead due to rotational latency. In addition it reduces the usable storage capacity by 1-3%.

A third technique, inline sector sparing, again allocates a spare sector at the end of each track, but resequences the sector ID's to skip the defective sector and include the spare sector at the end of the track, in effect pushing the sectors past the defective one towards the end of the track. The associated cost is the lowest of the three, being one sector time to skip the defective sector [21].

The handling of mapped-out sectors and tracks is an issue which can't be easily resolved without the cooperation of hard drive manufacturers. Although some SCSI and IDE hard drives may allow access to defect lists and even to mapped-out areas, this must be done in a highly manufacturer- and drive-specific manner. For example the SCSI-2 READ DEFECT DATA command can be used to obtain a list of all defective areas on the drive. Since SCSI logical block numbers may be mapped to arbitrary locations on the disk, the defect list is recorded in terms of heads, tracks, and sectors. As all SCSI device addressing is performed in terms of logical block numbers, mapped-out sectors or tracks cannot be addressed. The only reasonably portable possibility is to clear various automatic correction flags in the read-write error recovery mode page to force the SCSI device to report read/write errors to the user instead of transparently remapping the defective areas. The user can then use the READ LONG and WRITE LONG commands (which allow access to sectors and extra data even in the presence of read/write errors), to perform any necessary operations on the defective areas, and then use the REASSIGN BLOCKS command to reassign the defective sections. However this operation requires an in-depth knowledge of the operation of the SCSI device and extensive changes to disk drivers, and more or less defeats the purpose of having an intelligent peripheral.

The ANSI X3T-10 and X3T-13 subcommittees are currently looking at creating new standards for a Universal Security Reformat command for IDE and SCSI hard disks which will address these issues. This will involve a multiple-pass overwrite process which covers mapped-out disk areas with deliberate off-track writing. Many drives available today can be modified for secure erasure through a firmware upgrade, and once the new firmware is in place the erase procedure is handled by the drive itself, making unnecessary any interaction with the host system beyond the sending of the command which begins the erase process.

Long-term ageing can also have a marked effect on the erasability of magnetic media. For example, some types of magnetic tape become increasingly difficult to erase after being stored at an elevated temperature or having contained the same magnetization pattern for a considerable period of time [22]. The same applies for magnetic disk media, with decreases in erasability of several dB being recorded [23]. The erasability of the data depends on the amount of time it has been stored on the media, not on the age of the media itself (so that, for example, a five-year-old freshly-written disk is no less erasable than a new freshly-written disk).

The dependence of media coercivity on temperature can affect overwrite capability if the data was initially recorded at a temperature where the coercivity was low (so that the recorded pattern penetrated deep into the media), but must be overwritten at a temperature where the coercivity is relatively high. This is important in hard disk drives, where the temperature varies depending on how long the unit has been used and, in the case of drives with power-saving features enabled, how recently and frequently it has been used. However the overwrite performance depends not only on temperature-dependent changes in the media, but also on temperature-dependent changes in the read/write head. Thankfully the combination of the most common media used in current drives with various common types of read/write heads produce a change in overwrite performance of only a few hundredths of a decibel per degree over the temperature range -40°C to + 40°C, as changes in the head compensate for changes in the media [24].

Another issue which needs to be taken into account is the ability of most newer storage devices to recover from having a remarkable amount of damage inflicted on them through the use of various error-correction schemes. As increasing storage densities began to lead to multiple-bit errors, manufacturers started using sophisticated error-correction codes (ECC's) capable of correcting multiple error bursts. A typical drive might have 512 bytes of data, 4 bytes of CRC, and 11 bytes of ECC per sector. This ECC would be capable of correcting single burst errors of up to 22 bits or double burst errors of up to 11 bits, and can detect a single burst error of up to 51 bits or three burst errors of up to 11 bits in length [25]. Another drive manufacturer quotes the ability to correct up to 120 bits, or up to 32 bits on the fly, using 198-bit Reed-Solomon ECC [26]. Therefore even if some data is reliably erased, it may be possible to recover it using the built-in error-correction capabilities of the drive. Conversely, any erasure scheme which manages to destroy the ECC information (for example through the use of the SCSI-2 WRITE LONG command which can be used to write to areas of a disk sector outside the normal data areas) stands a greater chance of making the data unrecoverable.

Sidestepping the Problem

The easiest way to solve the problem of erasing sensitive information from magnetic media is to ensure that it never gets to the media in the first place. Although not practical for general data, it is often worthwhile to take steps to keep particularly important information such as encryption keys from ever being written to disk. This would typically happen when the memory containing the keys is paged out to disk by the operating system, where they can then be recovered at a later date, either manually or using software which is aware of the in-memory data format and can locate it automatically in the swap file (for example there exists software which will search the Windows swap file for keys from certain DOS encryption programs). An even worse situation occurs when the data is paged over a network, allowing anyone with a packet sniffer or similar tool on the same subnet to observe the information (for example there exists software which will monitor and even alter NFS traffic on the fly which could be modified to look for known in-memory data patterns moving to and from a networked swap disk [27]).

To solve these problems the memory pages containing the information can be locked to prevent them from being paged to disk or transmitted over a network. This approach is taken by at least one encryption library, which allocates all keying information inside protected memory blocks visible to the user only as opaque handles, and then optionally locks the memory (provided the underlying OS allows it) to prevent it from being paged [28]. The exact details of locking pages in memory depend on the operating system being used. Many Unix systems now support the `mlock()`/`munlock()` calls or have some alternative mechanism hidden among the `mmap()`-related functions which can be used to lock pages in memory. Unfortunately these operations require superuser privileges because of their potential impact on system performance if large ranges of memory are locked. Other systems such as Microsoft Windows NT allow user processes to lock memory with the `VirtualLock()`/`VirtualUnlock()` calls, but limit the total number of regions which can be locked.

Most paging algorithms are relatively insensitive to having sections of memory locked, and can even relocate the locked pages (since the logical to physical mapping is invisible to the user), or can move the pages to a "safe" location when the memory is first locked. The main effect of locking pages in memory is to increase the minimum working set size which, taken in moderation, has little noticeable effect on performance. The overall effects depend on the operating system and/or hardware implementations of virtual memory. Most Unix systems have a global page replacement policy in which a page fault may be satisfied by any page frame. A smaller number of operating systems use a local page replacement policy in which pages are allocated from a fixed (or occasionally dynamically variable) number of page frames allocated on a per- process basis. This makes them much more sensitive to the effects of locking pages, since every locked page decreases the (finite) number of pages available to the process. On the other hand it makes the system as a whole less sensitive to the effects of one process locking a large number of pages. The main effective difference between the two is that under a local replacement policy a process can only lock a small fixed number of pages without affecting other processes, whereas under a global replacement policy the number of pages a process can lock is determined on a system-wide basis and may be affected by other processes.

In practice neither of these allocation strategies seem to cause any real problems. Although any practical measurements are very difficult to perform since they vary wildly depending on the amount of physical memory present, paging strategy, operating system, and system load, in practice locking a dozen 1K regions of memory (which might be typical of a system on which a number of users are running programs such as mail encryption software) produced no noticeable performance degradation observable by system- monitoring tools. On machines such as network servers handling large numbers of secure connections (for example an HTTP server using SSL), the effects of locking large numbers of pages may be more noticeable.

Secure Deletion of Data from Magnetic and Solid-State Memory

Methods of Recovery for Data stored in Random-Access Memory

Contrary to conventional wisdom, "volatile" semiconductor memory does not entirely lose its contents when power is removed. Both static (SRAM) and dynamic (DRAM) memory retains some information on the data stored in it while power was still applied. SRAM is particularly susceptible to this problem, as storing the same data in it over a long period of time has the effect of altering the preferred power-up state to the state which was stored when power was removed. Older SRAM chips could often "remember" the previously held state for several days. In fact, it is possible to manufacture SRAM's which always have a certain state on power-up, but which can be overwritten later on - a kind of "writeable ROM".

DRAM can also "remember" the last stored state, but in a slightly different way. It isn't so much that the charge (in the sense of a voltage appearing across a capacitance) is retained by the RAM cells, but that the thin oxide which forms the storage capacitor dielectric is highly stressed by the applied field, or is not stressed by the field, so that the properties of the oxide change slightly depending on the state of the data. One thing that can cause a threshold shift in the RAM cells is ionic contamination of the cell(s) of interest, although such contamination is rarer now than it used to be because of robotic handling of the materials and because the purity of the chemicals used is greatly improved. However, even a perfect oxide is subject to having its properties changed by an applied field. When it comes to contaminants, sodium is the most common offender - it is found virtually everywhere, and is a fairly small (and therefore mobile) atom with a positive charge. In the presence of an electric field, it migrates towards the negative pole with a velocity which depends on temperature, the concentration of the sodium, the oxide quality, and the other impurities in the oxide such as dopants from the processing. If the electric field is zero and given enough time, this stress tends to dissipate eventually.

The stress on the cell is a cumulative effect, much like charging an RC circuit. If the data is applied for only a few milliseconds then there is very little "learning" of the cell, but if it is applied for hours then the cell will acquire a strong (relatively speaking) change in its threshold. The effects of the stress on the RAM cells can be measured using the built-in self test capabilities of the cells, which provide the ability to impress a weak voltage on a storage cell in order to measure its margin. Cells will show different margins depending on how much oxide stress has been present. Many DRAM's have undocumented test modes which allow some normal I/O pin to become the power supply for the RAM core when the special mode is active. These test modes are typically activated by running the RAM in a nonstandard configuration, so that a certain set of states which would not occur in a normally-functioning system has to be traversed to activate the mode. Manufacturers won't admit to such capabilities in their products because they don't want their customers using them and potentially rejecting devices which comply with their spec sheets, but have little margin beyond that.

A simple but somewhat destructive method to speed up the annihilation of stored bits in semiconductor memory is to heat it. Both DRAM's and SRAM's will lose their contents a lot more quickly at Tjunction = 140°C than they will at room temperature. Several hours at this temperature with no power applied will clear their contents sufficiently to make recovery difficult. Conversely, to extend the life of stored bits with the power removed, the temperature should be dropped below -60°C. Such cooling should lead to weeks, instead of hours or days, of data retention.

Secure Deletion of Data from Magnetic and Solid-State Memory

Erasure of Data stored in Random-Access Memory

Simply repeatedly overwriting the data held in DRAM with new data isn't nearly as effective as it is for magnetic media. The new data will begin stressing or relaxing the oxide as soon as it is written, and the oxide will immediately begin to take a "set" which will either reinforce the previous "set" or will weaken it. The greater the amount of time that new data has existed in the cell, the more the old stress is "diluted", and the less reliable the information extraction will be. Generally, the rates of change due to stress and relaxation are in the same order of magnitude. Thus, a few microseconds of storing the opposite data to the currently stored value will have little effect on the oxide. Ideally, the oxide should be exposed to as much stress at the highest feasible temperature and for as long as possible to get the greatest "erasure" of the data. Unfortunately if carried too far this has a rather detrimental effect on the life expectancy of the RAM.

Therefore the goal to aim for when sanitising memory is to store the data for as long as possible rather than trying to change it as often as possible. Conversely, storing the data for as short a time as possible will reduce the chances of it being "remembered" by the cell. Based on tests on DRAM cells, a storage time of one second causes such a small change in threshold that it probably isn't detectable. On the other hand, one minute is probably detectable, and 10 minutes is certainly detectable.

The most practical solution to the problem of DRAM data retention is therefore to constantly flip the bits in memory to ensure that a memory cell never holds a charge long enough for it to be "remembered". While not practical for general use, it is possible to do this for small amounts of very sensitive data such as encryption keys. This is particularly advisable where keys are stored in the same memory location for long periods of time and control access to large amounts of information, such as keys used for transparent encryption of files on disk drives. The bit-flipping also has the convenient side-effect of keeping the page containing the encryption keys at the top of the queue maintained by the system's paging mechanism, greatly reducing the chances of it being paged to disk at some point.

Secure Deletion of Data from Magnetic and Solid-State Memory

Conclusion

Data overwritten once or twice may be recovered by subtracting what is expected to be read from a storage location from what is actually read. Data which is overwritten an arbitrarily large number of times can still be recovered provided that the new data isn't written to the same location as the original data (for magnetic media), or that the recovery attempt is carried out fairly soon after the new data was written (for RAM). For this reason it is effectively impossible to sanitise storage locations by simple overwriting them, no matter how many overwrite passes are made or what data patterns are written. However by using the relatively simple methods presented in this paper the task of an attacker can be made significantly more difficult, if not prohibitively expensive.

Secure Deletion of Data from Magnetic and Solid-State Memory

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Frequently Asked Questions

Answers to the most Frequently Asked Questions about Eraser are available at Eraser home page.

Problems?

If you are having troubles using Eraser or have a question that you cannot see answered in the help file, you have two alternative ways of getting more help.

Read the Frequently Asked Questions

Answers to the most Frequently Asked Questions about Eraser are available at Eraser home page.

Read the source code

Eraser source code has been released under GNU GPL and you can download it at the home page.

Upgrading

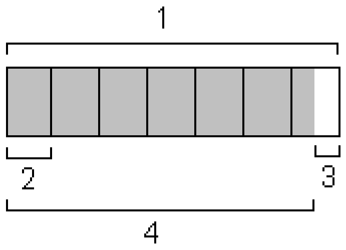
This is the last release of Eraser.

Author

Sami Tolvanen, the author of Eraser is a student in a university of technology in Finland. You can learn more by visiting his home page at http://www.tolvanen.com/sami/.

Eraser Home Page
http://www.tolvanen.com/eraser/

Space Allocated by a File



1 Allocated area (the actual space used).
2 A cluster (the smallest allocated area).
3 The cluster tip (unused area).
4 The file size (used area).

File menu commands

The File menu offers the following commands:

New Task Creates a new task to be added to the list.
View Log Opens the Scheduler log file (if it exists) using the associated viewer.
Import Imports all tasks that are saved in a file.
Export Exports all tasks into a file.
Exit Quits Eraser.

Edit menu commands

The Edit menu offers the following commands:

Paste	Pastes filenames from Explorer to the On-Demand list.
Select All	Selects all tasks on the list.
Delete	Removes the selected task from the list
Properties	Edits properties of the selected task.
Preferences | General	Edits general preferences.
Preferences | Erasing	Edits erasing preferences
Refresh	Refreshes the list.

Process menu commands

The Process menu offers the following commands:

Run	Starts processing the items selected on the list on the On-Demand eraser or the selected task on the Scheduler.
Run All	Starts processing all items on the list.
Stop	Stops processing of the selected task (on the Scheduler).

View menu commands

The View menu offers the following commands:

Toolbar	Shows or hides the toolbar.
Status Bar	Shows or hides the status bar.
Information Bar	Shows or hides the information bar.

Help menu commands

The Help menu offers the following commands, which provide you assistance with this application:

Help Topics Offers you an index to topics on which you can get help.

About Displays the version number of this application.

New Task command (File menu)

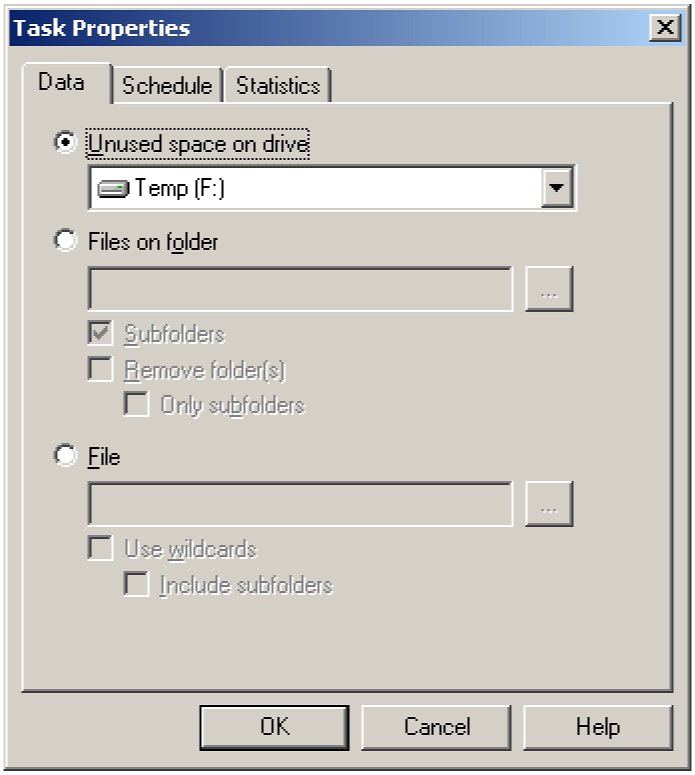
Use this command to create a task to be added to the On-Demand or the Scheduler list. Use the task properties window to define properties of the newly created task.

Shortcuts

Toolbar:
Keys: Ctrl+N

Task Properties - Data

On the first page of the task properties window you can set the data to be erased.



● Unused space on drive

Temp (F:)

○ Files on folder

☑ Subfolders

☐ Remove folder(s)

☐ Only subfolders

○ File

☐ Use wildcards

☐ Include subfolders

If you want to erase **unused data on a drive**, choose the first option and select a drive from the list. If you select **“All local hard drives”**, Eraser will overwrite unused space on every hard drive on the computer.

If you want to erase **files in a folder**, choose the second option and click the button to browse to the folder to be erased. If you do not want all files in the subfolders be erased as well, deselect the **“Subfolders”** option. If you would like the folder to be removed after erasing, select the **“Remove Folder(s)”** option, which will also force erasing of subfolders. You can leave the main folder and remove only subfolders by selecting the **“Only Subfolders”** option.

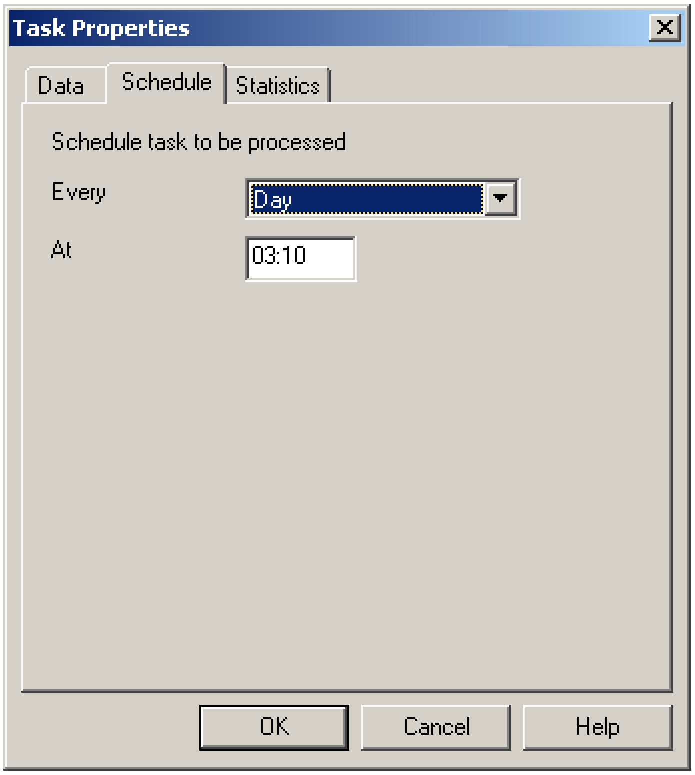
If you want to erase **a file**, choose the third option, click the button to open a file selection dialog box and browse to the file you want to be erased. If you select the **“Use Wildcards”** option, you may edit the filename manually and include wildcards in it – e.g. “C:\Windows\Temp\*.tmp” would erase all files with “.tmp” extension from the “C:\Windows\Temp” folder. If you want the wildcard search to be extended to the subfolders, select **“Include Subfolders”** – if this option is selected the previous command would also erase all files with “.tmp” extension from the subfolders of “C:\Windows\Temp” directory.

When using the On-Demand eraser, you can select the **“Keep Task on List”** option to set the task to stay on the list even after being erased – otherwise the task will be removed from the list after being processed. This option is not available when using the Scheduler.

When using the On-Demand eraser, this is the only information you will need to specify for a task. If you are using the Scheduler, you will need to continue to the next page.

Task Properties - Schedule

If you are using the Scheduler, in addition to what, you will also need to specify when to erase.



Schedule task to be processed

Every Day

At 03:10

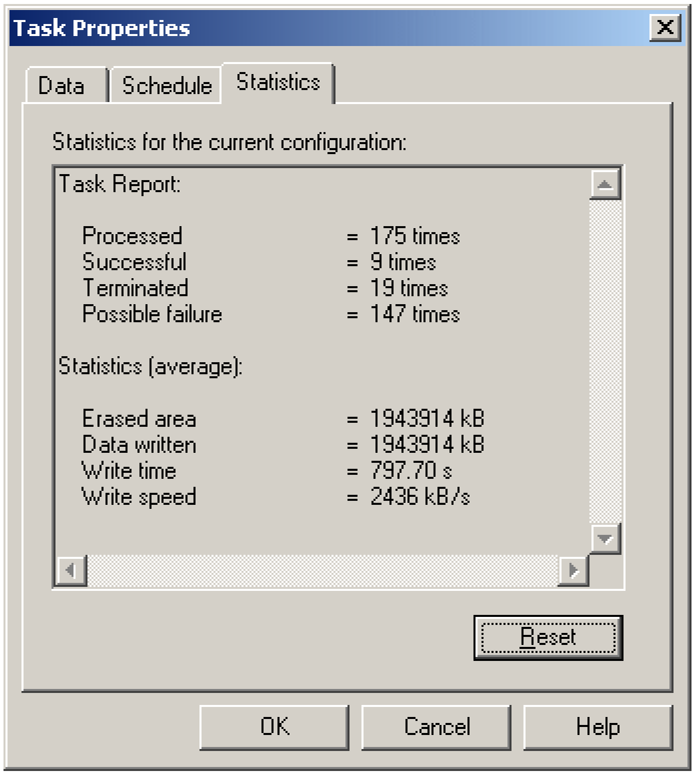
You can set a task to be processed **daily** or **weekly** by selecting the desired schedule from the list.

After selecting the day, you will need to enter the **time of the day**. The PM check box is available only if Windows is set to have 12-hour clock.

After saving the task by clicking OK, the Scheduler will run it at scheduled time. To view the results and statistics for the run, continue to the last page (only available on the Scheduler).

Task Properties - Statistics

On the last page you can view the statistics for the scheduled runs.



Statistics for the current configuration:

```
Task Report:

   Processed                 =  175 times
   Successful                =  9 times
   Terminated                =  19 times
   Possible failure          =  147 times

Statistics (average):

   Erased area               =  1943914 kB
   Data written              =  1943914 kB
   Write time                =  797.70 s
   Write speed               =  2436 kB/s
```

The page provides information about the success of the procedures and also gives statistics for the completed runs. The statistics will be reset when you change the data to be erased. You can also manually reset the statistics by pressing the **“Reset”** button.

View Log command (File menu)

Use this command to open the Scheduler log file with an associated viewer (if the file exists). To learn more about the Scheduler logging feature, see Viewing Results.

Shortcuts

Keys: Ctrl+L

Import command (File menu)

Use this command to import tasks from file.

For example, if you were previously using Eraser 4.1, you can export the scheduled tasks into a file, uninstall Eraser 4.1, install the new version and import the old tasks to be used with the new Scheduler. This way you do not need to re-enter all tasks manually.

You can export tasks into a file by using the export command.

Export command (File menu)

Use this command to export all tasks defined in the On-Demand eraser and the Scheduler into a file. The file format
Used by this version of Eraser is not compatible with the old version.

However, you may still import tasks from files created with older versions of Eraser using the import command.

Exit command (File menu)

Use this command to close Eraser.   You can also use the Close command on the application Control menu. Eraser will save all tasks in the On-Demand list and the Scheduler list into “default.ers” file.

When you quit Eraser, the Scheduler will be closed too and is therefore, unable to run scheduled tasks. You can minimize Eraser as a taskbar tray icon using the minimize command.

Shortcuts

Mouse: Double-click the application's Control menu button.

Click the close button on the title bar.

☒

Keys: Alt+F4

Paste command (Edit menu)

Use this command to insert files copied from the Windows Explorer to the On-Demand list.   This command is unavailable if there are no files on the clipboard and when the Scheduler view is active.

Shortcuts

Toolbar: 📋

Keys: Ctrl+V

Select All command (Edit menu)

Use this command to select all tasks on the list.

Shortcuts

Keys:	Ctrl+A

Delete command (Edit menu)

Use this command to remove the selected tasks from the list.

Shortcuts

Toolbar: ✕
Keys: Del

Properties command (Edit menu)

Use this command to edit the properties of the selected task using the task properties window.

Shortcuts

Toolbar:	
Keys:	Alt+Enter

Refresh command (Edit menu)

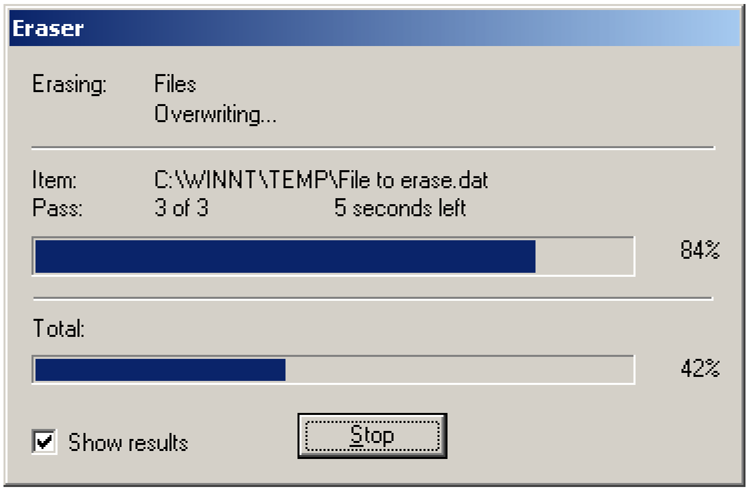
Use this command to refresh the list.

Shortcuts

Keys:	F5

Progress window

Eraser will show you progress information while erasing data. You can stop erasing any time by pressing the Stop button.


Eraser

Erasing: Files
Overwriting...

Item: C:\WINNT\TEMP\File to erase.dat
Pass: 3 of 3 5 seconds left

84%

Total:

42%

☑ Show results

The window consists of the following sections:

The type of the data being erased; possible values are

Files	When erasing files
Unused disk space	When erasing unused disk space
Source files	When using the Secure Move feature
Recycle Bin	When erasing Recycle Bin

The task currently being processed; possible values are

Overwriting	When erasing files or unused disk space
File names	When erasing files
Cluster tips	When erasing unused disk space
Directory entries	When erasing unused disk space
Master File Table records	When erasing unused disk space (Windows NT/2000 and NTFS drives only)

The data being erased

File name	When erasing files or cluster tips
Drive letter	When erasing unused disk space

The pass information ([current] of [total])

When erasing unused disk space Eraser will write several temporary files to the drive instead of one huge to improve performance and this value will show the pass being written to the current temporary file.

The estimated time left to finish

Nothing will be shown if less than five seconds.

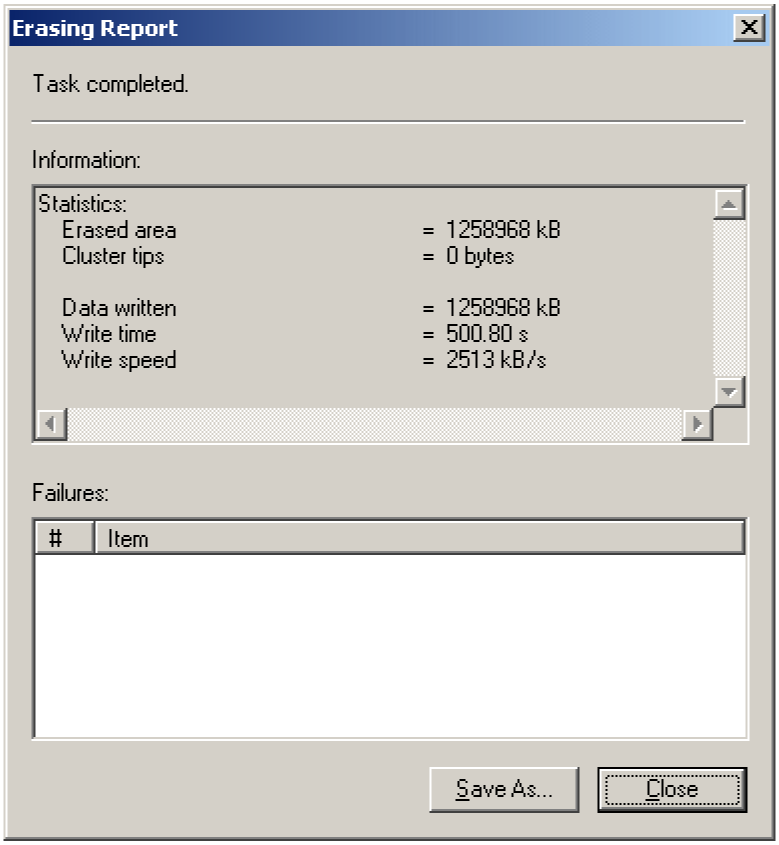
The progress bar (percent completed)

Progress information on the top progress bar shows completion percent for the item currently being processed, and the bottom progress bar shows the total progress.

When using the Shell Extension there will be a check box on the bottom of the window allowing you to choose whether to show the results (you can also change this setting using the General Preferences window). When using other user interfaces or when the show results option is selected, the Erasing Report window will be shown after the operation.

Erasing Report

After the operation Eraser will show you the summary of results in the Erasing Report window.



Task completed.

Information:

```
Statistics:
   Erased area                          =  1258968 kB
   Cluster tips                         =  0 bytes

   Data written                         =  1258968 kB
   Write time                           =  500.80 s
   Write speed                          =  2513 kB/s
```

Failures:

#	Item

The window consist of the following sections:

Status

Tells you whether Eraser was able to complete the task without interruptions. Even though the task is completed, it does not mean that all data was successfully erased. The possible values are:

Task completed.
All overwriting was completed.

Task terminated by user.
Overwriting could not be completed, because user terminated the operation.

Task was not completed.
An error occurred during overwriting that prevented Eraser from completing the task.

Information

Total size of erased area (including cluster tip area).

Cluster tips (the size of the cluster tip area erased; this is how much possibly sensitive data may have been on your drive without you ever knowing).

Total amount of data written (should be equal to the amount of passes multiplied with the total size of the erased area.

Time used (how long it took to write the data to the disk; actual time required may be longer due to other tasks performed during operation – like creating folders, deleting files, etc.).

Speed (the write speed)

Failures

Shows you a list of items that could not be properly processed or errors that occurred during overwriting.

Run command (Process menu)

Use this command to start the erasing of the selected items on the list when using the On-Demand eraser or start running of the selected task when using the Scheduler.

Shortcuts

Toolbar:	
Keys:	Ctrl+R

Run All command (Process menu)

Use this command to start the erasing of all items on the list when using the On-Demand eraser or start running all tasks when using the Scheduler.

Shortcuts

Toolbar:	
Keys:	Ctrl+Alt+R

Stop command (Process menu)

Use this command to stop the processing of the selected task on the Scheduler.

Shortcuts

Toolbar:	✖
Keys:	Ctrl+S

Open command (Tray menu)

Use this command to open the main window. You can minimize it again to the taskbar tray using the minimize command.

Enabled command (Tray menu)

Use this command to change the Scheduler state to disabled. When the Scheduler is disabled, it ignores the scheduled tasks until you enable it again.

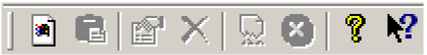
The tray icon will change to signal when the Scheduler is in disabled state. See the basics of the Scheduler for more information.

Toolbar command (View menu)

Use this command to display and hide the Toolbar, which includes buttons for some of the most common commands in Eraser. A check mark appears next to the menu item when the Toolbar is displayed.

See Toolbar for help on using the toolbar.

Toolbar



The toolbar is displayed across the top of the application window, below the menu bar. The toolbar provides quick mouse access to many tools used in Eraser,

To hide or display the Toolbar, choose Toolbar from the View menu (Alt, V, T).

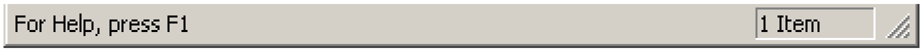
Click	To
	Create a new task.
	Paste files from Explorer to the On-Demand list.
	Edit properties of the selected task.
	Remove the selected tasks from the list.
	Run the selected task on the Scheduler or start erasing on the On-Demand eraser.
	Stop executing the selected Scheduler task.
?	View version information and copyright.
?	View help for some portion of the program.

Status Bar command (View menu)

Use this command to display and hide the Status Bar, which describes the action to be executed by the selected menu item or depressed toolbar button and the amount of tasks on the list. A check mark appears next to the menu item when the Status Bar is displayed.

See Status Bar for help on using the status bar.

Status Bar



For Help, press F1

1 Item

The status bar is displayed at the bottom of the Eraser window.   To display or hide the status bar, use the Status Bar command in the View menu.

The left area of the status bar describes actions of menu items as you use the arrow keys to navigate through menus.   This area similarly shows messages that describe the actions of toolbar buttons as you depress them, before releasing them.   If after viewing the description of the toolbar button command you wish not to execute the command, then release the mouse button while the pointer is off the toolbar button.

The right area of the status bar indicates the amount of tasks on the list.

Information Bar command (View menu)

Use this command to display and hide the Information Bar, shows the selected view (On-Demand, Scheduler or Explorer). A check mark appears next to the menu item when the Information Bar is displayed.

See Information Bar for more information.

Information Bar

The information bar is displayed at the top of the list.   To display or hide the information bar, use the Information Bar command in the View menu.

The information bar shows the name of the selected view: On-Demand, Scheduler or Explorer.

Help Topics command (Help menu)

Use this command to show the Help Topics.

About command (Help menu)

Use this command to display the copyright notice and version number of your copy of Eraser.

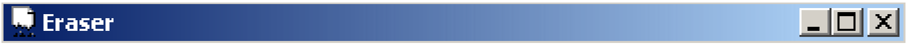
Context Help command

Use the Context Help command to obtain help on some portion of Eraser.   When you choose the Toolbar's Context Help button, the mouse pointer will change to an arrow and question mark.   Then click somewhere in the Eraser window, such as another Toolbar button.   The Help topic will be shown for the item you clicked.

Shortcut

Keys:	Shift+F1

Title Bar



The title bar is located along the top of a window. It contains the name of the application, the application control (system) menu and some shortcut buttons. If the Information bar is not visible, the title bar also contains the selected view.

To move the window, drag the title bar. Note: You can also move dialog boxes by dragging their title bars.

A title bar may contain the following elements:

- Application Control-menu button
- Maximize button
- Minimize button
- Name of the application
- Restore button

Scroll bars

Displayed at the right and bottom edges of the list. The scroll boxes inside the scroll bars indicate your vertical and horizontal location in the list view.   You can use the mouse to scroll to other parts of the document.

Size command (System menu)

Use this command to display a four-headed arrow so you can size the active window with the arrow keys.

✥

After the pointer changes to the four-headed arrow:

1. Press one of the DIRECTION keys (left, right, up, or down arrow key) to move the pointer to the border you want to move.
2. Press a DIRECTION key to move the border.
3. Press ENTER when the window is the size you want.

Note: This command is unavailable if you maximize the window.

Shortcut

Mouse: Drag the size bars at the corners or edges of the window.

Move command (Control menu)

Use this command to display a four-headed arrow so you can move the active window or dialog box with the arrow keys.

Note: This command is unavailable if you maximize the window.

Shortcut

Keys: Ctrl+F7

Minimize command (application Control menu)

Use this command to reduce the Eraser window to a taskbar tray icon. To show the main window again, double-click the taskbar tray icon.

Shortcut

Mouse: Click the minimize icon 🗕 on the title bar.
Keys: Alt+F9

Maximize command (System menu)

Use this command to enlarge the active window to fill the available space.

Shortcut

Mouse: Click the maximize icon □ on the title bar; or double-click the title bar.
Keys: Ctrl+F10 enlarges a document window.

Close command (Control menus)

Use this command to close the Eraser application.

Double-clicking a Control-menu box is the same as choosing the Close command.

Shortcuts

Keys: Alt+F4 closes the main application

Restore command (Control menu)

Use this command to return the active window to its size and position before you chose the Maximize command.

No Help Available

No help is available for this area of the window.

No Help Available

No help is available for this message box.