Secure File Deletion

Presented by John Krout
For PATACS+OPCUG
Saturday, July 15, 2024

Agenda

- What is a file?
- How does Windows delete a file?
- How does File Recovery software work?
- Why is deleting a file *securely* useful?
- How to use secure file deletion applications
    - CCleaner Free (zero-cost)
    - File Shredder (zero-cost)
    - System Mechanic (commercial)

What is a file?

What is a file?

- Most of us have a good intuitive understanding of the nature and purpose of a file:
- Name
- Data inside: text, music, photo, video or a combination
- Each file is stored in a persistent *storage device* such as a hard drive, Solid-State Drive (SSD), USB flash drive, or network drive, and on a *folder path* in the device.
- Windows File Explorer and the Windows File Open dialog window allow folder and file browsing

What is a File *System*?

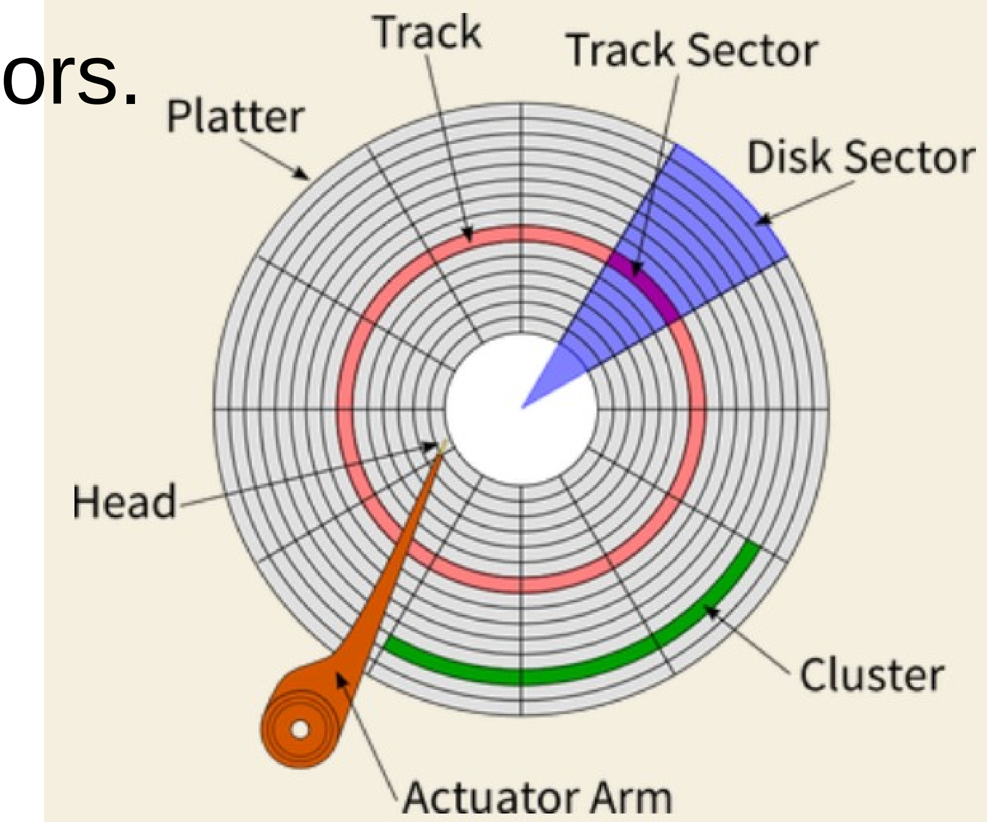
- A **File System** is a way of storing files and descriptions of file so that the computer, and the computer user, can create, find, update, and delete files easily.
- The descriptions of files (metadata) typically are stored in a special container called a **File Allocation Table (FAT)**. Each description includes a pointer to the start of the file in storage.
- Each storage device includes a FAT: internal hard drive, internal Solid-State Drive (SSD), USB hard drive, USB SSD, USB flash drive, Network Attached Storage (NAS), Cloud storage.

How does a file exist in storage?

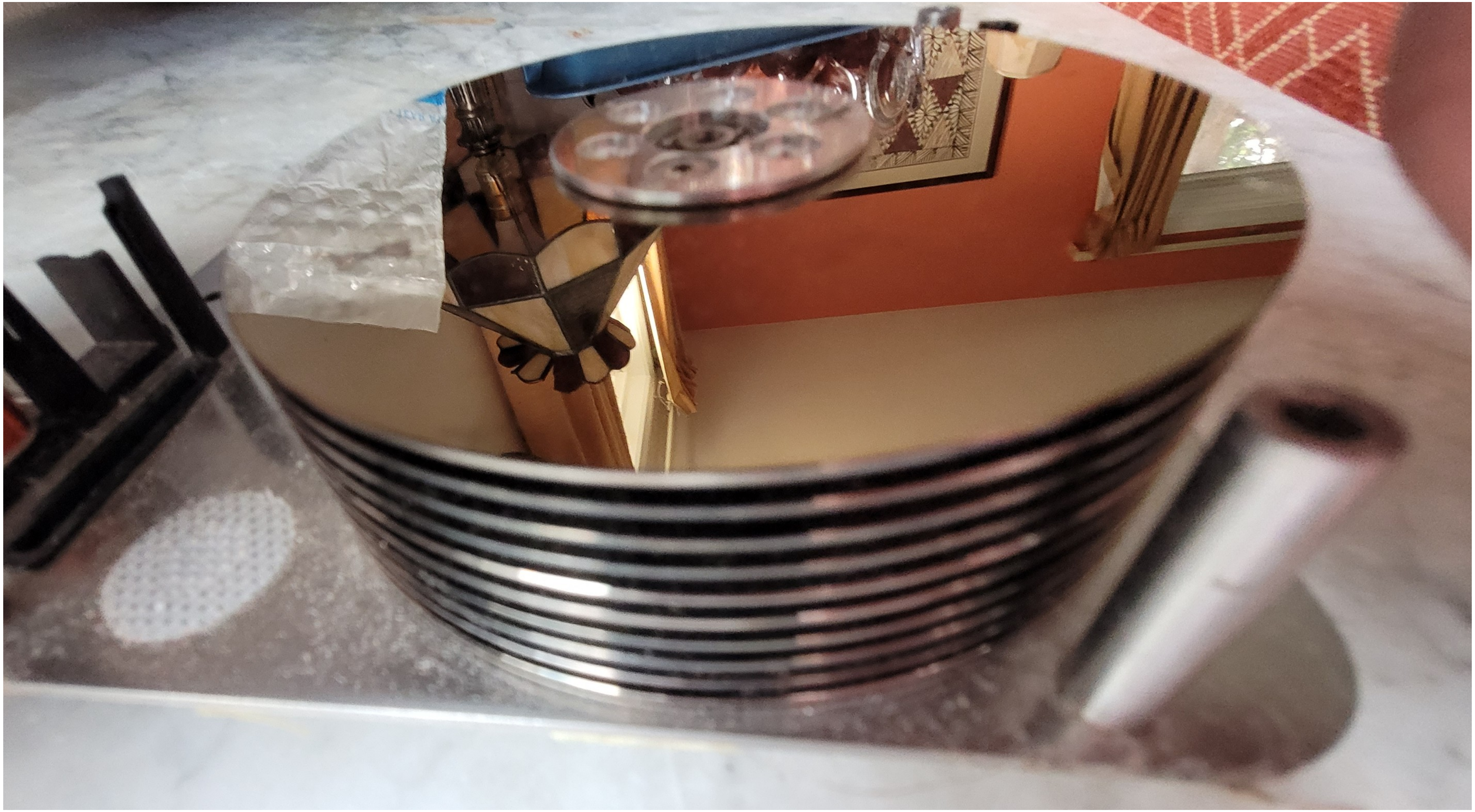
- File data is stored in groups of storage bytes. The FAT data includes the file name and the address of the first group in storage.
- File browsing shows you the file names and metadata (file size, creation date, etc) in the FAT, and lets you open folders to see folder contents
- Moving a file to a different folder of the storage device simply changes the path description in the file data for that file in the FAT.
- That path too is part of file metadata

How does a file exist in storage?

- Organization of a **hard drive**: many concentric tracks per platter surface
- A track is divided into sectors.
- Two surfaces per platter
- Possibly 2+ platters
- Actuator arm provides multiple electromagnets for reading and writing data in any track sector

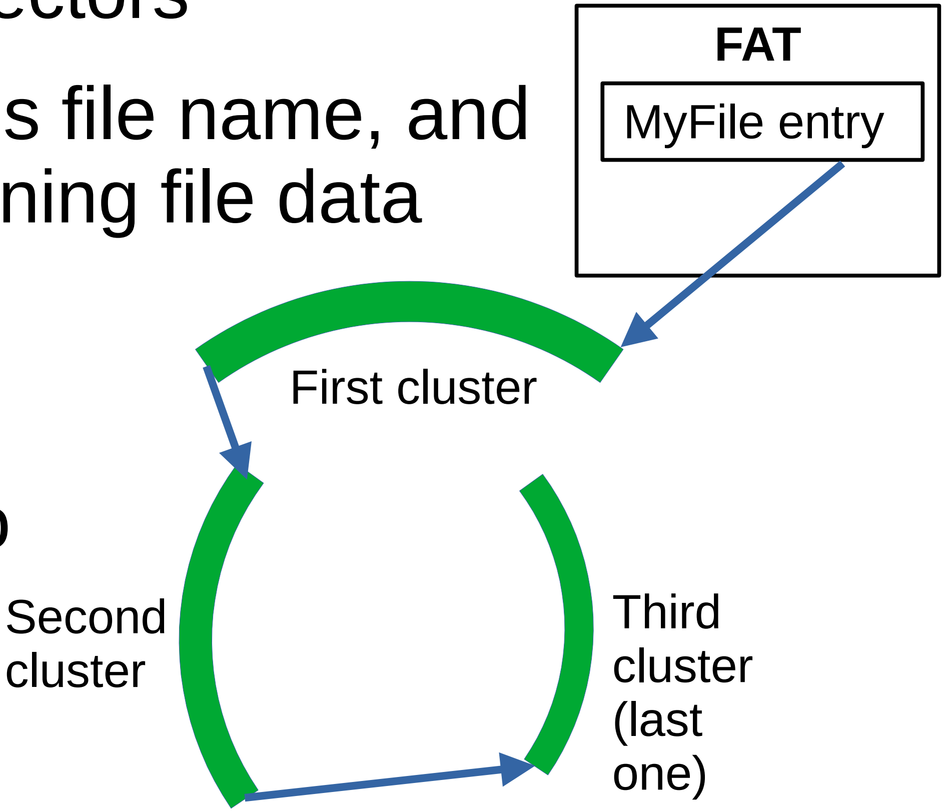


A hard drive with 10 platters



How does a file exist in storage?

- A **Cluster** is a group of track sectors
- The FAT entry for a file contains file name, and points to the first cluster containing file data
- End of first cluster points to second cluster
- End of second cluster points to third cluster, and so on
- End of last cluster points to nothing
- This type data structure is called a **linked list**



Normal file deletion

How does a file get deleted?

- The OS marks the FAT entry containing the file as deleted. The entry is still in the FAT table.
- OS periodic maintenance may physically remove FAT entries marked as deleted (seems likely, but I do not know this for sure).
- Each FAT entry marked as deleted still points to the first storage group containing file data.
- The OS makes NO change *inside* the storage groups containing file data immediately. The OS it does make the storage groups available to used again (and overwritten when used again).

Unused (free) storage

- Another storage table lists all *free* storage groups.
- When a file is deleted, its storage groups are added to the free list. No change is made to storage group *data*.
- When a new file is created in storage, the OS selects a free storage group in which file data will be recorded.
- When the file grows, more free storage groups are selected, and the OS extends the linked list of storage groups to which the file’s FAT entry points.
- Data of a large file such as a video can be contained in thousands of storage groups.

Summary of Normal Deletion

- The FAT entry metadata for the file is still in FAT and still points to the first cluster in storage.
- No change has been made to data in storage clusters containing the file.
- This condition allows for file recovery software to remove the deletion marker placed in the FAT data.
- The storage clusters containing the file go in the free list and may soon be overwritten when used to store another file.

Recovery of Delete Files

How does File Recovery work?

- File recovery works on one storage device at a time.
- File recovery examines FAT entries marked for deletion. Each entry points to a linked list of storage groups, hopefully still in the free list (not yet storing other data).
- File recovery checks each storage group linked list to determine if the groups are still free.
- If the storage groups are still free, then the file recovery removes the linked list from the free list, and un-marks the file’s FAT entry for deletion.

File Recovery Software

- File Recovery software has existed for a very long time.
- Scenario One: Users sometimes delete a file accidentally
- File Recovery software looks for every FAT file entry marked deleted, and checks the storage groups to see if all are still free (i.e., not yet recycled)
- The FAT entry deletion flag is removed, and the storage groups are removed from the free list.

Scenario 1: Accidental File deletion

- File Recovery software will work if *and only if* the storage groups for a deleted file have not yet been used to store a new file.
- CRITICAL POINT: If you realize you have deleted a file that you want to recover, DO NOT STORE ANY NEW FILE on the storage device.
- If you download and install File Recovery Software at that point, doing so in Windows does store a new file on drive C.
- This is a good reason ***not to store data files*** on drive C.

Scenario 2: FAT is damaged

- File recovery software cannot rely on FAT to provide a storage path or point to the first storage group for each file
- For this scenario, File Recovery Software finds ***every linked list*** of storage groups on the storage device, which takes a very long time, hours or possibly days.
- File Recovery Software assigns an arbitrary file name (usually a serial number) to each linked list.
- Scenario 2 file recovery software is usually **expensive**.

Preparedness

- The File Recovery application you will learn about today all addresses only Scenario 1: you have accidentally deleted a file.
- Most of us are in the habit of storing documents, photos, music etc on Windows drive C.
- To avoid downloading File Recovery Software *after* your accidental deletion, ***install File Recovery Software for Scenario 1 immediately***, and again whenever you obtain a new computer.

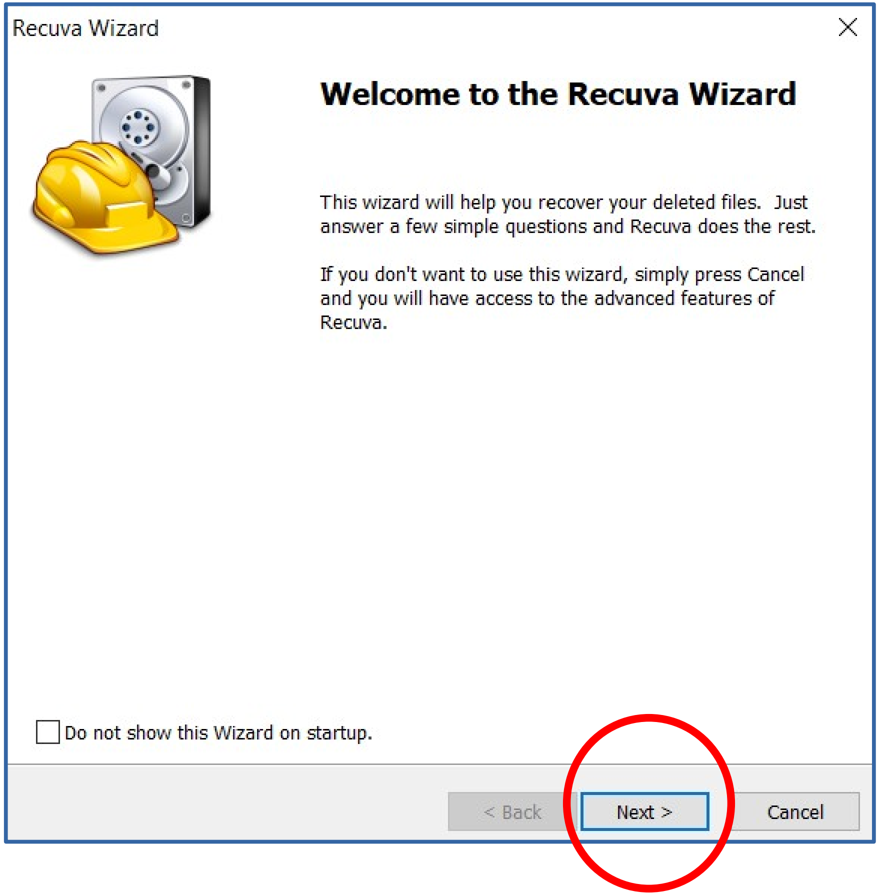
RECUVA
Deleted File
Recovery software

The Recuva application

- Zero-cost File Recovery application
- Available for Windows and Mac
- Identifies all files marked for deletion in the FAT
- If the marked file’s storage group linked list remains in the free list and is intact, then the file is recoverable.

The Recuva application

- Main screen
- Click the **Next button**



Recuva Wizard

Welcome to the Recuva Wizard

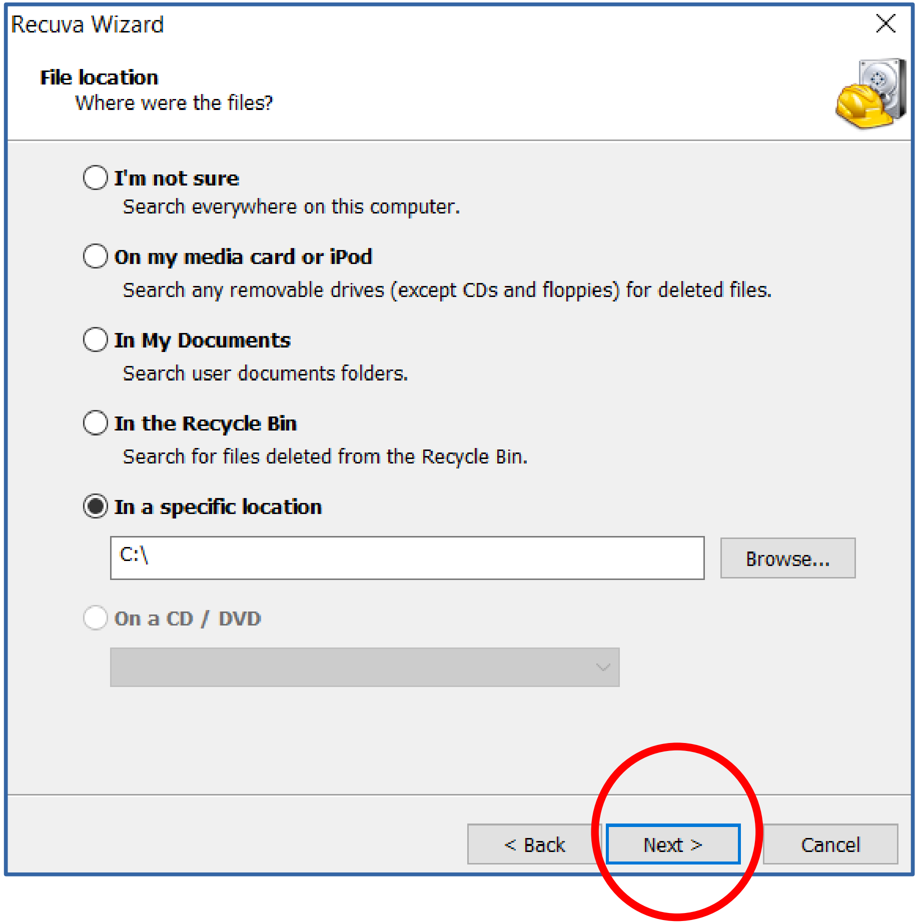
This wizard will help you recover your deleted files. Just answer a few simple questions and Recuva does the rest.

If you don't want to use this wizard, simply press Cancel and you will have access to the advanced features of Recuva.

□ Do not show this Wizard on startup.

The Recuva application

- Optionally select a file location
  (device and folder)
- Note if you deleted from the Recycle Bin, then choose that folder
- I tested Recuva by choosing drive C
- Click the **Next button**



Recuva Wizard

File location
Where were the files?

○ **I'm not sure**
Search everywhere on this computer.

○ **On my media card or iPod**
Search any removable drives (except CDs and floppies) for deleted files.

○ **In My Documents**
Search user documents folders.

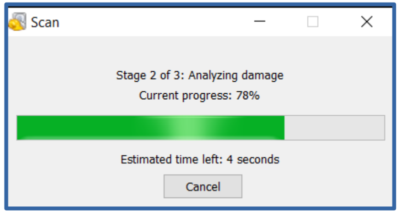
○ **In the Recycle Bin**
Search for files deleted from the Recycle Bin.

● **In a specific location**
C:\

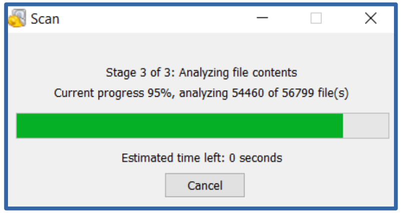
○ **On a CD / DVD**

The Recuva application

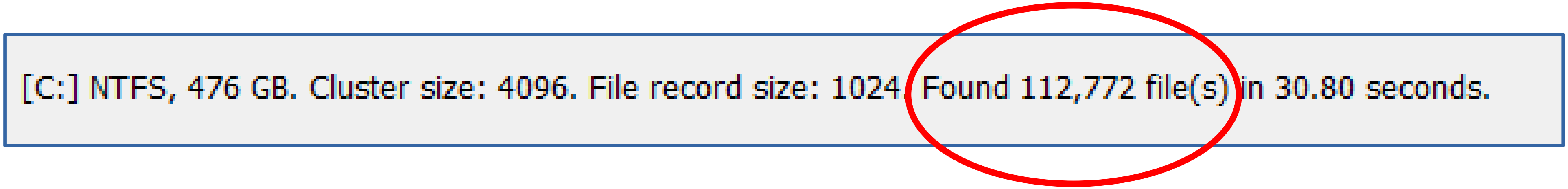
- If you recover deleted files from all of drive C, it may take some time to identify all of them.
- Status boxes show Recuva is still working.
- Look what was found when Recuva scanned my Windows 10 laptop drive :



Stage 2 of 3: Analyzing damage
Current progress: 78%
Estimated time left: 4 seconds



Stage 3 of 3: Analyzing file contents
Current progress 95%, analyzing 54460 of 56799 file(s)
Estimated time left: 0 seconds



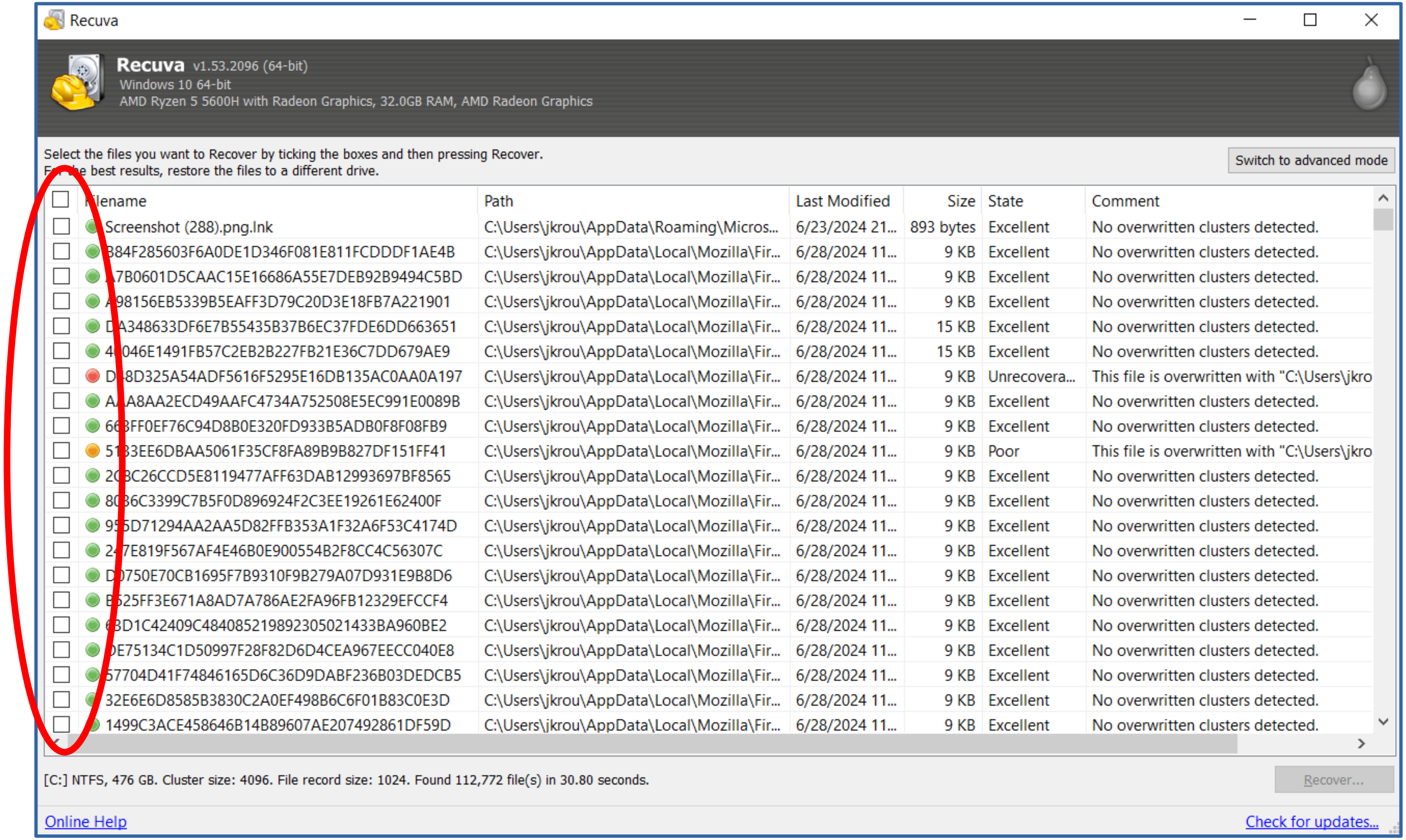
[C:] NTFS, 476 GB. Cluster size: 4096. File record size: 1024. Found 112,772 file(s) in 30.80 seconds.

The Recuva application

Red dot indicates file clusters have been overwritten already.

Note check-mark boxes.

Long file names are Windows temp files.



Recuva v1.53.2096 (64-bit)
Windows 10 64-bit
AMD Ryzen 5 5600H with Radeon Graphics, 32.0GB RAM, AMD Radeon Graphics

Select the files you want to Recover by ticking the boxes and then pressing Recover.
For the best results, restore the files to a different drive.

□	Filename	Path	Last Modified	Size	State	Comment
□	● Screenshot (288).png.lnk	C:\Users\jkrou\AppData\Roaming\Micros...	6/23/2024 21...	893 bytes	Excellent	No overwritten clusters detected.
□	● B84F285603F6A0DE1D346F081E811FCDDDF1AE4B	C:\Users\jkrou\AppData\Local\Mozilla\Fir...	6/28/2024 11...	9 KB	Excellent	No overwritten clusters detected.
□	● A7B0601D5CAAC15E16686A55E7DEB92B9494C5BD	C:\Users\jkrou\AppData\Local\Mozilla\Fir...	6/28/2024 11...	9 KB	Excellent	No overwritten clusters detected.
□	● A98156EB5339B5EAFF3D79C20D3E18FB7A221901	C:\Users\jkrou\AppData\Local\Mozilla\Fir...	6/28/2024 11...	9 KB	Excellent	No overwritten clusters detected.
□	● DA348633DF6E7B55435B37B6EC37FDE6DD663651	C:\Users\jkrou\AppData\Local\Mozilla\Fir...	6/28/2024 11...	15 KB	Excellent	No overwritten clusters detected.
□	● 4 046E1491FB57C2EB2B227FB21E36C7DD679AE9	C:\Users\jkrou\AppData\Local\Mozilla\Fir...	6/28/2024 11...	15 KB	Excellent	No overwritten clusters detected.
□	● D 8D325A54ADF5616F5295E16DB135AC0AA0A197	C:\Users\jkrou\AppData\Local\Mozilla\Fir...	6/28/2024 11...	9 KB	Unrecovera...	This file is overwritten with "C:\Users\jkro
□	● A A8AA2ECD49AAFC4734A752508E5EC991E0089B	C:\Users\jkrou\AppData\Local\Mozilla\Fir...	6/28/2024 11...	9 KB	Excellent	No overwritten clusters detected.
□	● 663FF0EF76C94D8B0E320FD933B5ADB0F8F08FB9	C:\Users\jkrou\AppData\Local\Mozilla\Fir...	6/28/2024 11...	9 KB	Excellent	No overwritten clusters detected.
□	● 51 3EE6DBAA5061F35CF8FA89B9B827DF151FF41	C:\Users\jkrou\AppData\Local\Mozilla\Fir...	6/28/2024 11...	9 KB	Poor	This file is overwritten with "C:\Users\jkro
□	● 2C8C26CCD5E8119477AFF63DAB12993697BF8565	C:\Users\jkrou\AppData\Local\Mozilla\Fir...	6/28/2024 11...	9 KB	Excellent	No overwritten clusters detected.
□	● 80 6C3399C7B5F0D896924F2C3EE19261E62400F	C:\Users\jkrou\AppData\Local\Mozilla\Fir...	6/28/2024 11...	9 KB	Excellent	No overwritten clusters detected.
□	● 955D71294AA2AA5D82FFB353A1F32A6F53C4174D	C:\Users\jkrou\AppData\Local\Mozilla\Fir...	6/28/2024 11...	9 KB	Excellent	No overwritten clusters detected.
□	● 247E819F567AF4E46B0E900554B2F8CC4C56307C	C:\Users\jkrou\AppData\Local\Mozilla\Fir...	6/28/2024 11...	9 KB	Excellent	No overwritten clusters detected.
□	● D0750E70CB1695F7B9310F9B279A07D931E9B8D6	C:\Users\jkrou\AppData\Local\Mozilla\Fir...	6/28/2024 11...	9 KB	Excellent	No overwritten clusters detected.
□	● B525FF3E671A8AD7A786AE2FA96FB12329EFCCF4	C:\Users\jkrou\AppData\Local\Mozilla\Fir...	6/28/2024 11...	9 KB	Excellent	No overwritten clusters detected.
□	● 63D1C42409C484085219892305021433BA960BE2	C:\Users\jkrou\AppData\Local\Mozilla\Fir...	6/28/2024 11...	9 KB	Excellent	No overwritten clusters detected.
□	● DE75134C1D50997F28F82D6D4CEA967EECC040E8	C:\Users\jkrou\AppData\Local\Mozilla\Fir...	6/28/2024 11...	9 KB	Excellent	No overwritten clusters detected.
□	● 57704D41F74846165D6C36D9DABF236B03DEDCB5	C:\Users\jkrou\AppData\Local\Mozilla\Fir...	6/28/2024 11...	9 KB	Excellent	No overwritten clusters detected.
□	● 32E6E6D8585B3830C2A0EF498B6C6F01B83C0E3D	C:\Users\jkrou\AppData\Local\Mozilla\Fir...	6/28/2024 11...	9 KB	Excellent	No overwritten clusters detected.
□	● 1499C3ACE458646B14B89607AE207492861DF59D	C:\Users\jkrou\AppData\Local\Mozilla\Fir...	6/28/2024 11...	9 KB	Excellent	No overwritten clusters detected.

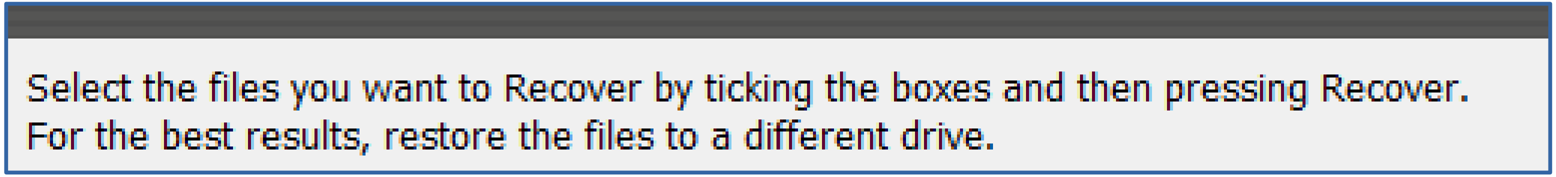
[C:] NTFS, 476 GB. Cluster size: 4096. File record size: 1024. Found 112,772 file(s) in 30.80 seconds.

The Recuva application

- Click the check-mark box to the left of any file you want to recover.
- Then click the Recover button in the lower right corner of the window.
- Note also you can recover files to a separate flashdrive or any other storage device.

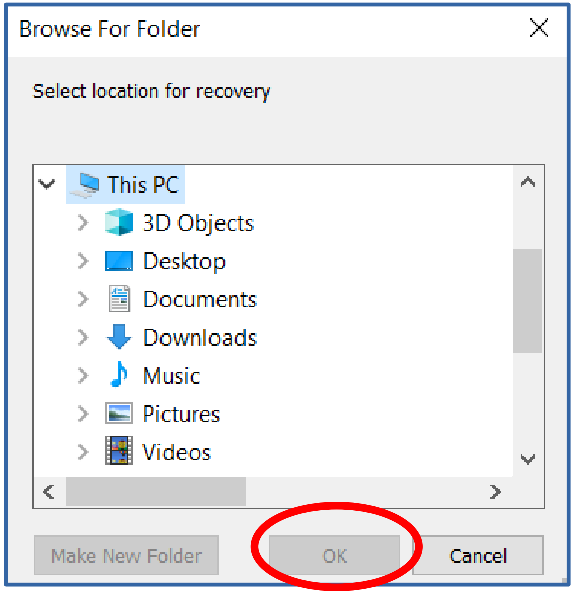
The Recuva application

- At the top left corner of the list of files, Recuva says:



Select the files you want to Recover by ticking the boxes and then pressing Recover.
For the best results, restore the files to a different drive.

- After selecting at least one file to recover, the **Recover button** in the lower right corner becomes active.
- Click the **Recover button**.
- A drive selector box appears. Select a drive and folder in which recovered files will be written.
- Click the **OK button**. The box closes.



Browse For Folder

Select location for recovery

SECURE FILE DELETION

Why use Secure File Deletion?

- Before sending the computer out for repair
- Before allowing the computer to be used by someone, even a house guest
- Before selling the computer
- Before allowing the computer to leave your hands for any other reason, like giving it to a relative, especially a young relative.
- Remember, ANYONE can find and use File Recovery software, even a bad apple.

How to cover all the bases

- Keep in mind that any next user of your computer can run File Recovery software to see any files that you have already deleted the normal way.
- To make those normally deleted files eligible for permanent deletion, then first run File Recovery software, at least for deleted files you can tell contain sensitive data.
- With those restored, *then* you can run Secure File Deletion to purge those recoverd sensitive files.

Normal vs Secure

DELETION TYPE:	**NORMAL**	**SECURE**
FILE ENTRY IN FAT	Marked as Deleted	Entry deleted
FILE DATA (storage clusters)	Clusters added to Free List; not overwritten at first	Clusters overwritten and added to Free List; linked list pointers deleted

Secure File Deletion Prep

- First, **back up your sensitive data** files on a separate storage system (such USB SSD, hard drive or flash drive).
- Secure file deletion overwrites new, unrelated data ***immediately*** into the storage blocks of a file to be deleted.
- Use Secure File Deletion on any Drive C files that might lead a bad apple to your accounts, or is private in nature, or will require extensive efforts to re-create (e.g., that memoir or novel in draft, business plan, love letters)
- File Recovery software *cannot* recover the overwritten file data.

Magnetic vs Non-magnetic storage

- Magnetic storage includes hard drives
- Non-magnetic includes Solid-State Drives (SSDs), flash drives, and memory cards
- Magnetic storage can retain tiny but detectable areas of magnetic data even after a single overwrite.
- Most Secure File Deletion software givens you the option to ***overwrite multiple times per file***, hoping that the accumulated effect will erase the tiniest areas.
- Use multiple overwrites **ONLY on a hard drive file**.
- Some USB storage devices are hard drives.

Magnetic vs Non-Magnetic Storage

- Many personal computers sold in the last two years contain an SSD instead of a hard drive. SSDs are faster.
- Make SURE you know which your computer contains.
- There is no point to using more than one overwrite per file on a flash drive or SSD.
- Multiple overwrites per file can **harm** an SSD.
- File recovery for securely deleted files on a hard drive is enormously expensive, sometimes involving use of an electron microscope. This is done when the cost is justified, generally by government law enforcement.

SECURE FILE DELETION APPLICATIONS

Secure File Deletion Applications

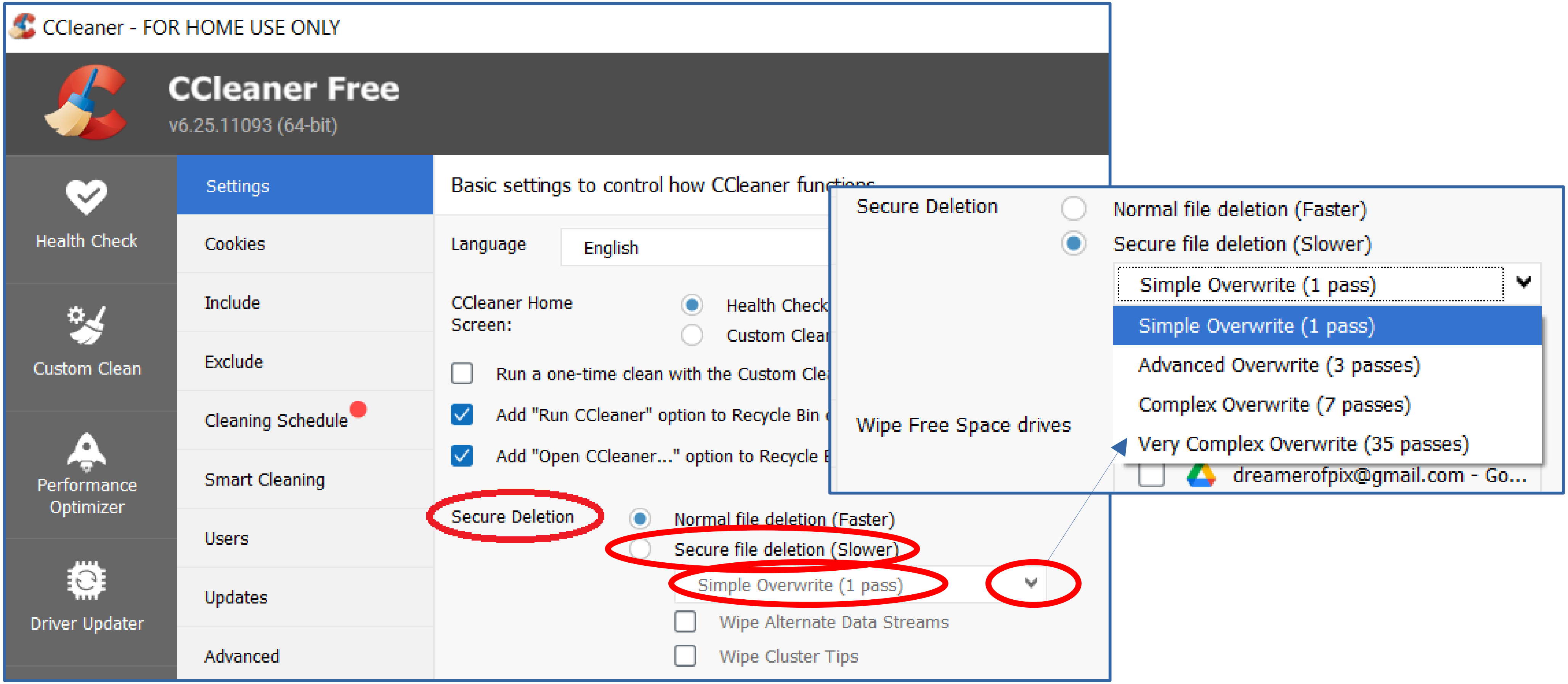
- **CCleaner Free**, zero-cost, widely used for its deletion of unwanted temporary browser files and temporary OS files.
- **File Shredder**, zero-cost, described in an article in the June 2024 edition of **PATACS Posts**. Also zero-cost.
- **System Mechanic**, a commercial application that has won many PC Magazine awards.
- This is NOT a complete list.

CCLEANER FREE

CCleaner Free

- Zero-cost downloadable software for Windows and Mac, popular among user group members for its temp file cleanup feature.
- It also includes an application-oriented performance optimizer (put seldom used apps to sleep), and update checkers for applications and drivers.
- It has a tool to overwrite ALL free storage groups on a storage device. WARNING: This tool eliminates all File Recovery options. It takes a LONG TIME. Its configuration can easily be changed by accident to overwrite the ENTIRE storage system (the nuclear option).

Configure secure file deletion



Basic settings to control how CCleaner functions

Language: English

CCleaner Home Screen: ● Health Check ○ Custom Clean

□ Run a one-time clean with the Custom Cle

☑ Add "Run CCleaner" option to Recycle Bin (

☑ Add "Open CCleaner..." option to Recycle B

Secure Deletion: ● Normal file deletion (Faster) ○ Secure file deletion (Slower)

Simple Overwrite (1 pass)

□ Wipe Alternate Data Streams

□ Wipe Cluster Tips

Secure Deletion: ○ Normal file deletion (Faster) ● Secure file deletion (Slower)

Simple Overwrite (1 pass)

- Simple Overwrite (1 pass)
- Advanced Overwrite (3 passes)
- Complex Overwrite (7 passes)
- Very Complex Overwrite (35 passes)

Wipe Free Space drives

□ dreamerofpix@gmail.com - Go...

Click sequence: **OPTIONS ▸ SETTINGS ▸ SECURE FILE DELETION ▸ Choose from menu of overwrites**

Is one overwrite (pass) enough?

- YES, on any SSD or flash drive or memory card.
- On a hard drive, **one overwrite per file is enough** so long as the anticipated bad apple is, for instance, a repairman, an individual purchaser of your computer, or a young relative with too much tech enthusiasm.
- Most of us have no reason to anticipate that a hard drive might be investigated by government law enforcement.
- 3 overwrites is the ***basic*** DoD standard **5220-22.M**.
- 27 overwrites is the **Guttman algorithm**, created long before non-magnetic storage was invented.

Multiple Overwrites Harm an SSD

- Each storage byte on an SSD is able to make a finite number of value changes.
- After the ceiling number is reached, a byte is dead and cannot change again.
- Multiple overwrites hasten the death of the bytes affected.
- This is another reason to set secure file deletion to overwrite once and only once per file.

How to use secure file deletion

- CCleaner Free secure file deletion enhances the Delete key behavior for files.
- Using Windows File Explorer, select a file or folder to delete.
- Then tap the **Delete key**.
- Normal deletion sends the selected file to the Recycle Bin.
- When using Secure File Deletion, the file is deleted immediately. It does NOT go to the Recycle Bin.
- Switch CCleaner Free back to Normal Deletion. After that, each deleted file does go to the Recycle Bin.

How to use secure file deletion

- The **first time** you tap the Delete key to securely delete a file, a dialog box appears, asking if you really want to do that.
- Click OK, that box disappears. The chosen file is securely deleted.
- When you again tap the Delete key after selecting a file, the box will not reappear.

Is a file really *securely* deleted?

- I used normal deletion to delete a file.
- Then I ran RECUVA file recovery software.
- It found and recovered files deleted normally.
- It could not find a file deleted securely.
- Note: this test does not prove data was *overwritten* in files deleted securely, or that the linked list pointers in the storage groups were erased, only that the FAT table entry for a file deleted securely was absent.

When CCleaner is shut down

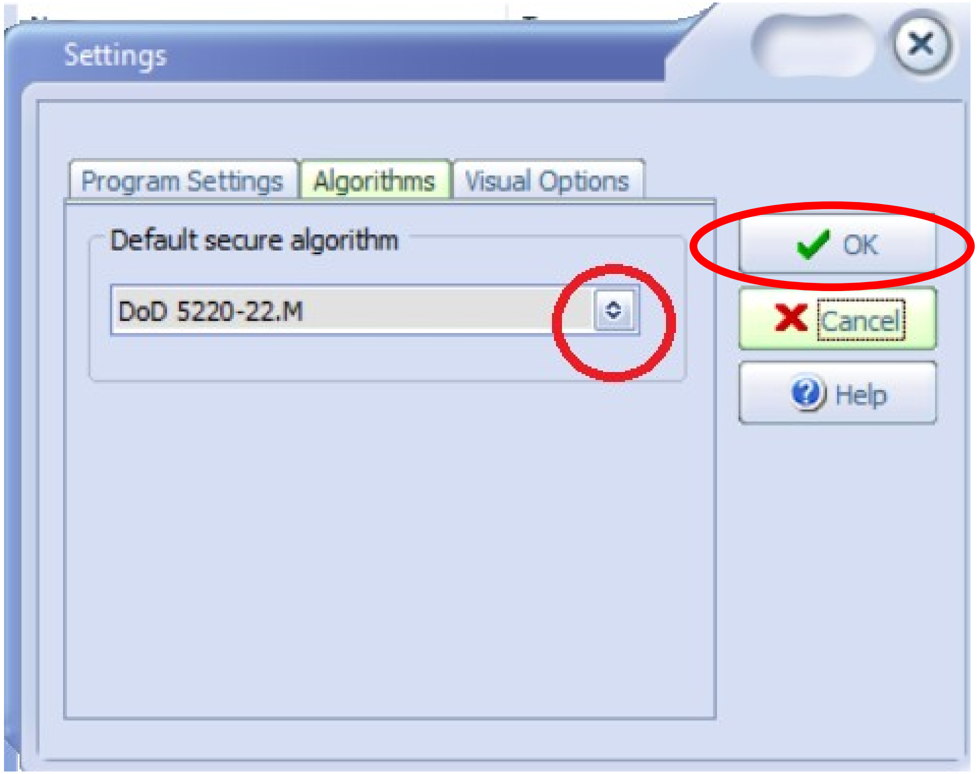
- Secure file deletion is disabled
- Any file deleted after that goes to the Recycle Bin.
- Secure file deletion works only while CCleaner is running and is configured for secure file deletion.
- To disable secure file deletion while CCleaner is running: in CCleaner, choose **OPTIONS►SETTINGS►NORMAL FILE DELETION**

FILE SHREDDER

File Shredder application

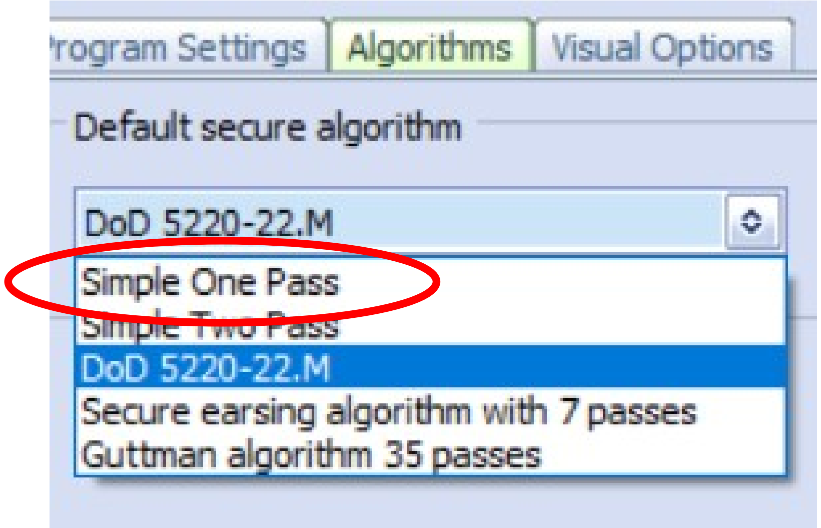
- This zero-cost application does only file shredding and storage device shredding
- Therefore its user interface is simpler than that of CCleaner Free.
- The software publisher also offers a Pro version that costs money.
- The basic approach is to create a list, inside the File Shredder window, of files to be securely deleted. You can remove files from that list before the final step to securely delete the listed files.

Config File Shredder secure deletion



Default secure algorithm

DoD 5220-22.M



Default secure algorithm

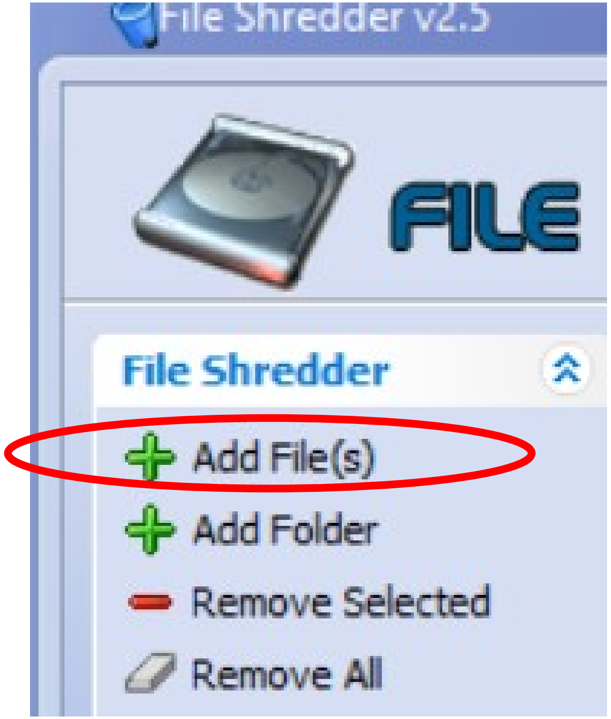
DoD 5220-22.M

Click sequence:

SHREDDER SETTINGS►ALGORITHMS tab►SECURE ALGORTHIMS menu►Simple One pass ►OK BUTTON

How to delete files securely

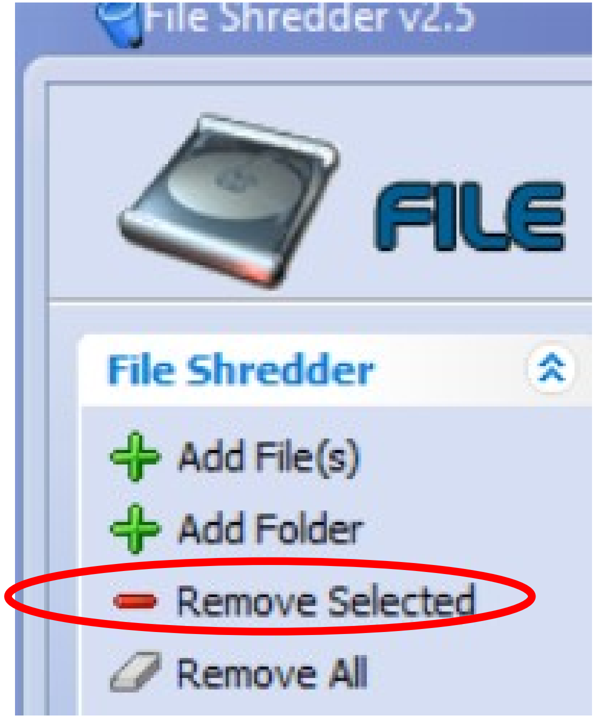
- At the File Shredder main window top left, click + **Add File(s)**
- A standard Open File dialog window appears.
- Select file names to be deleted securely, and click the **Open button**. The dialog window closes. The file names appear in the File Shredder right hand pane.



- + Add Folder conveniently selects all file contents of a chosen folder, and the folder itself.

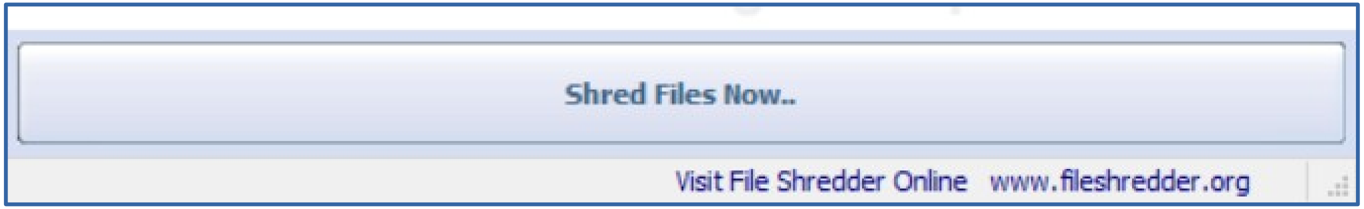
How to delete files securely

- You can *change your mind* and remove files from the File Shredder list.
- Select the files in the list that you do not want to securely delete.
- In the upper left corner, tap
  - **Remove Selected**.

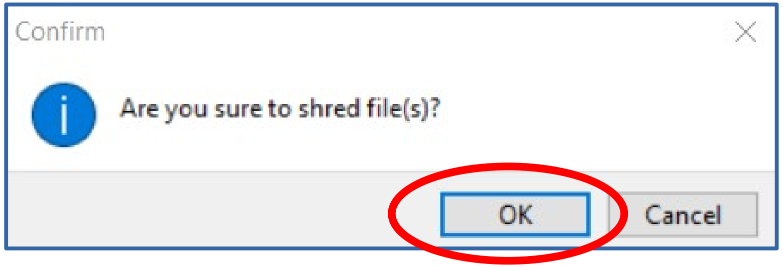


How to delete files securely

- At the bottom of the File Shredder window, click the big button labeled **Shred Files Now**



- When you click that button for the first time, File Shredder asks if you really want to do that.



Are you sure to shred file(s)?

- Click the **OK button.** That is the final step.
  The files are securely deleted and cannot be recovered.

- After the first time, File Shredder won’t ask for confirmation.
  It will delete the chosen files.

SYSTEM MECHANIC

System Mechanic

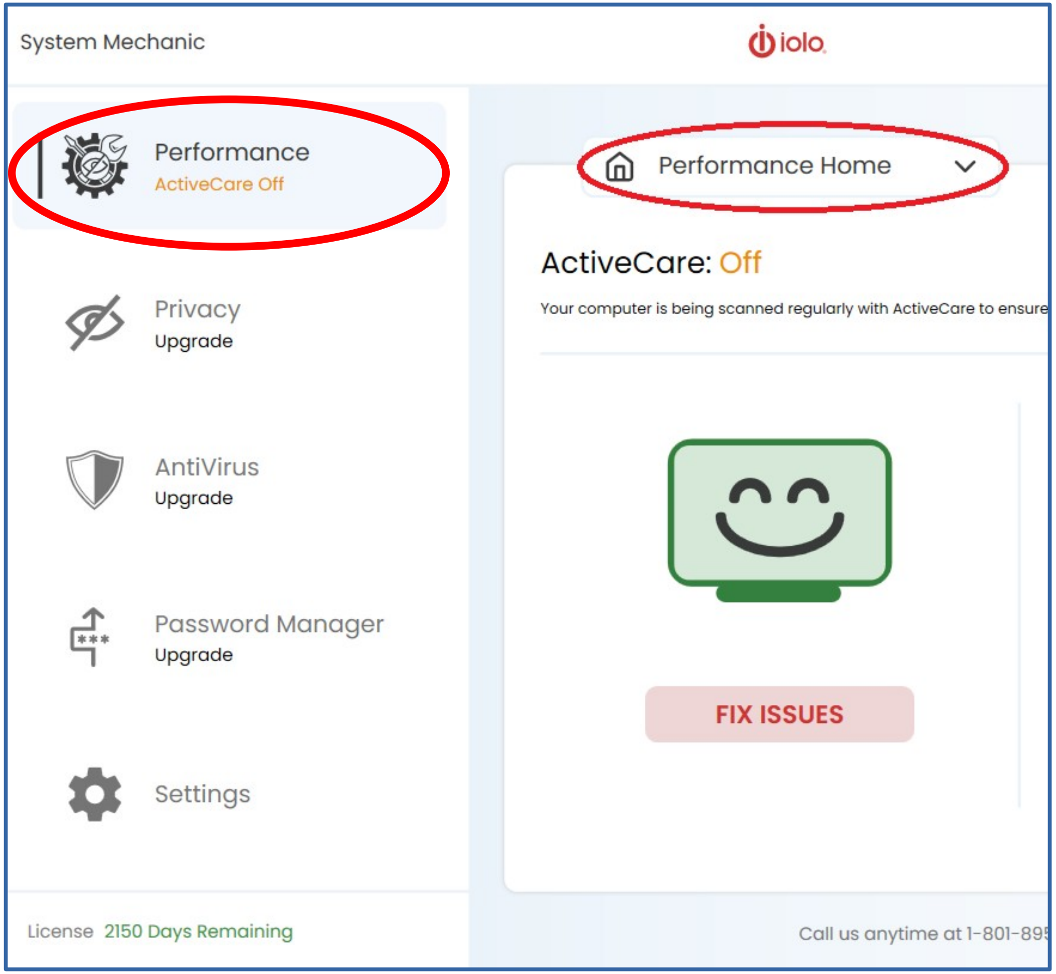
- System Mechanic is a commercial application. I have been using it for more than a decade. It has won PC Magazine Editors Choice awards for eight consecutive years.
- I tested build 24.3.1.11
- Aside from secure file deletion, it provides registry repair, drive defrag, memory defrag, temp files removal, and optional extra-cost VPN, Anti-virus, etc.
- Like CCleaner Free, it augments a bit of Windows to allow you to securely delete any files you select.

System Mechanic

- System Mechanic says it provides **military-grade** secure file deletion. That requires at least three overwrites per file, and sometimes more depending on context and file contents.
- I cannot find any way to adjust the number of overwrites per file done by System Mechanic.
- I believe System Mechanic will have to provide user config for the overwrite count, to avoid hastening byte death in SSDs.

Enabling Secure File Deletion

- If Performance is ***not*** selected in the left pane, then select Peformance.
- In the right pane, next to Performance Home, click the **down-arrow** to reveal a menu.

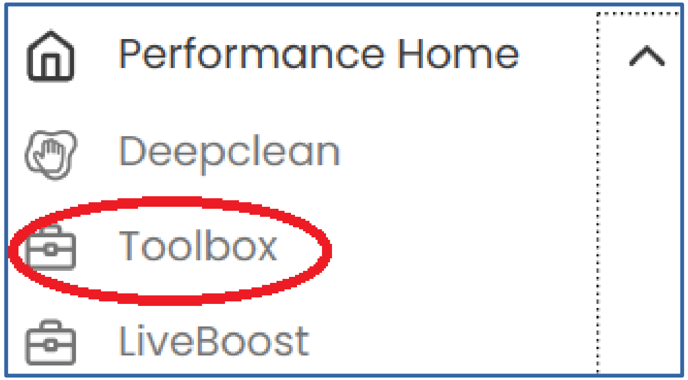


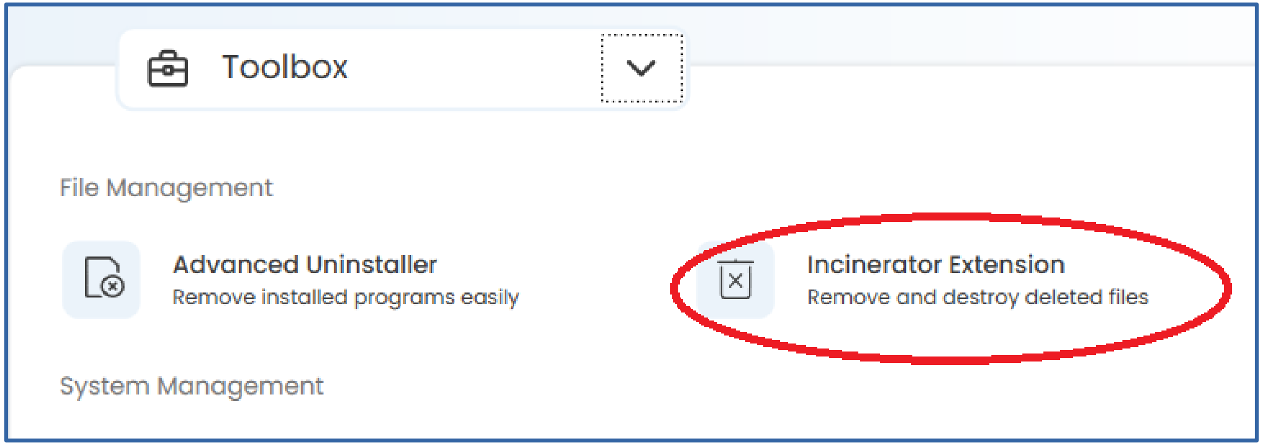
ActiveCare: Off

Your computer is being scanned regularly with ActiveCare to ensure

Enabling Secure File Deletion

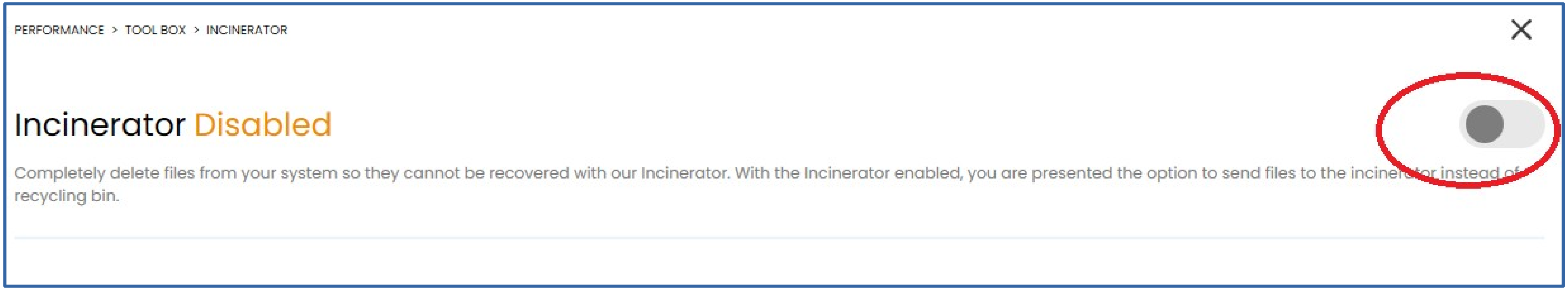
- In the menu, select **Toolbox**. The menu closes.
- The right pane shows Toolbox Options.
- Select **Incinerator Extension**.





Enabling Secure File Deletion

- The **Incinerator Extension** window contains a single switch. The default position is OFF.
- Click the switch to turn it ON.

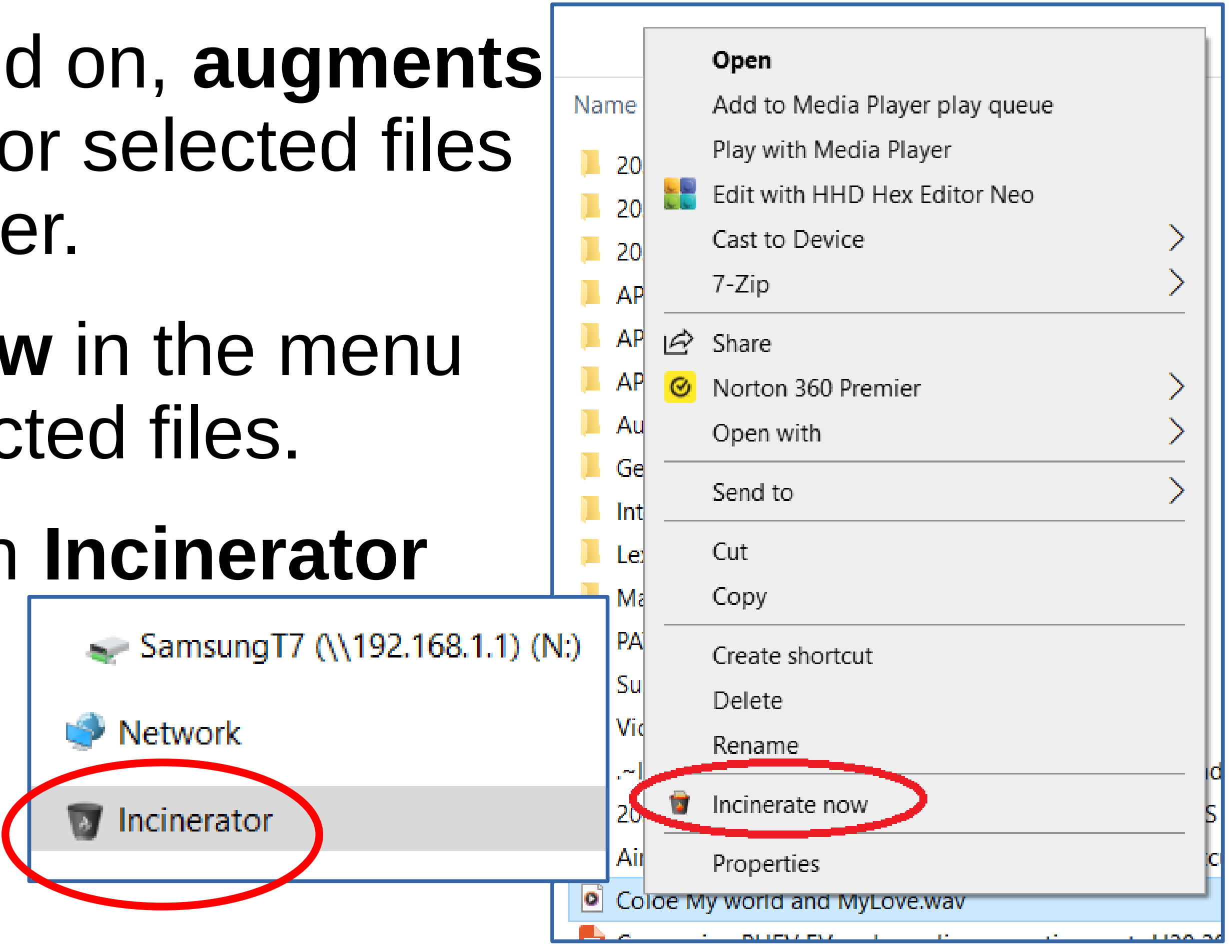


Incinerator Disabled

Completely delete files from your system so they cannot be recovered with our Incinerator. With the Incinerator enabled, you are presented the option to send files to the incinerator instead of recycling bin.

How to use Secure File Deletion

- Incinerator, when turned on, **augments the right-click menu** for selected files in Windows File Explorer.
- Choose **Incinerate Now** in the menu to securely delete selected files.
- Incinerator also puts an **Incinerator icon** in the left pane of Windows File Explorer. I tried dragging a file to that icon, and was not permitted to do so.



A test on a flash drive

- Flash drives are slower than hard drives or SSDs.
- Secure deletion of a flash drive 70 megabyte file took less than 2 seconds.
- Secure deletion of a flash drive 1 gigabyte file took more than a minute.
- That duration made me wonder if the System Mechanic military-grade secure deletion does more than 3 overwrites per file. DoD standard **5220-22.M** includes three different levels. The middle level uses 7 overwrites per file.

System Mechanic limitation

- System Mechanic does not appear to support single-overwrite for files on SSD and flash drives at this time.
- Perhaps it does so automatically.
  If so, then it is not telling anyone it does so.
- I do not recommend System Mechanic as it stands now for secure file deletion on SSDs.
- System Mechanic is OK for hard drives and flash drives.
- I have a USB SSD connected to my desktop computer, a USB SSD connected to my Router, and a drive C SSD in my laptop. SSDs are the wave of the near future.

Macs and system-on-a-chip

- The Macintosh computers using M1, M2, M3 or M4 systems on-a-chip all include persistent **SSD file storage** in those chips.
- Macintosh users owning any Mac including an M1 or M2 or M3 chip should use *single-overwrite* secure deletion of files stored on the SSD.
- CCleaner Free is available for Mac
- Apple sells the Pro version of File Shredder for Mac through Apple’s online store

How to obtain the software mentioned in this presentation

RECUVA

- Zero-cost File Recovery application for Windows and Mac
- Claims to recover from damaged disks (Scenario 2). I have not tried that.
- **www.ccleaner.com/recuva**

CCLEANER FREE

- Zero-cost disk utility software for Windows and Macintosh
- Includes secure file deletion
- **www.ccleaner.com**

File Shredder

- Free Secure File Deletion application for Windows and Macintosh
- **www.fileshredder.org**

System Mechanic

- Commercial computer and disk maintenance application
- Includes secure file deletion
- Zero-cost 30-day trial is available from:

www.iolo.com/downloads/download-system-mechanic/

The End