Media Damage and Hard Drive Data Recovery

Many clients are stunned to learn that their hard drives have suffered a head crash, resulting in significant internal damage. "But I only dropped it a few _____" (inches or feet – fill in the blank) is a typical, surprised response. A drive may crash or develop media issues without being jarred or dropped, but in most cases, gravity plays a role.

The term *media* refers to the platters. Data resides on the platter surfaces.

Figure 1 below shows the inside of a healthy drive. When power is turned off, this model "parks" or leaves the head(s) on the platter surface, near the center hub. Other drives park the read-write heads in a ramp, off of the platter surfaces.

Note that the platter surface is clean and shiny, and the internal filter is white.

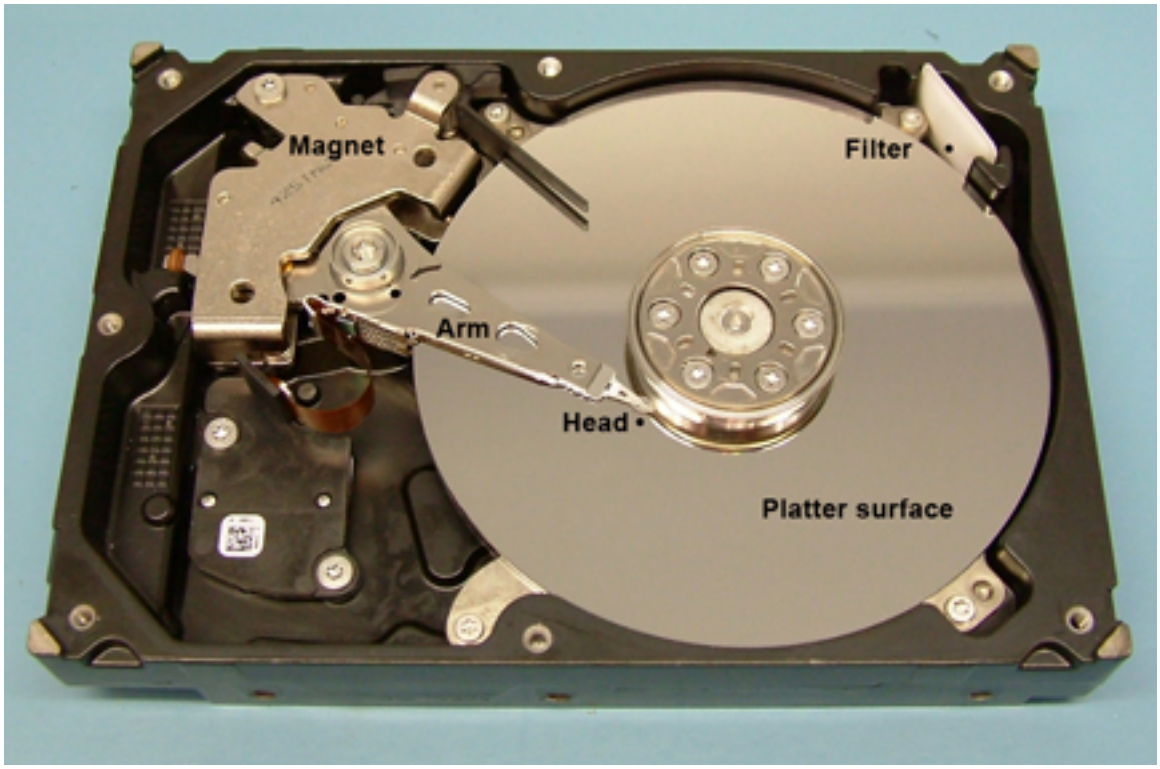

Figure 1. Inside of a Healthy Drive

During a mechanical drive's operation, the hard drive motor spins very fast, creating a very tiny cushion of air, which allows the head to "fly" atop the platter surface. Many drives have multiple heads and multiple platter surfaces.

The head travels back and forth across the platter, rapidly locating, reading, and storing your data, without actually touching the surface.

A physical jolt or shock may cause the read-write head to "crash" onto the platter media, and create a defect or "ding." A phonograph record serves as an analogy: bump a turntable while it is playing, and the needle will fly across the record surface, creating a permanent scratch. The record is ruined if the scratch is severe. Media damage usually presents a significant challenge to data recovery.

The next photo, **Figure 2**, shows what has happened to a drive that experienced a catastrophic head crash with media damage. Damage appears as scratches.

Figure 2. Drive with Head Crash & Media Damage

The damaged heads continue to scratch the platters as the drive rotates, and the "dings" became grooves. Small particles generated by the scratch fly around the drive and eventually contaminate everything, ruining other heads and creating more grooves. We call this "*cascading failure".* In this case, "your data is in the air filter," and it cannot be recovered.

Sometimes a shock causes only minor damage to the platter surface, such as a nick or light scratch. The drive may continue to function for a while. However, operating the drive with media damage eventually may ruin the head and perhaps degrade to cascading failure, needlessly making a recoverable drive unrecoverable.

The safest thing to do after an accident is to immediately turn off the hard drive and resist the temptation to try to use it. If you value your data, bring it to a recovery facility; they may be able to transfer your data from the drive without much data loss or expense. Operating a drive with mechanical failure is courting disaster; the more you use it, the less chance of successful recovery.

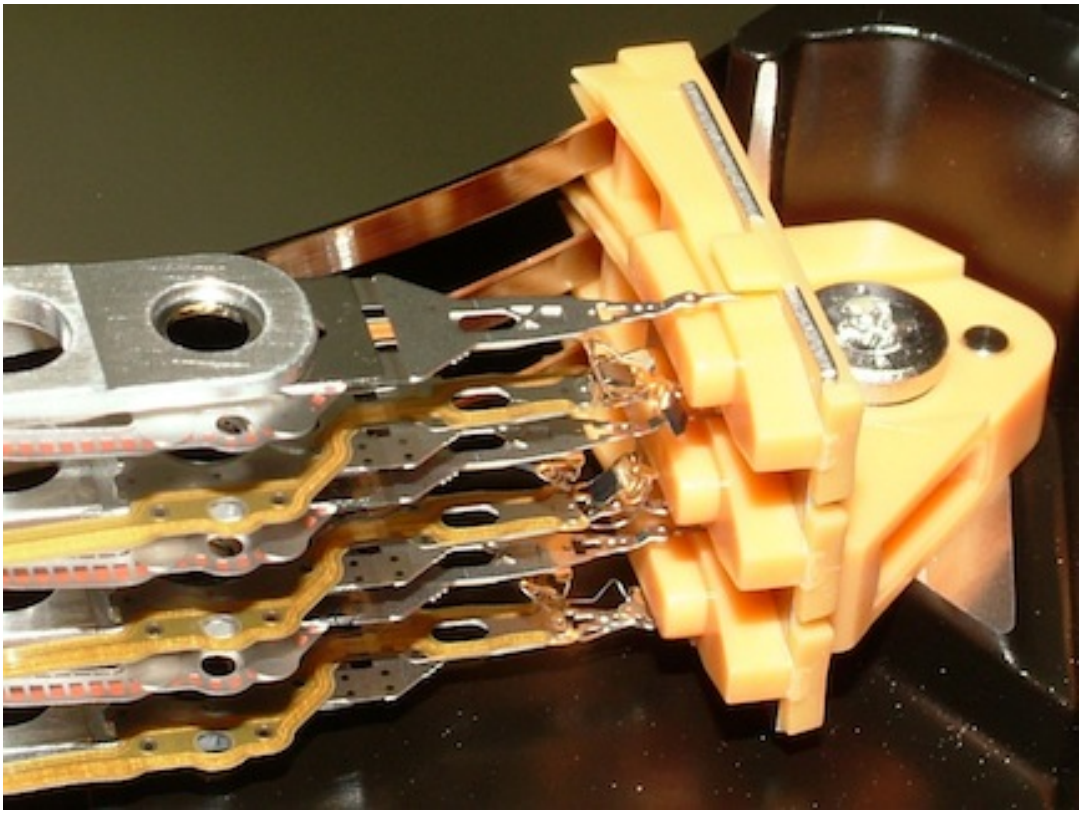

Figure 3. Damaged Heads Parked in a Ramp

Although it is generally true that a shock to an operating drive will cause more damage than to a stationary drive, a lot may depend upon whether the drive's heads are parked on a platter or a ramp. Even so, damage can occur to the heads even when parked on a ramp, if the force is severe enough.

Figure 3 shows damaged heads in a ramp. As soon as the drive is turned on, the deformed heads will move onto the platter and act like little knives, scraping data away and lessening the chance of recovery.

The debris kicked up by the process acts like large boulders randomly dropped onto a highway — a crash is sure to follow. Particles larger than 0.25 microns cannot pass between the air cushion gap between the head and the platter.

For perspective, the diameter of a human hair is about 80 microns, on average, which is 320 times larger. **Figure 4** shows a "crashed head." Scratches and debris (contamination) are clearly visible.

Most media damaged drives fall somewhere between the two extremes. Often, there are minor scratches that will corrupt some of the data.

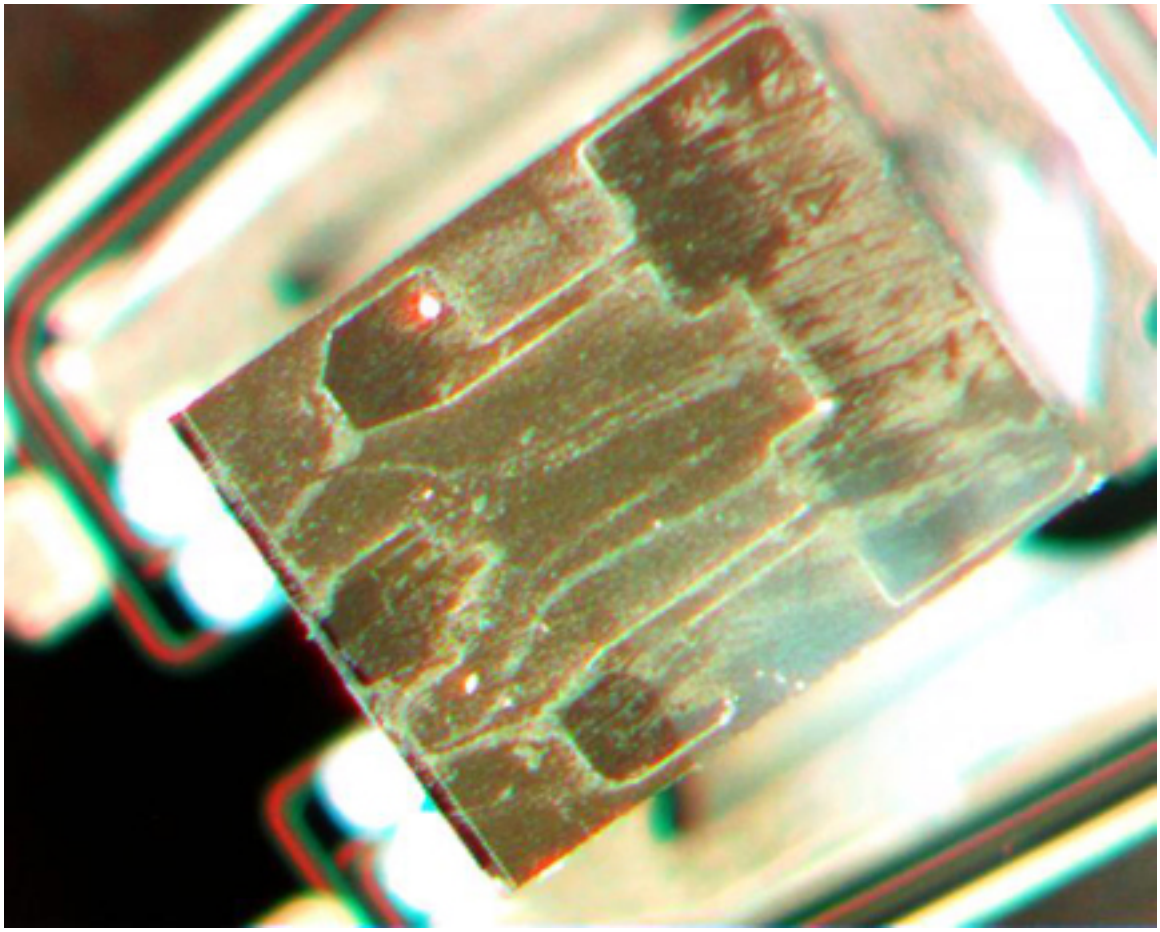

Figure 4. Close-up of Scratched and Contaminated Head

Crashed Drive Recovery Scenarios

Crashed drives fall into two broad categories: *recoverable* and *unrecoverable*.

Recoverable drives:

Remember that data recovery is a salvage operation; this is particularly true for a dropped or jolted drive.

In the best scenario, media damage is minor, and a dropped drive can be copied or *imaged* successfully. Any damage will be in unused areas or in parts of the drive that do not contain important client data. A recovery of up to 100% is possible.

In a worse scenario, there is significant damage on one or more platter surfaces, and only a partial recovery is possible. Perhaps the very worst scenario is when only a partial recovery is possible, *and* the drive's directory, which contains the names and locations of the files, is corrupted or unrecoverable. In this case, we can retrieve — with some exceptions — files only by their types, without their file names or original folder locations. This is termed a *raw recovery*.

We service drives in a Class 100 work environment (also called a clean room area), which is engineered to filter out small particles from the air and prevent contamination of the drive and subsequent failure.

Defective parts must be identified and replaced before the recovery process is started. Hard drive manufacturers do not sell spare parts, so a recovery firm must first find a suitable *donor drive* with compatible parts. Locating a good parts candidate can be difficult.

The imaging process may begin after the bad parts are replaced and any firmware issues are resolved. Even so, one must know a few basic principles of drive operation to fully grasp the problems, challenges, and limitations of partial recovery.

Most hard drives have multiple heads. During operation, the drive switches between heads, reading or writing to one head for a predetermined interval, and then switches to the next head. A "chunk" of data read this way is sometimes called a *wrap*.

Some hard drives — like Maxtor® — read only a small bit of data before switching heads. On the other extreme, most Samsung® drives will read more than a gigabyte of before switching.

Let's suppose that your drive has four heads and one of them has failed, due to a scratch on the platter. In many cases, that head can be switched off or physically removed, and data is read from the remaining good heads.

Data located on an unread platter is *not* recoverable, unless it exists elsewhere on the drive, which is unusual.

Although a 75% recovery of data (three out of four platters) is the theoretical maximum, in practice it will be less. This is because any file that is partly located on the "missing" platter will be recovered as incomplete, i.e. corrupted. A drive switches platters automatically without regard to the integrity of the data files.

To use a crude analogy, recovering a drive without all of the platters is like cutting regular sections out of a book (see **Figure 5**). Perhaps you will be able to read a paragraph or so from every page, but then there will be a blank space before the text continues. The important thing to remember is that this "hole" in the data persists throughout the entire drive.

Using our analogy, a large percentage of small files (corresponding to individual sentences in our book) can be read intact. Larger files, such as videos or music, (corresponding to entire pages) cannot be fully read.

In a raw recovery situation, the client will receive recovered files in folders according to type. Each file will have to be reopened, renamed if necessary, and saved to an appropriate place.

Unrecoverable drives:

If we discover damage as extensive as shown in **Figure 2**, we would declare that case to be unrecoverable. The load of debris caught by the filter shows that the drive is completely contaminated, and an examination of the heads will probably look like **Figure 4**.

Even a mildly dirty or contaminated head can create micro-scratches, which may not be apparent to the naked eye.

There is no practical, universal "platter reading machine." Each drive must be repaired to continue the recovery process. Decontamination is essential before replacement parts are installed, to prevent another head crash when the drive spins up.

Even if donor heads enable the drive to start, once the heads contact a damaged area, they will be immediately ruined.

Every hard drive has a special *service area*, which contains the software for its operation, which manages defects, and updates various logs. When a drive is first turned on, the heads travel to this area first. However, if critical files are damaged in the service area, recovery may not be possible. This is another reason why it is a bad idea to try to power cycle a damaged hard drive.

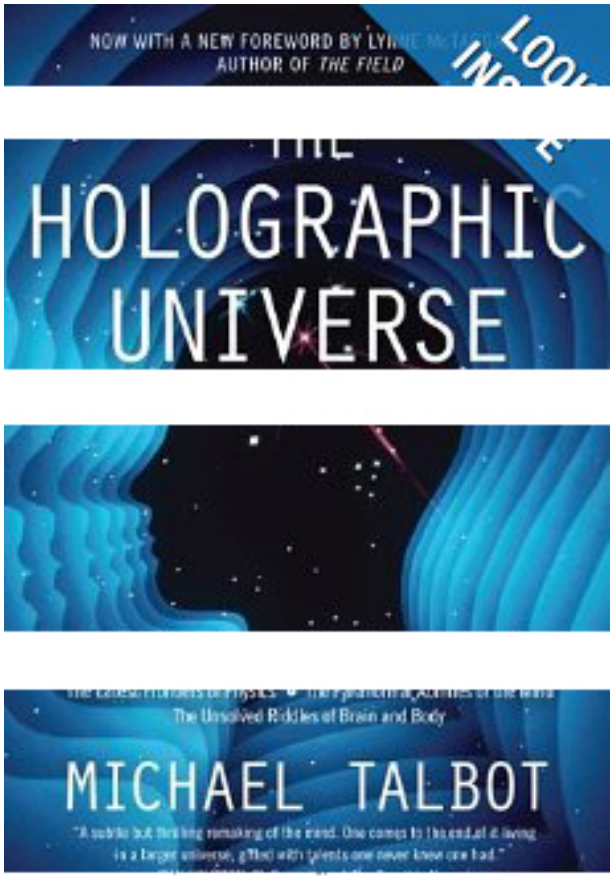

Figure 5. Interleave Analogy

Conclusion

Media damage presents a challenge to data recovery. In many, if not most cases, 100% recovery is not possible, and the client must decide if a partial recovery is going to be acceptable. It may not be practical to try to recover large files, such as music and video, if there is significant media damage.

Ironically, the amount of time, effort and expense required to perform a partial recovery is often a multiple of other cases, in which 100% recovery is possible. As always, data recovery is a salvage operation.