Witness Marks

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Start with an assumption that just seconds before the aircraft impacts that it is pristine and that all systems and instruments are operating normally. In a split instant, that will no longer be the case.

An F-16 hitting the ground in a vertical dive at 600 kts, will crush the radome into the cockpit in less than 1/100 of a second and the engine will come through the cockpit in less than 1 /10 of a second. There is a very quick stop. G forces will be in all in excess of one hundred and as high as one thousand. Crushing is expected throughout, as adjacent parts are compressed into each other, then torn, and shredded apart. If the clock was keeping perfect time, it will stop within 1/10 of a second.

In accidents where the impact angle is less the initial impact may be deformed by subsequent impacts. It is the first impact that is crucial to the investigator simply because it is the impact that will leave marks throughout that will determine the position of systems at the time of impact. The secondary impacts tend to move some systems obfuscating the true impact conditions.

It is imperative to utilize one or all three things when analyzing witness marks.

1. Control drawing blueprints and build up prints or maintenance manual for the part or component.
2. An exemplar piece.
3. Personal expertise with the parts or components.

Witness marks come in many varieties:

1. Paint transfers
2. Paint scratches
3. Bends
4. Gouges and indentations
5. Scratches and scoring
6. Imprints
7. Crushing

For instance in one Air Force fighter Gyro platform teardown it was noted that:

1. The box was severely crushed and compressed.
2. The component parts remained within the box.
3. The two individual gyros weighed several lbs each and were made out of hard and tough steel alloy. They look a little like a toadstool with a stem and a relatively thick disc mounted on top to become a spinning top.
4. Each individual gyro is mounted in a series of gimbals giving the gyro freedom of motion in all axis. Actually, when running the gyros remain aligned as initialized and the aircraft has freedom of motion around the stabilized gyros.
5. The system is designed to be as friction free as possible at the gimbals bearings so motion is uninhibited.
6. There are sensors that continually take electronic readings of gimbals positions and from this, a determination can be made of all three axis of aircraft attitude roll, pitch, and azimuth.

7. When initialized (started up) one gyro is spun up in the vertical position. The other is started in horizontal. The horizontal one gives readings in pitch and azimuth while the vertical one gives readings in roll and pitch.
8. The metal of the gimbals is much softer than that of the gyro itself.
9. When operating normally the gyros spin at about 25,000 R.P.M. or 430 revolutions a second. A point on the outside of the rotating disc is traveling at about 300 mph!

This particular platform was in an F-16 fighter that hit the ground vertically at 600 knots. It crushed and yet all the internal pieces were inside the crushed!

What was found when this platform was dismantled?

1. The Gyros remained within the case.
2. Capture and impact marks were found on the gimbals and electronic pick offs sufficient to make determinations of attitude with a validity of plus or minus 10 degrees. (When compared to the A.D.I. cockpit instrument readings and actual aircraft impact they were vastly different while they should have been identical)
3. The only single scoring found on either gyro was opposite the direction of expected rotation and at an angle to expected rotation instead of in line but opposing rotation.
4. There was no smearing of the softer gimbals metal material onto the spinning gyro.
5. There was no bluing due to frictional heating.
6. The stem of a gyro was broken in compression.

What would an experienced investigator expect to find when such a platform operating normally sustained such an impact?

1. Usually the gyros themselves break out of the crushed case due to their extreme Kinetic energy from rotating at 25,000 R.P.M. Sam Taylor has said it is not unusual to find the gyros hundreds of yards from the aircraft as there rotational speed and energy rolls them away dramatically. The fact they were found in place was indicative that they were not running. The gyros almost explode due to the extreme rotational speed and the rotational forces of the escaping gyros devastate the container.

2. Smearing and bluing of the softer gimbals material is usually present when a 25,000-RPM gyro is freed and displaced into its surrounding gimbals. The absence of any such smearing is evidence that the gyros were not spinning at impact.

3. An angular score on a steel gyro not in line and opposite rotation can only occur when the gyro was stopped. In an impact such as this the mark must have been made during impact crushing and after the gyro had stopped rotating. This suggests that the gyro was stopped before impact.