Accident Investigative Methodology- Sorting it All Out.

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The Integrated Method, The Differential Method, The Hypothetical Exclusion Method, The Time Line Method, The Factual Exclusion Method, The cause factor method, The Legal Causation Method and The " But for" test Method.

Most aviation accidents result when a series of planned and unplanned dynamic events that occur and combine with human or mechanical failure to create a catastrophe. In aviation, as in most accident's, it is unusual for a singular event to cause an accident. Quite the opposite is the norm.

It is up to the investigative group to identify all such events and failures surrounding an accident, and then to classify each such event as to the apparent contribution the event played in the catastrophic outcome.

The United States Government in its investigative methodology initiates its investigations utilizing the Differential Method combined with the Exclusion of Fact Methods.

The **Differential Method** dissects the tragic event into logical and definable subsections. This method is used almost exclusively in Air Crash Disasters. It dissects the investigation into sub committees whose job it is to gather and document all pertinent facts within the category. The findings of each subgroup will be integrated later. Some regular groups include:

- o Aircraft Structures
- o Aircraft Power plants.
- o Aircraft systems.
- o Flight Planning Package.
- o Air Traffic Control and Reconstruction.
- o Weather.
- o Cockpit Voice Recorder, Flight Data Recorder
- o Human Physiology, Autopsy and toxicology.
- o Maintenance.
- o Human Factors.
- o Other specialties as required. (Fire, explosive, sabotage)

The potential shortfall of the differential method is that some meaningful material may be discarded or overlooked at a committee level and therefore be lost to the board. Another shortfall may occur if one committee, by strength of personality or ego, is given preferential treatment over another. A singular committee, focused on important data, may try to interpret other committee findings to support their scenario, while

other inferences may be equally generated from the same facts. The system usually functions well as long as all committee findings are complete and scrutinized appropriately when differing scenarios are tested for validity.

In the General Aviation Arena the basic guideline seems to be a combined Differential Method while a conducting a forced Factual Exclusion discipline. In a General Aviation Accident the Investigator in charge is required to fill out a format checklist that covers most of the same subject areas that a major investigation covers by committee. Since the work is done primarily by one man, and since he has instant result from his own work product, he may restrict himself to the most fruitful areas as they develop. The form requires action in all of the logical areas, and
once completed non fruitful areas are excluded.

A **Factual Exclusion Method** simply collects facts sufficient to exclude a system or a scenario from being a player. At a time that such a conclusion can be drawn, then effort is curtailed within that area. For instance, an investigator might determine that this was daylight, CAVU day with no wind and 60 degree temperatures.
Such a simple factual finding would be enough to suggest that further inquiry in the weather was unneeded.

Often a simple analysis of prop damage, spark plug condition, and compression check and rotation of the prop for internal integrity, combined with little else may be enough to exclude further tests, and sufficient to conclude that engine teardown is probably unneeded.

The **forced factual exclusion** method of investigation is simply following a protocol or checklist that attempts to insure that no facts are left un-gathered. A Factual exclusion method does not attempt to evaluate the data as it is gathered as to positive contribution to the accident. It only excludes, and cuts off investigative efforts where they are obviously not warranted. Probative meanings to the facts gathered are determined secondary to gathering all facts.

An **Integrated Method** of accident investigation simultaneously gathers fact and sorts them both to exclude areas of non concern, and to note areas of high probability, even as the investigation is ongoing.

The Hypothetical Exclusion Method is simple to conduct, but is potentially flawed because it only works if the assumptions are correct and complete. In such an undertaking, the investigator lists all possible scenarios that could possibly result in the specific accident. The hypotheses are created and limited by logic experience and the fact situation. Once the list of hypotheticals is complete, the investigator attempts to first exclude scenarios by listing facts under the hypothec that detract. Some hypothetical scenarios are readily discarded while others remain. After this exercise of exclusion is complete, facts that support remaining scenarios are added and hopefully only a few scenarios remain. Ideally the method would result in only one possible

situation.

The method of listing supporting evidence under a probable scenario is almost universally utilized by lawyers to test the results of any investigation. It is a requirement in law to support your opinion with data and fact. Thus trial lawyers are attuned to such a test questioning.

“And sir what do you rely upon to support your opinion?”

As an example a DC-8, went out of control during a level left turn at night. (See appendix Q) At first the belief was that the accident was caused by pilot error - spatial disorientation.

The aircraft path over the ground was known. The Flight data recorder provided some data such as g forces, altitude, heading, but the airspeed was broken.

Analysis of this data showed that the pilot did not simply roll the aircraft beyond flying limits of bank angle. With this supposition defeated by FDR data the question remained, what could cause a behemoth DC-8 to turn rapidly, go out of control, while the pilot was fighting desperately to overcome the problem. Hypotheses were tested:

Spatial Disorientation rolled into too steep bank over a fifteen second interval:

Facts against:

o Captain said “What’s wrong", 5 seconds later he said" What is happening”
Off the top this doesn't sound like disorientation. (Usually a disoriented person doesn't recognize anything is wrong)

o other pilots plus a pilot in the jump seat did not respond. Most pilots would agree that in fifteen seconds one of the other pilots might probably have said, “Hey stupid, you’re in a steep bank?” Not all of the pilots could have been simultaneously disoriented could they? "

o Flight Data Recorder g reading and heading rate of change, does not support steep bank angle attainment.

Then the next step was to hypothesize what could create such a flight path and resultant loss of control.....

Excessive yawing and loss of control.
From: Flight Control Drag Units (spoilers) - contrary evidence
From: Loss of outboard engines - contrary evidence
From: Uncalled for engine reversal.- contrary evidence
From: Airframe deformation - contrary evidence

From: Rudder Input- uncommanded- substantial evidence.
From: Incapacitation - contrary evidence
From: Suicide - contrary evidence
From: Onboard explosive - contrary evidence

Once data would be found to support a hypo it would be so noted and when data was found to oppose a hypo it too would be noted.
Hopefully one scenario would be left with sufficient evidence to support a conclusion. In this case all data supported a rudder hard over.

In this case the supporting data included:

- o A Rudder Power pack in Manual reversion
- o A trim Tab released to manual.
- o A Rudder over slightly to the left.
- o ailerons still powered.
- o Cabin release of rudder to manual reversion.
- o a complete flight simulator profile that duplicated actual flight conditions.
- o Super positioning of flight and voice recorder data from this flight on top of USAIR 737 Pittsburgh known rudder hard over was almost identical.

Very often Lawyers prefer a **time line method** of flight path reconstruction and investigation, when possible. Here all factual data is first documented. Each event that is known to have occurred is given a label, and if the precise time such event occurred is known the event is so marked. When the time of such an event is unknown it is left blank.

The accident is then plotted and reconstructed. Often such investigations will use the point of crash as time zero. Anything that happens before may be annotated with a minus sign, while post crash gets a plus sign. This is similar to NASA using T-2 to mean to minutes before launch. Post crash events are very important to legal investigations because they may point out second impact deficiencies or crashworthiness aspects. Events and facts prior to the crash may have a significant time lapse between the event and the accident.(This is especially true in design deficiency S.P.L.T. litigation investigation.) It may also be true in a maintenance sense. To wit, an example: “Six months before the accident a military aircraft underwent a major overhaul and fatigue audit. It was found that the wing had some fatigue cracking that was judged insignificant. At the accident wing failure was attributed to propagation of that earlier discovered fatigue crack. "

The construction of such a complete time line is very cumbersome. At some point these same facts and events that are listed, are analyzed as to whether they potentially caused or contributed to another event. If they did they are so annotated. An analysis of such facts and events is conducted while posing the obvious question. “What event did this fact or event trigger or contribute to." When a chain of causation exists the events are linked to the event they caused by a line. Eventually the hope of the

investigator is to be able to chart an unbroken chain of causation from triggering events to the accident and beyond if crashworthiness is a possibility.

Thus the time line method morphs into a chain of causation line. Having gathered all the facts and having created lines of causation, now the myriad of meaningless facts can be discarded leaving a very straight forward and complete picture of the timely structuring of fact and events that caused or contributed to the accident.

Such seems to be the case in the USAIR 737 rudder hard over case. The knowledge that there was a rudder excursion seems documented. The unanswered question seems to be why.

Often the time line method will provide an emerging picture of a line of causation that appears broken. However, such may not really be the case; instead the evidence to prove the chain is simply still missing. Often, the existence or probability existence of that piece of missing evidence can be proven by using circumstantial evidence.

LEGAL INVESTIGATIONS

The parameters of a Government investigation may be curtailed by budget, time and adverse circumstance. As reported in another section, a typical government accident investigation, usually does not delve as deeply into corporate records as a legal investigation may through its discovery powers.

Legal Investigations go several steps beyond and utilize other tests to warrant the results of the investigative process. First the legal investigation may be started utilizing any or all of the methods, as well as others, described above. Here in the facts, events, and data obtained through the investigative process are all discarded as garbage until they can be elevated to the status of evidence. The investigation and all its results are totally meaningless in a court of law, until their validity and probative value can be shown.

As was vividly shown by the O.J. Simpson trial, every piece of forensic evidence is opened to scrutiny, every fact found seemed open to differing inference. The governments reports, in this case police reports were tested for their very trustworthiness. The general rule that a government factual investigation is trustworthy and admissible is not always so.

Thus the attorney attempting to enter data gathered through an investigation is burdened to elevate that data to a status of evidence in admissible form.

Speculation and lay opinion will not suffice; neither will possible events be given probative value. Hearsay evidence will be excluded for the most part. Evidence that is too prejudicial will be withheld. Evidence of other previous accidents will be

scrutinized very closely before being admitted as probative evidence of similarity. The list goes on.

To accomplish the goal of proving the truth, the attorney must look at each event, factual finding and data and see that it is supportable when compared to the evidentiary exclusion rules. It ain't what you know, but what you can prove that becomes paramount. An unbroken chain of causation can only be linked by an unbroken chain of admissible evidence.

Another test that the evidence is important to any chain of causation is the application of a "**but for test**". It is a test in which the investigator asks himself "But for the existence of a certain event or fact, would the accident have occurred anyway."
An affirmative answer to such a question may suggest that the event or fact may not be a player in the accident chain of causation.

A differing examination and investigation is conducted by attorneys concerning the results of an aircraft accident. Once the results of causation are fully recognized, the lawyer attempts to place blame in line with the existing framework of the laws of the forum. The question is whose fault was this accident. What laws allow me redress for this fault?

Then the last investigation to be conducted is to analyze whether or not the parties at fault have some special immunity, such as government immunity as between government and soldier, or government contract defense immunities. The last scrutiny is purely economic in nature. If a lawsuit is found favorable to the plaintiff, can the defendant pay the judgment?

The Same Crash - Different Investigations- Different results.

The following examples are slightly condensed and fictionalized to illustrate the point that differing methodology and differing depth of investigation can paint an accident in an entirely different light.

EXAMPLE I.

A 4 passenger, single engine light aircraft takes off and attains an altitude of 2,000 AGL. At that time fire is noticed burning through the rear baggage bin behind the rear seats. The pilot attempts a crash landing in a field. During the descent that took about two to three minutes the passenger is severely burned on her legs and back of the neck as the rear seats all catch on fire. On crash she is thrown clear while the pilot remains inside and is killed.

The N.T.S.B. conducts its investigation and comes to a conclusion.

1. The aircraft had been worked on for a faulty E.L.T.

2. The faulty E.L.T. had been removed awaiting a new E.L.T.

3. The E.L.T. antennae lead had been either simply left to dangle or had been tied off. If it had been tied off, it came loose and dangled.

4. The E.L.T. lead dangled into the battery lead and caused a short circuit.

5. The heat and sparks from the short caught the waterproof plastic battery case on fire.

6. The fire progressed through the plastic separator for the baggage compartment and the tail of the aircraft.

7. The aircraft interior caught fire: Molding, side walls, seats, rugs, seat cushions et al.

8. The pilot did not successfully land the aircraft.

N.T.S.B. conclusion: Faulty maintenance procedure allowed E.L.T. lead to come in contact with the battery causing a short and the fire.

The legal investigation shows:

a. The survivor states that the aircraft became so hot she contemplated jumping out airborne. She said it happened within two minutes.

b. Swatches of rug, seat cover, seat pad, molding and sidewall material were burn tested under Industry Standard test procedures.
None of the materials complied with required standards when the heat source was removed.

The legal conclusion: The N.T.S.B. was correct as to the cause of the accident. Safety would have been enhanced if the N.T.S.B. had taken the next logical step and asked, “Why did the aircraft burn so quickly?”

EXAMPLE II.

A one year old single engine aircraft suffers a mid air separation in daylight, good weather conditions. The aircraft was near the outer marker to a major airport. A C-130 was landing about 4 to 5 miles in front.

The N.T.S.B.:

1. Weather was not a factor.

2. The aircraft had complied with an A.T.C. request to keep his speed up due to Jet traffic.

3. Radar had showed that the aircraft speed was slightly in excess of redline.

4. Tail parts were found the farthest from the wreckage.

5. Tail parts showed both up and down bending.

6. No fatigue was found, all breaks were overload.

7. There was no flight control stop hammering.

8. Maintenance history showed a towing accident that had involved the tail.

9. The C-130 was considered as a possible wake turbulence source.

Conclusion: Overstress of the aircraft. Pilot conducted flight beyond redline.

The legal investigation showed:

a. Reconstruction of radar data showed the aircraft slightly above redline, but well below design dive and demonstrated flutter speeds.

b. Farmer, witness said that aircraft was going fast, straight and level, made a loud engine noise and the tail came off.

c. Company records show that the aircraft had a hump flutter mode close to design damping limits and another flutter mode only slightly beyond redline speed.

d. Weather reconstruction combined with radar track reconstruction showed that the C-130 turbulence would not have been a player.

The legal conclusion: The N.T.S.B. was correct, the pilot had erred allowed the aircraft to go slightly too fast. The point was that the aircraft should not have come apart below, flutter or dive speed since there is supposedly a safety margin included to pick redline speed !