

**John Barry Smith
www.corazon.com
barry@corazon.com
Copyright May 2002
All Rights Reserved**

**AIRCRAFT
ACCIDENT
REPORT
Pan Am Flight 103
Part I
Consideration of Reasonable Probable Causes**



**Report on the accident to
Boeing 747-121, N739PA
at Lockerbie, Dumfriesshire, Scotland
on 21 December 1988
by John Barry Smith,
Independent Aircraft Accident Investigator**

Part I: Consideration of Reasonable Probable Causes

Abstract and excerpts from AAIB 2/90: The aircraft, Flight PA103 from London Heathrow to New York, had been in level cruising flight at flight level 310 (31,000 feet) for approximately seven minutes when the last secondary radar return was received just before 19.03 hrs. The radar then showed multiple primary returns fanning out downwind. Major portions of the wreckage of the aircraft fell on the town of Lockerbie with other large parts landing in the countryside to the east of the town. Lighter debris from the aircraft was strewn along two trails, the longest of which extended some 130 kilometres to the east coast of England.

The AAIB report concludes that the detonation of an improvised explosive device led directly to the destruction of the aircraft with the loss of all 259 persons on board and 11 of the residents of the town of Lockerbie. Five recommendations are made of which four concern flight recorders, including the funding of a study to devise methods of recording violent positive and negative pressure pulses associated with explosions.

This Smith Pan Am Flight 103 AAR concludes that there are four reasonable alternatives to the bomb explanation based on the subsequent similar accidents of United Airlines Flight 811 and Trans World Airlines Flight 800. Of the four reasonable alternatives, two can be ruled out with confidence: Missile strike and center fuel tank explosion; and two ruled in: Firing of a rather large shotgun and the shorted wiring/forward cargo door rupture/explosive decompression/inflight breakup explanation which closely matches the probable cause of the United Airlines Flight 811 accident. Since the discovered hazards of faulty wiring or switch and nonplug cargo doors currently exist in the five hundred early model Boeing 747s in service, further official investigation is warranted and urgently needed.

Table of Contents

Part I: Consideration of Reasonable Probable Causes

1. Factual Information
 - 1.1 History of the Flight
2. Premise Explanations for Pan Am Flight 103
 - 2.1 Explosion in flight in the forward cargo compartment leading to inflight breakup.
 - 2.1.2 Discussion
 - 2.1.3 Conclusion:
 - 2.2.1 Premise: Surface to air or air to air missile strike inflight:
 - 2.2.2. Discussion:
 - 2.2.3 Conclusion:
 - 2.3.1 Premise: Center Fuel Tank explosion with undetermined ignition source:
 - 2.3.2 Discussion:
 - 2.3.3 Conclusion:
 - 2.4.1 Premise: Explosion in the forward cargo compartment on the starboard side caused by explosive decompression caused by structural failure of a ruptured open forward cargo door at one or both of the midspan latches caused by faulty electrical wiring or switch shorting on the door unlatch motor.
 - 2.4.2. Discussion:
 - 2.4.3 Conclusion:
 - 2.5.1. Premise: Explosion of a improvised explosive device (bomb) in the forward cargo compartment on the left side.
 - 2.5.2 Discussion:
 - 2.5.3 Conclusion:
 - 2.6.1 Premise: Firing of a rather large shotgun in a baggage container.

- 2.6.2. Discussion:
- 2.6.3 Conclusion:
- 2.7. Summary:
- 3. Sequence of disintegration.
- 4. Hindsight Pattern.
- 5. Specific Conclusions for Pan Am Flight 103:
- 6. Concluding Comment:

Part II: Comparison to Similar Accidents

- 1. Introduction:
- 2. Purpose of Part II:
- 3. Premise Explanation: Explosion in the forward cargo compartment of explosive decompression caused by structural failure of ruptured open forward cargo door at one or both of the midspan latches caused by faulty electrical wiring:
- 4. Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800 had probable causes which were initially thought to be bomb explosions:
- 5. Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800 had the original cause of bomb explosion modified.
- 6. Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800 had breakups in their airframes in a similar amidships location.
- 7. Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800 had at least nine never recovered bodies.
- 8. Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800 had passengers that showed explosive decompression type injuries and no evidence of bomb explosion injuries.
- 9. Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800 had experienced a sudden, loud, audible sound on the cockpit voice recorder at event start time:
- 10. Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800 had the source of the sudden, loud, audible sound as a bomb explosion disputed and the source of the sudden, loud, audible sound as an explosive decompression supported.
- 11. Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800 had an abrupt power cut to the data recorders immediately after a sudden, loud, audible sound at event start time.
- 12. Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800 had an explosion in or adjacent to the forward cargo compartment.
- 13. Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800 had similar shattered fuselage skin in and around the forward cargo door.
- 14. Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800 had relatively mild damage on the port side of the nose forward of the wing directly opposite the shattered zone around the forward cargo door at the same initial event time.
- 15. Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800 had similar damage to their airframe structures from inflight ejected debris.
- 16. Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800 had foreign object damage to engine number three.
- 17. Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800 had incomplete reports of the status of the forward cargo door.
- 18. Air India Flight 182, Pan Am Flight 103, and Trans World Airlines Flight 800, and United Airlines Flight 811 to a much lesser extent, had similar debris patterns on the surface of the ground or sea bottom.

19. Summary of matching evidence for all aircraft:
20. Summary of matching evidence between Pan Am Flight 103 and United Airlines Flight 811 specifically:
21. Cargo Door Operation for Boeing 747:
22. Inadvertent Cargo Door Opening Causes:
23. Wiring:
24. Comment:
25. General Conclusions for Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800:
26. Specific Conclusions for Pan Am Flight 103:
27. Contributing causes:
28. Recommendations:

Part III: Door Story

Forward Cargo Door Areas Compared for United Airlines Flight 811, Pan Am Flight 103, Air India Flight 182, and Trans World Airlines Flight 800.

1. Introduction.
2. Normal Operation.
3. United Airlines Flight 811.
4. Air India Flight 182.
5. Pan Am Flight 103.
6. Trans World Airlines Flight 800
7. Conclusions.

Part IV: Comparison between AAIB 2/90 and Smith AAR for PA 103

1. Observations:

Engine number three was the only engine to fall apart from the others; it was the only one to catch fire; and it contained ingested debris from within the aircraft.

2. Observation:

Forward fuselage section was bent to starboard and then entirely detached.

3. Observations:

There are only two small fragments of plastic which are the only 'hard' evidence of a bomb (there is much evidence of an explosive decompression).

4. Observation:

The overall evidence of damage from an explosion of a powerful plastic bomb in the port side of the forward cargo hold is very limited.

5. Observation:

The sudden loud sound on the cockpit voice recorder can be linked to the explosive decompression sound of a cargo door opening in flight on an airliner.

6. Observation:

Inflight damage to the airframe of Pan Am Flight 103 does not match airframe damage from a staged bomb explosion event in a Boeing 747 at Bruntingthorpe.

7. Observations:

In the AAIB report there is a grammatical error in verb tense and irrelevant inclusions of phrases and conclusions for bomb explosion which are unsupported by evidence.

8. Observations:

There are two photographs in the AAIB report of the port 'bomb' side hole

9. Observation:

The latch status of the forward cargo door is omitted whilst the latch status of the identical aft cargo door (frames 1800-1920) and the CRAF door is given and stated as 'latched.'

10. Observation:

There is much more airframe damage on the starboard side of the airframe away from the ‘bomb’ explosion in areas such as the leading edge of the right wing and the right horizontal stabilizer.

11. Observation:

There was a single primary return received by both Great Dun Fell and Claxby radars approximately 16 seconds before SSR returns were lost.

12. Observation:

The aircraft, Flight PA103 from London Heathrow to New York, had been in level cruising flight at flight level 310 (31,000 feet)

13. Observation:

Pan Am Flight 103 was proceeding normally until a sudden, loud, audible sound was immediately followed by an abrupt power cut to the data recorders.

14. Observation:

The evidence of Pan Am Flight 103 was matched to Air India Flight 182 in AAIB 2/90 but not to United Airlines Flight 811.

15. Conclusions.

Glossary

Acronyms

References and Source Materials

Definitions

Appendices:

Appendix A: Boeing 747 Accidents

Appendix B: Avianca Accident

Appendix C: Comet Accidents

Appendix D: DC-10 Accidents

Appendix E: Boeing History

Appendix F: Cargo Door Incidents

Appendix G: Wiring

Appendix H: Miscellaneous Accidents

Appendix I: Questions

Appendix J: Bruntingthorpe

Appendix K: Weapon Firings

Appendix L: AAIB 2/90

Appendix M: NTSB 92/02

Appendix N: Pressure Relief Doors

Glossary:

Acronyms and Abbreviations:

CASB, Canadian Aviation Safety Board, now TSB, Transportation Safety Board, of Canada

UK AAIB, United Kingdom Air Accidents Investigation Branch, Farnborough, U.K

NTSB USA, National Transportation Safety Board, United States of America

CVR, cockpit voice recorder

DFDR, digital flight data recorder

ATC, air traffic control

AAR, aircraft accident report

MEC, main equipment compartment

PSI, pounds per square inch

FOD, foreign object damage

IED, improvised explosive device

KTS, knots

TAS, true air speed
IAS, indicated air speed
AI, Air India
PA, Pan Am World Airways
UAL, United Airlines,
TWA, Trans World Airlines
JAL, Japan Air Lines
NAVAVNSAFECEN, Naval Aviation Safety Center
a.c. alternating current
AC advisory circular
AD airworthiness directive
ALPA Air Line Pilots Association
amp ampere
AOA angle-of-attack
APU auxiliary power unit
ARTCC air route traffic control center
ASR airport surveillance radar
ATC air traffic control
ATP airline transport pilot
CAM cockpit area microphone
CFR Code of Federal Regulations
c.g. center of gravity
CVR cockpit voice recorder
CWT center wing fuel tank
d.c. direct current
DNA deoxyribonucleic acid
E/E electrical/electronics
EME electromagnetic environment
EMI electromagnetic interference
EPR engine pressure ratio
F Fahrenheit
FAA Federal Aviation Administration
FARs Federal Aviation Regulations
FBI Federal Bureau of Investigation
FDR flight data recorder
FQIS fuel quantity indication system
GPS global positioning system
HF high frequency
Hg mercury
HIRF high-intensity radiated fields
Hz hertz (cycles per second)
JFK John F. Kennedy International Airport (New York, New York)
MHz megahertz
msl mean sea level
NASA National Aeronautics and Space Administration
NOAA National Oceanic and Atmospheric Administration
NPRM notice of proposed rulemaking
PETN pentaerythritol tetranitrate
P/N part number
psi (pressure expressed in) pounds per square inch
P&W Pratt & Whitney

RDX cyclotrimethylenetrinitramine
SB service bulletin
SDR service difficulty report
SL service letter
S/N serial number
STA body station
STC supplemental type certificate
TWA Trans World Airlines, Inc.
USAF U.S. Air Force
USCG U.S. Coast Guard

References and Source Materials:

AAIB Aircraft Accident Report No 2/90, Pan Am 103, 22 December 1988, Boeing 747
Blacks Law Dictionary, Sixth Edition 1990
Canadian Aviation Bureau Aviation Occurrence, Air India Boeing, 747-237B VT-EFO Report
Indian Kirpal Report, Report Of The Court Investigating Accident To Air India Boeing 747
Aircraft VT-ETO, "Kanishka" On 23rd June 1985
NAVAVNSAFECEN Investigation 69-67, RA-5C, 14 June, 1967
Netherlands Aviation Safety Board AAR 92-11, El Al Flight 1862, Boeing 747
NTSB AAR 90/01 UAL Flight 811, 23 February 1989, Boeing 747
NTSB AAR 92/02 UAL Flight 811, 23 February 1989, Boeing 747
NTSB AAR 00/03 TWA Flight 800, 17 July 1996, Boeing 747
NTSB AAR 93/06, JAL Flight 46E, 31 March, 1993, Boeing 747

Definitions: Definitions as used in this report:

Bomb: 'Bomb' may mean an explosive device designed to release destructive material at high velocity upon detonation; an explosive device placed in an aircraft with an intent to detonate.

Cargo Door: In the Boeing 747 both the forward and aft lower cargo doors are similar in appearance and operation. They are located on the lower starboard side of the fuselage and are outward opening and nonplug. The door opening is approximately 110 inches wide by 99 inches high, as measured along the fuselage.

Cargo Compartments: The forward and aft freight holds are used for the storage of cargo and baggage in standard air-transportable containers. The forward freight compartment has a length of approximately 40 feet and a depth of approximately 6 feet. The containers are loaded into the forward hold through a large cargo door on the starboard side of the aircraft.

Conclusion of fact: An inference drawn from the subordinate or evidentiary facts.

Conclusive evidence: That which is incontrovertible, either because the law does not permit it to be contradicted, or because it is so strong and convincing as to overbear all proof to the contrary and establish the proposition in question beyond reasonable doubt.

Ear Barotrauma: Injury to the tympanic membrane (eardrum) when a sudden pressure differential exists between the middle ear cavity and the external ear.

Evidence: A species of proof, or probative matter, legally presented at the trial of an issue, by the act of the parties and through the medium of witnesses, records, documents, exhibits, concrete objects, etc., for the purpose of inducing belief in the minds of the court or jury as to their contention.

Circumstantial Evidence: The proof of various facts or circumstances which usually attend the main fact in dispute, and therefore tend to prove its existence, or to sustain, by their consistency, the hypothesis claimed. Testimony not based on actual personal knowledge or observation of the facts in controversy, but of other facts from which deductions are drawn, showing indirectly the facts

sought to be proved. Evidence of facts or circumstances from which the existence or nonexistence of fact in issue may be inferred. Inferences drawn from facts proved.

Direct Evidence: Evidence in the form of testimony from a witness who actually saw, heard, or touched the subject of questioning.

Tangible Evidence: Evidence which consists of something that can be seen or touched. In contrast to testimonial evidence, tangible evidence is real evidence.

Expert: One who is knowledgeable in a specialized field, that knowledge being obtained from either education or personal experience. One who by reason of education or special experience has knowledge respecting a subject matter about which persons having no particular training are incapable of forming an accurate opinion or making a correct deduction.

Expert Testimony: Opinion evidence of some person who possesses special skill or knowledge in some science, profession, or business which is not common to the average man and which is possessed by the expert by reason of his special study or experience.

Expert Witness: One who by reason of education or specialized experience possesses superior knowledge respecting a subject about which persons have no particular training are incapable of forming an accurate opinion, or deducing correct conclusions. One possessing, with reference to particular subject, knowledge not acquired by ordinary persons.

Explosion: To burst or cause to burst violently and noisily. The sudden and rapid escape of gases from a confined space, accompanied by high temperatures, violent shock, and loud noise.

Explosive Decompression: Explosive decompression is an aviation term used to mean a sudden and rapid loss of cabin pressurization of higher internal air pressure venting outside to the lower pressure air.

Finding: The result of the deliberations of a jury or a court. A decision upon a question of fact reached as the result of a judicial examination or investigation by a court, jury, referee, coroner, etc. A recital of the facts found.

Outward Opening Nonplug: A type of cargo door which undergoes stress to open in flight under a high pressure differential because it opens outward and the door does not 'plug up' or 'block' the opening.

Premise: A statement of fact or a supposition made or implied as a basis of argument.

Reasonable doubt: The standard used to determine the guilt of innocence of a person criminally charged. Reasonable doubt which will justify acquittal is doubt based on reason and arising from evidence or lack of evidence, and it is doubt which a reasonable man or woman might entertain, and it is not fanciful doubt, is not imagined doubt, and is not doubt that juror might conjure up to avoid performing an unpleasant task or duty. Reasonable doubt is such a doubt as would cause prudent men to hesitate before acting in matters of importance to themselves. Doubt based on reasons which arise from evidence or lack of evidence.

Starboard Side: The right side of the fuselage looking from aft to forward. The port side is the left side looking aft to forward. The starboard side of the aircraft faces the viewer when the nose is to the right. Both cargo doors are on the starboard side of the Boeing 747.

Shorted wiring/forward cargo door rupture/explosive decompression/inflight breakup explanation: Mechanical explanation for the inflight breakup of Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800 as caused by an explosion in the forward cargo compartment of explosive decompression when the forward cargo door ruptures open in flight, probably at one or both of the midspan latches and probably caused by faulty wiring inadvertently turning on the door unlatch motor.

Introduction:

This AAR has been created by an independent aircraft accident investigator who has no affiliation with the manufacturer, law enforcement agencies, attorney, airlines, or victim's families. Much of

the text is quoted verbatim from official government documents. The primary document is Aircraft Accident Report No 2/90 (EW/C1094) produced by the Air Accidents Investigation Branch of the United Kingdom.

Any reference to an 'explosion' does not imply a bomb explosion. An 'explosion' can be caused by a fuel tank explosion or an explosive decompression explosion. A reference to an 'improvised explosive device' does not imply a bomb as there are devices which can be improvised, intentionally or unintentionally, to cause an explosion such as blasting caps, firecrackers, fireworks, starting pistols, and gas tanks. Evidence of explosive residue does not imply the explosion of a bomb as the residue could have been put there intentionally as part of a dog sniffing drill or the residue could have come from troop's clothing rubbing on the seats and thus have a benign explanation. Whenever there is evidence of an explosion in an aircraft, and there certainly was an explosion in Pan Am Flight 103, corroborating evidence is required to rule in or rule out the possibilities of a bomb explosion, a missile hit, a fuel tank explosion, or an explosive decompression explosion from metal fatigue or inadvertent fuselage rupture such as caused by a suddenly ruptured open cargo door. Each premise shall be examined and supported by evidence.

This Smith AAR has the benefit of hindsight with the ability to review and analyze dozens of subsequent Boeing 747 accidents as well as evaluating previous accidents of other types. There exists an early model Boeing 747 at Bruntingthorpe that suffered a staged bomb explosion in a cargo compartment which left much actual evidence. There also exists an early model Boeing 747, United Airlines Flight 811, that suffered an explosion of explosive decompression in a cargo compartment which left much evidence. Pan Am Flight 103 was an early model Boeing 747 that suffered an explosion in a cargo compartment which left much evidence which can be compared with other similar events. This AAR shall compare the evidence of Pan Am Flight 103 to that of the other other three explosive events to identify which of the three is most closely matched, the bomb explosion, the center fuel tank explosion, or the ruptured open cargo door explosive decompression explosion.

1. Factual Information

1.1 History of the Flight

Boeing 747, N739PA, arrived at London Heathrow Airport from San Francisco and parked on stand Kilo 14, to the south-east of Terminal 3. Many of the passengers for this aircraft had arrived at Heathrow from Frankfurt, West Germany on a Boeing 727, which was positioned on stand Kilo 16, next to N739PA. These passengers were transferred with their baggage to N739PA which was to operate the scheduled Flight PA103 to New York Kennedy. Passengers from other flights also joined Flight PA103 at Heathrow. After a 6 hour turnround, Flight PA103 was pushed back from the stand at 18.04 hrs and was cleared to taxi on the inner taxiway to runway 27R. The only relevant Notam warned of work in progress on the outer taxiway. The departure was unremarkable.

Flight PA103 took-off at 18.25 hrs. As it was approaching the Burnham VOR it took up a radar heading of 350° and flew below the Bovingdon holding point at 6000 feet. It was then cleared to climb initially to flight level (FL) 120 and subsequently to FL 310. The aircraft levelled off at FL 310 north west of Pole Hill VOR at 18.56 hrs. Approximately 7 minutes later, Shanwick Oceanic Control transmitted the aircraft's oceanic clearance but this transmission was not acknowledged. The secondary radar return from Flight PA103 disappeared from the radar screen during this transmission. Multiple primary radar returns were then seen fanning out downwind for a considerable distance. Debris from the aircraft was strewn along two trails, one of which extended

some 130 km to the east coast of England. The upper winds were between 250° and 260° and decreased in strength from 115 kt at FL 320 to 60 kt at FL 100 and 15 to 20 kt at the surface.

Two major portions of the wreckage of the aircraft fell on the town of Lockerbie; other large parts, including the flight deck and forward fuselage section, landed in the countryside to the east of the town. Residents of Lockerbie reported that, shortly after 19.00 hrs, there was a rumbling noise like thunder which rapidly increased to deafening proportions like the roar of a jet engine under power. The noise appeared to come from a meteor-like object which was trailing flame and came down in the north-eastern part of the town. A larger, dark, delta shaped object, resembling an aircraft wing, landed at about the same time in the Sherwood area of the town. The delta shaped object was not on fire while in the air, however, a very large fireball ensued which was of short duration and carried large amounts of debris into the air, the lighter particles being deposited several miles downwind. Other less well defined objects were seen to land in the area.

The AAIB report concludes that the detonation of an improvised explosive device led directly to the destruction of the aircraft.

2. Premise Explanations for Pan Am Flight 103

The AAIB report conclusion is interpreted by most to mean a bomb blew Pan Am Flight 103 out of the sky. That interpretation may not be correct as there are alternatives based on subsequent similar accidents such as United Airlines Flight 811 and Trans World Airlines Flight 800. An alternative probable cause to Pan Am Flight 103 must be considered if the alternative were:

1. Plausible.
2. Reasonable.
3. Well documented by official investigative reports.
4. Has close precedent.
5. Reveals current hazard.

There is one solid conclusion and five reasonable explanations for probable cause based upon subsequent similar fatal inflight accidents to early model Boeing 747s:

- 2.1. Explosion in flight in the forward cargo compartment leading to inflight breakup as an initial event and is a solid conclusion.
- 2.2. Missile strike. (Brought up by Trans World Airlines Flight 800.)
- 2.3. Center fuel tank explosion with undetermined ignition source. (Brought up by Trans World Airlines Flight 800.)
- 2.4. Shorted wiring/forward cargo door rupture/explosive decompression/inflight breakup. (Brought up by United Airlines Flight 811.)
- 2.5. Explosion in flight from a bomb in the forward cargo compartment. (Brought up by Air India Flight 182, Pan Am Flight 103, Trans World Airlines Flight 800, and United Airlines Flight 811.)
- 2.6. Firing of a rather large shotgun in forward cargo compartment. (Brought up by Pan Am Flight 103.)

2.1 Premise: Explosion in flight in the forward cargo compartment leading to inflight breakup.

2.1.2 Discussion: The unanimous conclusion by authorities of a sudden inflight breakup implies an explosion of explosive decompression since the hull of Pan Am Flight 103 was pressurized to a 8.9 pounds per square inch differential between inside and outside air at 31000 feet above mean sea level. Explosive decompression is a symptom of a sudden hull breakup, not the cause. If the hull is not compromised by a break, hole, or tear in it, decompression does not occur. Any break of substantial size in that highly pressurized hull, for reasons such as a bomb explosion, a midair collision, or an inadvertently opened cargo door, would be sufficient to cause an explosive decompression and subsequent partial or full inflight breakup. Inflight breakups can be caused by an explosive decompression which can be caused by a 'bomb' explosion, or structural failure, or an inadvertent door opening. All bomb explosions, all structural failures, and all inadvertent door openings do not cause inflight breakups; in fact, many aircraft have suffered those events and landed safely. On the other hand, any one of those events has the potential to cause an inflight breakup and have done so in the past, depending on the sizes of the bomb, the skin tear, or the open door.

When a catastrophic event occurs, such as an explosion of a bomb or a large door opening in flight, much evidence is left behind for investigators to recover, examine, and evaluate specific to that cause. All explosions of any kind leave certain similar evidence regardless of the cause of the explosion. Evidence of an explosion does not imply a 'bomb' nor an explosive decompression from any source. Even when there is a single piece of tangible evidence that indicates a specific type of explosion such as a bomb, structural failure, or an inadvertent door opening, other corroborative evidence is required to sustain the conclusion of the type of explosion since all types of explosions can cause similar evidence and explosive decompressions from any source can mimic a bomb explosion and vice versa.

From AAIB Aircraft Accident Report No 2/90: '2.14 Summary: The combined effect of the direct and indirect explosive forces was to destroy the structural integrity of the forward fuselage.' UK AAIB Report 2/90 Page 56. 'The forward fuselage and flight deck area separated from the remaining structure within a period of 2 to 3 seconds.' UK AAIB Report 2/90 Page 57 'Although the pattern of distribution of bodies on the ground was not clear cut there was some correlation with seat allocation which suggested that the forward part of the aircraft had broken away from the rear early in the disintegration process.' UK AAIB Report 2/90 Page 30

The evidence which shows there was an explosion in the forward cargo compartment can be summed up by the following evidence.

- A. Inflight breakup just forward of the wing causing damage to wing leading edge and engines.
- B. Debris pattern showing nose came off the aircraft in flight.
- C. Suddenness of event.
- D. Sudden loud sound on the CVR.
- E. Abrupt power cut to the FDR.
- F. First pieces to leave aircraft were from area just forward of the wing.
- G. Trajectory pattern shows explosion in forward cargo compartment.
- H. Outwardly peeled skin in forward cargo compartment area.

There is now revealed a new structural weakness in the forward cargo compartment for Boeing 747s and by implication all pressurized jets with large outward opening nonplug cargo doors.

For the Boeing 747: The four eight foot vertical slices in the fuselage skin for the sides of the forward and aft cargo doors are held in place by only one latch in each side. So, each eight foot vertical slice has one midspan latch to hold four feet closed on each side of it. The midspan latch has no locking sector on the latching cam to prevent inadvertent back driving in flight. All of the eight bottom latches on each door, for a total of sixteen latches, have locking sectors. The four midspan latches for the two cargo doors have none. The weakness is at the midspan latches and the absence of locking sectors. One latch with no locking sector for eight feet of fuselage slice is not enough. The midspan latch ruptures open in flight and causes the tell tale peeled back and down skin from the latch such as in Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800 and apparently Air India Flight 182.

2.1.3 Conclusion: There was an explosion in the forward cargo compartment which caused an explosive decompression that led the the inflight breakup of Pan Am Flight 103.

There are many ways for an explosion to occur in the forward cargo compartment at the forward cargo door: (Current official opinion in parentheses)

- A. Bomb explosion. (Partially accepted for two flights, ruled out for two flights.)
- B. Crew or passenger error. (Ruled out for all flights.)
- C. Electrical fault in switch or wiring. (Accepted for two flights, ruled out for two flights.)
- D. Pneumatic overpressure. (Ruled out for all flights.)
- E. Cargo shift. (Ruled out for all flights.)
- F. Compressed air tank explosion. (Ruled out for all flights.)
- G. Fire in compartment. (Ruled out for all flights.)
- H. Missile strike. (Ruled out for all flights.)
- I. Midair collision. (Ruled out for all flights.)
- J. Fuel tank explosion. (Accepted for one flight, ruled out for three flights.)
- K. Stowaway. (Ruled out for all flights.)
- L. Electromagnetic interference. (Ruled out for all flights.)
- M. Comet or meteor. (Ruled out for all flights.)
- N. Space debris. (Ruled out for all flights.)
- O. Turbulence. (Ruled out for all flights.)
- P. Out of rig door. (Ruled out for all flights.)
- Q. Lightning. (Ruled out for all flights.)
- R. Metal fatigue. (Ruled out for all flights.)
- S. Improperly latched. (Initially accepted for one flight, then ruled out for all flights.)
- T. Design error. (Accepted for one flight, ruled out for three flights.)
- U. Repair error. (Ruled out for all flights.)
- V. Maintenance error. (Accepted for one flight, ruled out for three flights.)
- W. Collision with terrain. (Ruled out for all flights.)

Of the twenty three ways to cause an explosive decompression in the forward cargo compartment in flight, only five are reasonable for Pan Am Flight 103 based on precedent and other evidence.

1. Missile strike. (Brought up by Trans World Airlines Flight 800.)
2. Center fuel tank explosion with undetermined ignition source. (Brought up by Trans World Airlines Flight 800.)
3. Shorted wiring/forward cargo door rupture/explosive decompression/inflight breakup. (Brought up by United Airlines Flight 811.)
4. Bomb. (Brought up by Air India Flight 182 and Pan Am Flight 103 and Trans World Airlines Flight 800 and United Airlines Flight 811.)
5. Rather large shotgun. (Brought up by Pan Am Flight 103.)

2.2.1 Premise: Surface-to-air or air-to-air missile strike inflight:

2.2.2. Discussion: A missile could have struck the aircraft in flight. Only a hit in the forward cargo compartment would have caused the abrupt power cut to the recorders and the sudden loud sound in addition to all the other evidence of inflight damage to the airframe forward of the wing. There is no corroborative evidence that a missile struck Pan Am Flight 103. There were no military planes nearby nor reports of missing missiles, there were no reports of missile sightings at event time, there is no wreckage evidence of residue, missile casing, pitting, or cratering which follows a high explosive detonation, and there was no missile explosion sound on the CVR. The reasons that a missile strike was ruled out for Trans World Airlines Flight 800 are the same reasons that a missile strike can be ruled out for Pan Am Flight 103.

Page 257 to page 259 of NTSB AAR 00/03 for Trans World Airlines Flight 800: ‘2.2.1.2 Consideration of a High-Energy Explosive Device Detonation (Bomb or Missile Warhead) Several factors led to speculation that the accident might have been caused by a bomb or missile strike. These factors included heightened safety and security concerns because of the 1996 Olympics then being held in the United States, the fact that TWA flight 800 was an international flight, and the sudden and catastrophic nature of the in-flight breakup. In addition, numerous witnesses to the accident reported seeing a streak of light and then a fireball, which some people believed represented a missile destroying the airplane. Further, some anomalous primary radar targets were recorded by the Islip, New York, radar site in the general vicinity of TWA flight 800 at the time of the accident that apparently could not be explained. Accordingly, the Safety Board considered the possibility that a bomb exploded inside the airplane or that a missile warhead from a shoulder-launched missile exploded upon impact with the airplane. Testing performed by the Federal Bureau of Investigation (FBI) found trace amounts of explosives on three separate pieces of airplane wreckage (described by the FBI as a piece of canvaslike material and two pieces of floor panel). However, none of the damage characteristics typically associated with a high-energy explosion of a bomb or missile warhead (such as severe pitting, cratering, petalling, or hot gas washing) were found on any portion of the recovered airplane structure, including the pieces on which the trace amounts of explosives were found. Only about 5 percent of the airplane's fuselage was not recovered, and none of the areas of missing fuselage were large enough to have encompassed all of the damage that would have been caused by the detonation of a bomb or missile. Although several large holes are visible in the reconstructed portion of the airplane fuselage, almost all of the structure that originally filled in these holes is attached to the remaining structure but is folded either inward or outward. No area of structure in the reconstructed portion of the airplane contained any unexplained holes large enough to represent the entry point of a missile. Further, the victims remains showed no evidence of injuries that could have been caused by high-energy explosives, nor was there any damage to the airplane seats and other interior components consistent with a high-energy explosion. Investigators considered several scenarios to determine how the trace amounts of explosive residue might have gotten on the wreckage from the accident airplane. Trace amounts of explosive residue could have been transferred to the contaminated pieces from the military personnel (and their associated clothing, boots, and equipment) that were on board the accident airplane when it was used to transport troops during the Gulf War in 1991. In addition, explosives were placed and then removed from several locations in the accident airplane during a dog-training explosive detection exercise about 1 month before the accident. Despite being unable to determine the exact source of the trace amounts of explosive residue found on the wreckage, the lack of any corroborating evidence associated with a high-energy explosion indicates that these trace amounts did not result from the detonation of a high-energy explosive device on TWA flight 800. Accordingly, the Safety Board concludes that the in-flight breakup of TWA flight 800 was not initiated by a bomb or a missile strike.”

2.2.3 Conclusion: Based upon lack of corroborative evidence, a missile strike as a probable cause for Pan Am Flight 103 may be ruled out.

2.3.1 Premise: Center Fuel Tank explosion with undetermined ignition source:

2.3.2 Discussion: There was a fire in the wing and engine number three but no evidence of inflight fire around the center fuel tank. The center tank may have been on fire as it fell, but it did not explode according to the recovered wreckage. The sound on the CVR was not a fuel tank explosion sound. The pieces of wreckage which left the plane first were not from the center fuel tank. The sides of the fuselage near the center tank were damaged in much different degrees and should be evenly bilateral if a center tank exploded. None of the passenger victims were burned extensively. The reasons for determining that Trans World Airlines Flight 800 suffered an inflight center fuel tank explosion with undetermined ignition source are absent for Pan Am Flight 103.

2.3.3 Conclusion: Based upon lack of corroborative evidence, a center fuel tank explosion with undetermined ignition source as a probable cause for Pan Am Flight 103 may be ruled out.

2.4.1 Premise: Explosion in the forward cargo compartment on the starboard side caused by explosive decompression caused by structural failure of a ruptured open forward cargo door at one or both of the midspan latches caused by faulty electrical wiring or switch shorting on the door unlatch motor.

2.4.2. Discussion:

A. The wiring/cargo door explanation is plausible as a sequence of events from wiring short to airframe breakup as it all could happen according to physical laws of nature.

B. It's reasonable because of the explosive effects of an unintentional hull rupture in a pressurized jet as learned from the Comet and DC-10 experiences.

C. It's well documented by the Kirpal Report, the Canadian Aviation Safety Board AAR, Three NTSB AARs (90/01 and 92/02, and 00/03), AAIB Aircraft Accident Report No 2/90 (EW/C1094), and aviation safety public docket information.

D. It has close precedent because of United Airlines Flight 811 (NTSB AAR 92/02).

E. It reveals a current hazard of aging defective wiring in early Boeing 747s of which about 500 are still in service and it reveals a poorly designed outward opening nonplug cargo door.

The corroborative evidence is literally in volumes: NTSB AAR 90/01 and NTSB AAR 92/02 for United Airlines Flight 811 and AAIB 2/90 for Pan Am Flight 103. Below are specific matches between PA 103 and UAL 811 gleaned from those government AARs.

Both were:

Aged.

High flight time.

Early model-100.

Poly x wired.

Boeing 747.

Experienced hull rupture forward of the wing on right side in cargo door area.

Shape of hull rupture forward of the wing on the right side is rectangle with specific rectangular shape.

Fodded number three engine.

On fire number three engine.

Sudden sound on CVR

Loud sound on the CVR.

Short duration sound on the CVR.

Abrupt power cut to FDR.
 Outwardly peeled and down skin in cargo door area from aft midspan latch.
 Longitudinal break at midline of the forward cargo door at midspan latch.
 More severe inflight damage on starboard side.
 At least nine never recovered bodies.
 Vertical fuselage tear lines forward of the wing and aft of cargo door.
 Torn off and missing skin in forward cargo door area on starboard side.
 Outward peeled skin on upper forward fuselage.
 Destruction initially thought to be have been caused by a bomb.

The photographs and analysis which matches up the forward cargo door areas of Pan Am Flight 103, United Airlines Flight 811, Trans World Airlines Flight 800, and a drawing of Air India Flight 182 are shown in Part III: Door Story, of this Smith AAR.

A detailed examination of a possibly defective forward cargo door was done in the later AAR for United Airlines Flight 811 (NTSB 92/02). It includes close examination of the latch pins for bluing from overpressure, the hinges for overtravel, the torque tubes for bending, the bellcranks for slack, the overpressure relief doors for operation, the manual locking handle for status, the locking sectors for damage, and other evaluations. There is no discussion of the forward cargo door in AAIB 2/90 and in fact, the latching status is omitted as well as a picture of the starboard side door area. The forward cargo door area does need the depth of examination that was conducted for United Airlines Flight 811 and described in Part II: Comparison, of this Smith AAR.

A bomb is one interpretation one may make when words of ‘improvised explosive device’ are stated but it could also be a complex device called a forward cargo door with latches, cams, bellcranks, overpressure relief doors, manual locking handle, viewing ports, and torque tubes. It could be an explosive device because of the experience of United Airlines Flight 811 where the crew described the initial event when the forward cargo door opened inflight as a “tremendous explosion.” The door may have been improvised by fate that let polyimide aromatic insulated wiring called Poly X be installed in planes that are now flying at twice the expected in service life using wiring that is prone to chafing and cracking, especially in the presence of moisture. (The forward cargo compartment has a special bilge built in to hold the excess moisture in the compartment from condensation.) The outward opening device may be considered improvised by the designers who created nonplug cargo doors while making the passenger doors the safer plug type.

The cargo doors on Boeing 747s have been the subject of many Airworthiness Directives over the years to correct problems such as bent sills, exposed wiring, too soft metal, and poorly placed safety placards There are many Service Difficulty Reports of leaking seals requiring emergency landings. Cargo doors on Boeing 747s are extremely complex devices, proven capable of explosive action, poorly designed, and prone to failure. They have failed in flight before in addition to the fatal event of United Airlines Flight 811. (From NTSB 92/02: Previous Cargo Door Incident On March 10, 1987, a Pan American Airways B-747-122, N740PA, operating as flight 125 from London to New York, experienced an incident involving the forward cargo door. According to Pan Am and Boeing officials who investigated this incident, the flightcrew experienced pressurization problems as the airplane was climbing through about 20,000 feet. The crew began a descent and the pressurization problem ceased about 15,000 feet. The crew began to climb again, but about 20,000 feet, the cabin altitude began to rise rapidly again. The flight returned to London. When the airplane was examined on the ground, the forward cargo door was found open about 1 1/2 inches along the bottom with the latch cams unlatched and the master latch lock handle closed. The cockpit cargo door warning light was off.) (Note that Pan Am Flight 125

was the same airline as Pan Am Flight 103 and the aircraft, N740PA, is the sister ship of N739PA- PA 103.)

Cargo doors can be, under certain conditions of flight, improvised explosive devices. They are not bombs although they may cause similar damage if they inadvertently rupture open in flight.

2.4.3 Conclusion: Based upon an abundance of corroborative evidence, (Detailed in Part II: Comparison) an electrical problem of wiring or switch causing a hull rupture in flight as a probable cause for Pan Am Flight 103 may be ruled in pending further investigation.

2.5.1. Premise: Explosion of a improvised explosive device in the forward cargo compartment on the left side.

2.5.2 Discussion: The evidence which explains how the investigators may have been misled into the belief that a relatively mild blast was actually a powerful bomb explosion is detailed in Part IV: Comparison of reports, of this Smith AAR. The evidence which refutes an explosion of a bomb in the forward cargo compartment on the left side can be summed up by the following evidence.

If a powerful bomb were to explode in the forward cargo hold of Pan Am Flight 103 on the left side, certain corroborating evidence would be present such as hot-gas pitting on pieces of metal, punctures, shrapnel, explosive residue, pitting, cratering, explosive type injuries to passengers sitting in the cabin, timer, fuze, and a bomb explosion sound on the cockpit voice recorder.

For Pan Am Flight 103:

- A. Pitting: Present
- B. Cratering: Present
- C. Hot gas washing: Absent
- D. Holes: Absent
- E. Punctures: Absent
- F. Shrapnel: Absent
- G. Explosive residue: Found.
- H. Burn injuries to passengers sitting in the cabin: Absent
- I. Sooted metal: Present
- J. Timer or bomb casing: Fragments of plastic.
- K. Fuze: Absent
- L. Bomb explosion sound on the cockpit voice recorder: Absent

Bombs have been considered for Air India Flight 182 and Trans World Airlines Flight 800 as well as Pan Am Flight 103 and thus extensively investigated. The same reasons for ruling out a bomb for Trans World Airlines Flight 800 are the same reasons to rule it out for Air India Flight 182 and Pan Am Flight 103.

The NTSB states in AAR 00/03 regarding Trans World Airlines Flight 800: Page 180, footnote 368: 'Evidence of a bomb explosion included deformation of materials away from a location at the height of the passenger seat pan, hot-gas pitting damage on multiple pieces of wreckage that formed a pattern radiating from the same location (including into the CWT), punctures radiating from the same location, and shrapnel. Further, according to the FBI's laboratory report, No. 91204034 S YQ YB/91207052 S YQ YB, dated January 30, 1990, chemical analysis of a piece of wreckage from the right side of the CWT identified the presence of RDX and PETN high explosive. These two explosives comprise about 86 percent of the composition of SEMTEX, which is a rubberlike material manufactured by Synthesia Corporation of Semtin, Czechoslovakia,

primarily for use in mining and other civil engineering activities. According to the FBI, SEMTEX has been used by criminal and terrorist elements in Europe since 1966. (SEMTEX was identified as the material used in the bomb placed on Pan Am flight 103. For additional information, see section 1.11.1.2.)’

Page 257 to page 259 of NTSB AAR 00/03 for Trans World Airlines Flight 800 ‘2.2.1.2 Consideration of a High-Energy Explosive Device Detonation (Bomb or Missile Warhead) Several factors led to speculation that the accident might have been caused by a bomb or missile strike. These factors included heightened safety and security concerns because of the 1996 Olympics then being held in the United States, the fact that TWA flight 800 was an international flight, and the sudden and catastrophic nature of the in-flight breakup. In addition, numerous witnesses to the accident reported seeing a streak of light and then a fireball, which some people believed represented a missile destroying the airplane. Further, some anomalous primary radar targets were recorded by the Islip, New York, radar site in the general vicinity of TWA flight 800 at the time of the accident that apparently could not be explained. Accordingly, the Safety Board considered the possibility that a bomb exploded inside the airplane or that a missile warhead from a shoulder-launched missile exploded upon impact with the airplane. Testing performed by the Federal Bureau of Investigation (FBI) found trace amounts of explosives on three separate pieces of airplane wreckage (described by the FBI as a piece of canvaslike material and two pieces of floor panel). However, none of the damage characteristics typically associated with a high-energy explosion of a bomb or missile warhead (such as severe pitting, cratering, petalling, or hot gas washing) were found on any portion of the recovered airplane structure, including the pieces on which the trace amounts of explosives were found. Only about 5 percent of the airplane's fuselage was not recovered, and none of the areas of missing fuselage were large enough to have encompassed all of the damage that would have been caused by the detonation of a bomb or missile. Although several large holes are visible in the reconstructed portion of the airplane fuselage, almost all of the structure that originally filled in these holes is attached to the remaining structure but is folded either inward or outward. No area of structure in the reconstructed portion of the airplane contained any unexplained holes large enough to represent the entry point of a missile. Further, the victims remains showed no evidence of injuries that could have been caused by high-energy explosives, nor was there any damage to the airplane seats and other interior components consistent with a high-energy explosion. Investigators considered several scenarios to determine how the trace amounts of explosive residue might have gotten on the wreckage from the accident airplane. Trace amounts of explosive residue could have been transferred to the contaminated pieces from the military personnel (and their associated clothing, boots, and equipment) that were on board the accident airplane when it was used to transport troops during the Gulf War in 1991. In addition, explosives were placed and then removed from several locations in the accident airplane during a dog-training explosive detection exercise about 1 month before the accident. Despite being unable to determine the exact source of the trace amounts of explosive residue found on the wreckage, the lack of any corroborating evidence associated with a high-energy explosion indicates that these trace amounts did not result from the detonation of a high-energy explosive device on TWA flight 800. Accordingly, the Safety Board concludes that the in-flight breakup of TWA flight 800 was not initiated by a bomb or a missile strike.”

From AAIB Aircraft Accident Report No 2/90 ‘1.13 Medical and pathological information The results of the post mortem examination of the victims indicated that the majority had experienced severe multiple injuries at different stages, consistent with the in-flight disintegration of the aircraft and ground impact. There was no pathological indication of an in-flight fire and no evidence that any of the victims had been injured by shrapnel from the explosion. There was also no evidence which unequivocally indicated that passengers or cabin crew had been killed or injured by the effects of a blast. Of the casualties from the aircraft, the majority were found in areas which

indicated that they had been thrown from the fuselage during the disintegration. Although the pattern of distribution of bodies on the ground was not clear cut there was some correlation with seat allocation which suggested that the forward part of the aircraft had broken away from the rear early in the disintegration process. The bodies of 10 passengers were not recovered and of these, 8 had been allocated seats in rows 23 to 28 positioned over the wing at the front of the economy section.'

Most of the required evidence that corroborates a bomb explosion on Pan Am Flight 103 is missing and those few traces of residue can now be explained as benign based upon Trans World Airlines Flight 800. Evidence of Semtex was found on both Pan Am Flight 103 and Trans World Airlines Flight 800 yet called benign for one and could be for the other, too. The two tiny pieces of plastic hard evidence are suspect as to location and purpose.

The initial event time was officially determined to be the sudden loud sound on the CVR. The initial event of the sudden loud sound is likely the explosive decompression sound when the rupture/structural failure occurred and the air molecules rushed out making the sudden loud sound on the CVR. Pan Am Flight 103 has been matched to Air India Flight 182 in the AAIB report. This initial event sudden sound on the CVR for Air India Flight 182 has been matched to a DC-10 explosive decompression sound when its cargo door opened in flight. All four Boeing 747 sudden sound events have been matched by NTSB in Chart 12 of the public docket for Trans World Airlines Flight 800 (Chart 12 on cover sheet of Part II). The accidents are all linked together by the sudden loud sound on the CVR which is the primary, not the secondary event, of the structural failure when the door ruptured open and explosive decompression ensued. (Detailed in Part II: Comparisons.)

The time of the structural failure of the ruptured open forward cargo door on the starboard side and the opening of the 20 inch hole on the port side was determined to be the initial event time of the sudden loud sound by the AAIB wreckage distribution drawings in Appendix B in the AAIB report which are based upon the distance from the datum line of the retrieved wreckage. These data showed at initial event time the large rectangular shaped fuselage skin area around the shattered forward cargo door occurred at the same time as the 20 inch hole on the smoother port side. As the seconds progressed, the subsequent drawings show the damage holes getting bigger and bigger with the starboard cargo door side hole always remaining larger.

Based on wreckage distribution data, it can be deduced by the evidence that the 20 inch hole on the port side occurred at about the same time as the twenty foot by thirty foot hole on the starboard side and both were at initial event time of the sudden loud sound on the CVR.

2.5.3 Conclusion: Based upon a very small amount or a benign finding of corroborative evidence, an explosion of a powerful explosion from a bomb as a probable cause for Pan Am Flight 103 may be ruled doubtful.

2.6.1 Premise: Firing of a rather large shotgun in a baggage container.

2.6.2. Discussion: The firing of a rather large shotgun may have given evidence which led investigators to conclude a powerful bomb had been detonated causing the destruction of Pan Am Flight 103. (Detailed in Part IV: Comparison of Reports.)

The evidence and AAIB interpretation indicated a relatively mild directed blast existed a corner of a baggage container, traveled about 25 inches and caused a 20 inch hole in the fuselage skin. The sound of the mild directed blast was not heard on the cockpit voice recorder. Bombs are loud,

spherical, and powerful. Shotgun blasts are relatively mild and directed.

The damage in the baggage container and adjacent area was from a mild directed blast as if a rather large shotgun had gone off at close range. (AAIB stated in Aircraft Accident Report No 2/90 (EW/C1094) section: 1.12.2.1 Fuselage: "Where these panels formed the boundary of the shatter zone, the metal in the immediate locality was ragged, heavily distorted, and the inner surfaces were pitted and sooted - rather as if a very large shotgun had been fired at the inner surface of the fuselage at close range," and 8. Analysis: "With the two container reconstructions placed together it became apparent that a relatively mild blast had exited container 4041 through the rear lower face to the left of the curtain and impinged at an angle on the forward face of container 7511.)'

An AAIB official opined the cause of the damage he/she personally viewed to be as if a rather large shotgun had been fired at the fuselage at close range. It may not have been exactly a shotgun but some other type of directed firearm.

This AAIB opinion may have been correct in its assessment of the cause of the mild blast, pitting, sooting, distortions, ragged, and shattered skin as if a very large shotgun had been fired at the inner surface of the fuselage at close range. It may be that pitting, sooting, distortions, ragged, and shattered skin could also have been erroneously interpreted as evidence of a bomb explosion.

Loaded guns have been inserted into baggage holds of airliners before and have been accidentally discharged as detailed in Appendix K. (April 26, 2000 Gun goes off in bag being loaded into jet. Associated Press - Portland "A high-powered handgun went off in the baggage compartment of an Alaska Airlines jetliner on the tarmac at Portland International Airport, sending a bullet into the passenger compartment within inches of passengers' feet. Nobody was injured.")

Shotgun cartridges give sooty residue when fired. A shotgun fires in a directed manner and would give a relatively mild blast compared to a high explosive bomb. The sound of the weapon firing is not heard on the cockpit voice recorder because the power had been abruptly cut in the adjacent main equipment compartment after the tremendous explosive decompression when the huge hole appeared on the starboard side of the hold or the gunshot was over shouted by the tremendous noise from the huge hole and the explosive decompression.

The evidence corroborates the firing of a device called a rather large shotgun in a baggage container which caused a relatively mild directed blast which resulted in a 20 inch hole in the fuselage skin on the port side. This damage was not sufficient to cause the nose to come off Pan Am Flight 103 because the structure was designed to withstand a hold that size in the pressurized hull by the presences of stiffeners, ribs, and belts. The firing of the shotgun was after the explosive decompression because the sound of the gunshot is not on the cockpit voice recorder.

The location in the forward cargo compartment in the baggage container which had its lower quadrant blown way may have held a rather large shotgun which was stored in baggage, was loaded, and was safe unless a tremendous explosion happened nearby. A tremendous explosion did happen nearby when the opposite fuselage blew out when a huge twenty foot by forty foot hold appeared suddenly where the forward cargo door and skin above it used to be. The rather large shotgun went off, the relatively mild explosion left soot on a rib, burst through the corner of the baggage container, went 25 inches and made a 20 inch hole in the port side of the fuselage. A sooty rib was soon found on the ground and immediately incorrectly declared proof a bomb had gone off instead of a shotgun cartridge.

2.6.3 Conclusion: Based upon the presence of corroborative evidence, the firing of rather large shotgun in the forward cargo hold Pan Am Flight 103 may be ruled in as occurring but ruled out as the cause of the subsequent structural failure pending further investigation.

2.7. Summary: To summarize conclusions about Pan Am Flight 103 based upon subsequent events such as United Airlines Flight 811 and Trans World Airlines Flight 800:

1. There was an explosion in the forward cargo compartment inflight because of corroborative evidence.
2. Missile strike unlikely because of absence of corroborative evidence. (Brought up by Trans World Airlines Flight 800.)
3. Center fuel tank explosion with undetermined ignition source unlikely because of absence of corroborative evidence. (Brought up by Trans World Airlines Flight 800.)
4. Shorted wiring/forward cargo door rupture/explosive decompression/inflight breakup likely because of presence of corroborative evidence and the precedent of United Airlines Flight 811. (Brought up by United Airlines Flight 811.)
5. Bomb explosion unlikely because of absence of corroborative evidence.. (Brought up by Air India Flight 182 and Pan Am Flight 103 and Trans World Airlines Flight 800 and United Airlines Flight 811.)
6. Firing of a rather large shotgun in baggage container is likely to have occurred because of presence of corroborative evidence. (Brought up by Pan Am Flight 103.)

3. Sequence of disintegration. Combined from Air Accidents Investigation Branch Aircraft Accident Report No 2/90 (EW/C1094) and Smith AAR:

Water may have met the cracked insulated wire in the cargo door area. The now exposed and bare wire shorted against the metal fuselage. The electricity then flowed around safety cutout switches and powered on the cargo door actuator unlatch electric motor which attempted to rotate all ten cam sectors to unlocked positions around their latching pins. The eight lower cam sectors may have been prevented from unlatching around the latching pins because of the bottom eight locking sectors. However, the two midspan latches had no locking sectors to prevent the inadvertent rotation of the midspan latching cams around the midspan latching pins. The midspan cams may have turned just past center with no locking sectors to prevent the backdriving of the cams, an operation only supposed to be allowed on the ground. Possibly other factors such as an out of rig cargo door, a poor repair job on the door area, the slack in bellcranks, torque tubes, and worn latch pins may combined to have allowed the two midspan latches to rotate just past center permitting the almost 100,000 pounds of internal pressure on the 99 inch by 110 inch door to rupture outward inflight relieving the maximum pressure differential on the internal fuselage.

The eight foot by nine foot squarish forward cargo door would have instantly burst open at the midspan latches sending the latches, door material, and large pieces of fuselage skin spinning away, possibly being picked up on radar. The forward cargo compartment would have spewn its contents outward onto the starboard side of the fuselage. The severe explosion of explosive decompression caused the forward cargo door to be fractured and shattered into a few large pieces and many small pieces which gave a frayed appearance from an outward force. The door skin peeled out and down from the aft midspan latch.

The top part of the door swung outward and upward on its hinge and then separated taking large vertical pieces of fuselage skin with it, exposing stringers and bulkheads. The resulting damage zone appeared as a huge rectangle of shattered door, skin, and stringers. Some pieces of the door and fuselage skin flew directly aft and impacted the leading edge of the right wing, the vertical stabilizer and the right horizontal stabilizer inflight.

This explosion of explosive decompression blew out a large hole about twenty feet wide and thirty feet high on the starboard side of the nose forward of the wing. It looked as if a bomb had gone off inside the forward cargo hold. Fuselage skin was peeled outward at various places on

the starboard side of the nose.

This door, located on the forward starboard side of the aircraft, was broken horizontally about one half of the distance above the lower frame. The damage to the door and the fuselage skin near the door appeared to have been caused by an outward force. The fractured surface of the cargo door appeared to have been badly frayed. The cargo door pieces and the adjacent skin had holes, flaps, fractures, inward concavity, tears, deformities, outward bent petals, curls, missing pieces, cracks, separations, curved fragments, spikes, and folds.

The now uncompressed air molecules rushed out of the huge hole equalizing the high pressure inside the fuselage to the low pressure outside the aircraft while making a sudden very loud audible sound. This sudden rushing outward air was recorded on the Cockpit Voice Recorder as a sudden loud sound. The sound did not accurately match any bomb explosion sounds on other aircraft but did match the explosive decompression sound on another wide body airliner, a DC-10 cargo door open event.

The tremendous explosive force in the forward cargo hold severely disrupted the adjacent main equipment compartment which housed power cables and abruptly shut off power to the Flight Data Recorders. The resulting data tapes showed a sudden loud audible sound followed by an abrupt power cut to the flight data recorder and the cockpit voice recorder.

The initial explosion triggered a sequence of events which effectively destroyed the structural integrity of the forward fuselage. Little more than remained between stations 560 and 760 (approximately) than the window belts and the cabin sidewall structure immediately above and below the windows, although much of the cargo-hold floor structure appears to have remained briefly attached to the aircraft.

The main portion of the aircraft simultaneously entered a manoeuvre involving a marked nose down and left roll attitude change, probably as a result of inputs applied to the flying control cables by movement of structure.

Failure of the left window belt then occurred, probably in the region of station 710, as a result of torsional and bending loads on the fuselage imparted by the manoeuvre (i.e. the movement of the forward fuselage relative to the remainder of the aircraft was an initial twisting motion to the right, accompanied by a nose up pitching deflection).

The forward fuselage deflected to the right, pivoting about the starboard window belt, and then peeled away from the structure at station 800. During this process the lower nose section struck the No 3 engine intake causing the engine to detach from its pylon. This fuselage separation was apparently complete within 3 seconds of the explosion.

Structure and contents of the forward fuselage struck the tail surfaces contributing to the destruction of the outboard starboard tailplane and causing substantial damage to the port unit. This damage occurred approximately 600 metres track distance after the explosion and therefore appears to have happened after the fuselage separation was complete.

Fuselage structure continued to break away from the aircraft and the separated forward fuselage section as they descended.

The aircraft maintained a steepening descent path until it reached the vertical in the region of 19,000 feet approximately over the final impact point. Shortly before it did so the tail fin began to disintegrate.

The mode of failure of the fin is not clear, however, flutter of its structure is suspected.

Once established in the vertical dive, the fin torque box continued to disintegrate, possibly permitting the remainder of the aircraft to yaw sufficiently to cause side load separation of Nos 1, 2 and 4 engines, complete with their pylons.

Break-up of the rear fuselage occurred during the vertical descent, possibly as a result of loads induced by the yaw, leaving a section of cabin floor and baggage hold from approximately stations 1241 to 1920, together with 3 landing gear units, to fall into housing at Rosebank Terrace.

The main wing structure struck the ground with a high yaw angle at Sherwood Crescent.'

4. Hindsight Pattern. A pattern has been revealed which includes Pan Am Flight 103.

Significant Direct and Tangible Evidence Obtained for Four B747 Breakups in Flight

| | AI 182 | PA103 | UAL 811 | TWA 800 |
|---|--------|-------|---------|---------|
| Boeing 747 | Yes | Yes | Yes | Yes |
| Early model -100 or -200 | Yes | Yes | Yes | Yes |
| Polyimide wiring (Poly X type) | Yes | Yes | Yes | Yes |
| Sudden airframe breakup in flight (partial or total) | Yes | Yes | Yes | Yes |
| Breakup occurs amidships | Yes | Yes | Yes | Yes |
| High flight time (over 55,000 flight hours) | No | Yes | Yes | Yes |
| Aged airframe (over 18 years of service) | No | Yes | Yes | Yes |
| Previous maintenance problems with forward cargo door | Yes | Maybe | Yes | Maybe |
| Initial event within an hour after takeoff | No | Yes | Yes | Yes |
| Initial event at about 300 knots while proceeding normally in all parameters | Yes | Yes | Yes | Yes |
| Initial event has unusual radar contacts | Maybe | Yes | Yes | Yes |
| Initial event involves hull rupture in or near forward cargo door area | Yes | Yes | Yes | Yes |
| Initial event starts with sudden sound | Yes | Yes | Yes | Yes |
| Initial event sound is loud | Yes | Yes | Yes | Yes |
| Initial event sound is audible to humans | Yes | Yes | Yes | Yes |
| Initial event followed immediately by abrupt power cut to data recorders | Yes | Yes | Yes | Yes |
| Initial event sound matched to explosion of bomb sound | No | No | No | No |
| Initial event sound matched to explosive decompression sound in wide body airliner | Yes | Yes | Yes | Yes |
| Torn off skin on fuselage above forward cargo door area | Yes | Yes | Yes | Yes |
| Unusual paint smears on and above forward cargo door | Maybe | Maybe | Yes | Yes |
| Evidence of explosion in forward cargo compartment | Yes | Yes | Yes | Yes |
| Foreign object damage to engine or cowling of engine number three | Yes | Yes | Yes | Yes |
| Fire/soot in engine number three | Maybe | Yes | Yes | Yes |
| Foreign object damage to engine or cowling of engine number four | Yes | Yes | Yes | Yes |
| Right wing leading edge damaged in flight | Yes | Maybe | Yes | Maybe |
| Vertical stabilizer damaged in flight | Yes | Yes | Yes | Maybe |
| Right horizontal stabilizer damaged in flight | Yes | Yes | Yes | Yes |
| More severe inflight damage on starboard side than port side | Yes | Yes | Yes | Yes |
| Port side relatively undamaged by inflight debris | Yes | Yes | Yes | Yes |
| Vertical fuselage tear lines just aft or forward of the forward cargo door | Yes | Yes | Yes | Yes |
| Fracture/tear/rupture at a midspan latch of forward cargo door | Maybe | Yes | Yes | Yes |
| Midspan latching status of forward cargo door reported as latched | No | No | No | No |
| Airworthiness Directive 88-12-04 implemented (stronger lock sectors) | No | No | No | Yes |
| Outwardly peeled skin on upper forward fuselage | Yes | Yes | Yes | Yes |
| Rectangular shape of shattered area around forward cargo door | Yes | Yes | Yes | Yes |
| Forward cargo door fractured in two longitudinally | Yes | Yes | Yes | Maybe |
| Status of aft cargo door as intact and latched | Yes | Yes | Yes | Maybe |
| Passengers suffered decompression type injuries | Yes | Yes | Yes | Yes |
| At least nine missing and never recovered passenger bodies | Yes | Yes | Yes | Yes |
| Wreckage debris field in two main areas, forward and aft sections of aircraft | Yes | Yes | No | Yes |
| Initial official opinion of probable cause as bomb explosion. | Yes | Yes | Yes | Yes |
| Initial official opinion modified from bomb explosion | Yes | Yes | Yes | Yes |
| Structural failure considered for probable cause | Yes | Yes | Yes | Yes |
| Inadvertently opened forward cargo door considered for probable cause | Yes | No | Yes | Yes |
| Official probable cause as bomb explosion | Yes | Yes | No | No |
| Official probable cause as 'improvised explosive device' | No | Yes | No | No |
| Official probable cause as explosion by unstated cause | Yes | No | No | No |
| Official probable cause as explosion in center fuel tank with unknown ignition source | No | No | No | Yes |
| Official probable cause as improper latching of forward cargo door | No | No | Yes | No |

| | | | | |
|--|--------|-------|---------|---------|
| Official probable cause as switch /wiring inadvertently opening forward cargo door | No | No | Yes | No |
| "Bomb' allegedly loaded two flights previous to detonation flight | Yes | Yes | N/A | N/A |
| "Bomb' allegedly loaded one flight previous to detonation flight | N/A | N/A | N/A | Yes |
| Takeoff after sunset on fatal flight | Yes | Yes | Yes | Yes |
| Takeoff after scheduled takeoff time on fatal flight | Yes | Yes | Yes | Yes |
| "Bomb' allegedly goes off on ground after a flight | N/A | N/A | N/A | N/A |
| Significant Direct and Tangible Evidence Obtained for Four B747 Breakups in Flight | AI 182 | PA103 | UAL 811 | TWA 800 |

The pattern above is based on similar evidence in only four early model Boeing 747 inflight fatal events. The pattern is clear yet complex and detailed. When a forward cargo door ruptures open in flight, certain things have to happen and they happened for Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800.

The significance of the pattern is that it is possible only one cause is for all and that cause, faulty electrical wiring or switch, still exists, is a current hazard. There is urgency.

An additional significance of the pattern is that enough current hard evidence exists to justify a supplemental safety investigation into Air India Flight 182, Pan Am Flight 103, based upon subsequent similar accidents such as United Airlines Flight 811 and Trans World Airlines Flight 800 from which much new relevant knowledge was gained, such as the aging aircraft study which revealed the dangers of Kapton/Poly X wiring and that an electrical problem can cause a cargo door to rupture open in flight causing fatalities in a Boeing 747.

5. Specific Conclusions for Pan Am Flight 103:

- A. Explosion in forward cargo compartment likely.
- B. A powerful Semtex bomb exploding in port side of forward cargo compartment unlikely and not supported by evidence.
- C. Firing of a rather large shotgun with a baggage container at close range to the fuselage likely and supported by evidence.
- D. Explosion decompression caused by missile strike or center fuel tank explosion with unknown ignition source unlikely and not supported by evidence.
- E. A shorted wiring/forward cargo door rupture/explosive decompression/inflight breakup sequence likely and supported by evidence and precedent.

6. Concluding Comment on Part I: The hazard of faulty wiring or switch still exists in the five hundred early model Boeing 747s in service and the design flaw of inadequate midspan latches with no locking sectors exists in many thousands of Boeing airliners in service today. These hazards present dangers which are preventable.