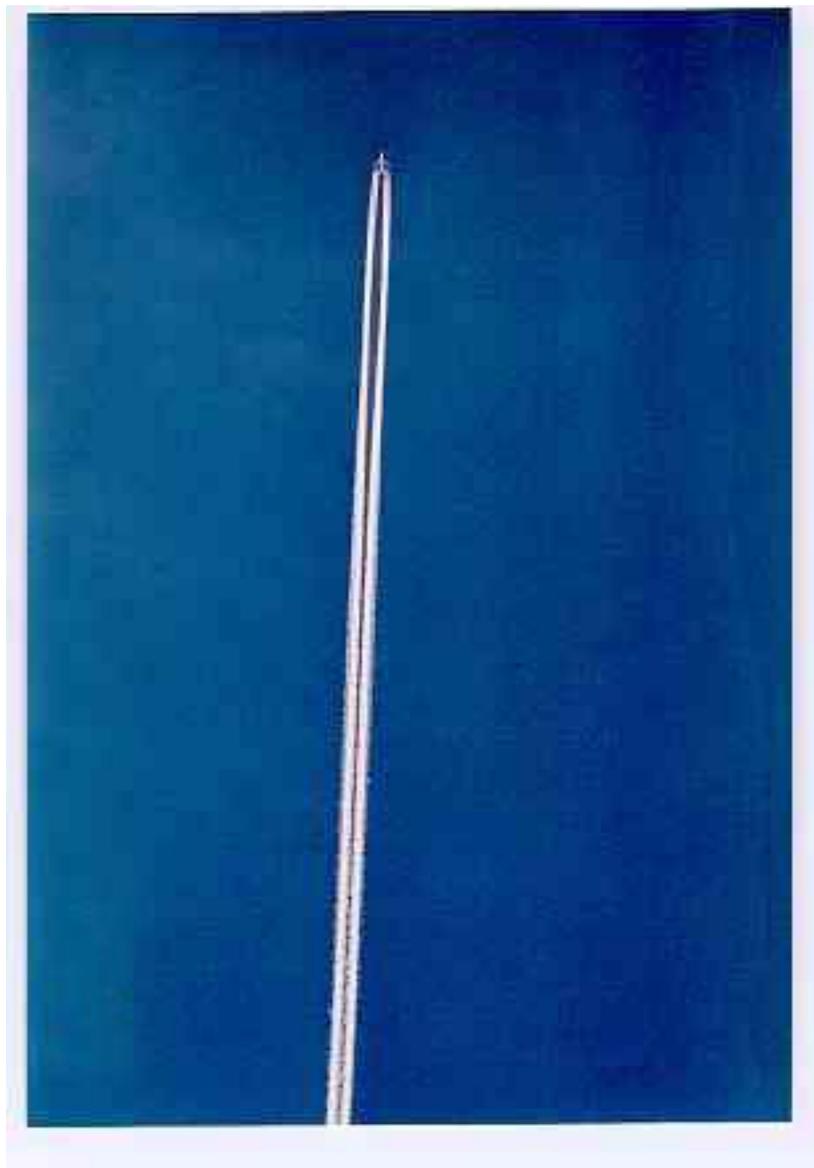


John Barry Smith
www.corazon.com
barry@corazon.com
Copyright 2001
All Rights Reserved

**AIRCRAFT
ACCIDENT
REPORT**
Air India Flight 182



**Report on the Accident to Boeing 747-237B VT-EFO, Air India Flight 182,
Off Cork, Ireland on 23 June 1985
by John Barry Smith,
Independent Aircraft Accident Investigator**

Abstract: Air India Flight 182, a Boeing 747-237B, registration VT-EFO, was on a flight from Mirabel airport, Montreal, Canada, to Heathrow airport, London, UK, when it disappeared from the radar scope at a position of latitude 51 degrees 0 minutes North and longitude 12 degrees 50 minutes West at 0714 Greenwich Mean Time (GMT), 23 June 1985, and the pieces crashed into the ocean about 110 miles west of Cork, Ireland. There were no survivors among the 329 passengers and crew members. There was unanimous official opinion among authorities that an inflight breakup caused by an explosion in the forward cargo compartment occurred. Based on the direct, tangible and circumstantial evidence of four similar accidents as described in six aircraft accident reports and using the benefit of hindsight, the conclusion of this investigator and author of this report is that the probable cause of the accident to Air India Flight 182 was faulty wiring shorting on the door unlatch motor causing the forward cargo door to inadvertently rupture open in flight probably at one or both of the midspan latches leading to an explosion of explosive decompression in the forward cargo compartment and subsequent aircraft breakup.

Contents:

1. Air India Flight 182

Glossary

Acronyms
References and Source Materials
Definitions

Formatting Style

Introduction

2. Premise Explanations for Air India Flight 182

- 2.1 Explosion in flight in the forward cargo compartment
 - 2.1.1 Proponents
 - 2.1.2 Analysis
 - 2.1.3 Conclusion
- 2.2 Explosion of a bomb in the aft cargo compartment
 - 2.2.1 Proponent
 - 2.2.2 Analysis
 - 2.2.3 Conclusion
- 2.3 Explosion in the forward cargo compartment with its cause unstated
 - 2.3.1 Proponent
 - 2.3.2 Analysis
 - 2.3.3 Conclusion
- 2.4 Explosion in the forward cargo compartment, inclusive of a bomb detonation
 - 2.4.1 Proponent
 - 2.4.2 Analysis

- 2.4.3 Conclusions
- 2.5 Explosion in the forward cargo compartment caused by explosive decompression of undetermined cause, exclusive of a bomb detonation
 - 2.5.1 Proponent
 - 2.5.2 Analysis
 - 2.5.3 Conclusions
- 2.6 Explosion in the forward cargo compartment caused by 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
 - 2.6.1 Proponent
 - 2.6.2 Analysis
 - 2.6.3 Conclusion

3. Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, Trans World Airlines Flight 800 Wiring/Cargo Door/Explosive Decompression Matching Evidence

Introduction

4. Formatting style

5. Background

6. Purpose

7. Premise Explanation: Explosion in the forward cargo compartment caused by 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

- 7.1 Matching Significant Circumstantial Evidence
- 7.2 All four aircraft had probable causes initially thought to be bomb explosions.
- 7.3 All four aircraft had the probable cause of bomb explosion modified.
- 7.4 All four aircraft had initial breakups in their airframes in a similar amidships location.
- 7.5 All four aircraft had at least nine missing never recovered bodies.
- 7.6 All four aircraft had passengers which showed explosive decompression type injuries and no evidence of bomb explosion injuries.
- 7.7 All four aircraft experienced a sudden, loud, audible sound on the cockpit voice recorder at event start time.
- 7.8 All four aircraft had the source of the sudden, loud, audible sound as a bomb explosion disputed and the source as an explosive decompression supported.
- 7.9 All four aircraft had an abrupt power cut to the data recorders immediately after the sudden, loud, audible sound.
- 7.10 All four aircraft had an explosion in or adjacent to the forward cargo compartment.
- 7.11 All four aircraft had similar shattered fuselage skin in and around the forward cargo door.
- 7.12 All four aircraft had relatively mild damage on the port side of the nose forward of the wing.
- 7.13 All four aircraft had similar damage to their airframe structures from inflight ejected debris
- 7.14 All four aircraft had foreign object damage to engine number three.

7.15 All four aircraft had incomplete reports of the status of the forward cargo door, in particular, the status of both of the midspan latches.

7.16 All four aircraft had similar debris patterns on the surface of the ground or sea bottom.

7.17 Summary of matching evidence for all aircraft

7.18 Summary of matching evidence between Air India Flight 182 and United Airlines Flight 811 Table 1

8. Cargo Door Operation Boeing 747

9. Choice of Explosion Cause

10. Inadvertent Cargo Door Opening Causes

11. Wiring

12. Sequence of destruction for Air India Flight 182

13. Comment

14. Hindsight

15. General Conclusions

16. Specific Conclusions for Air India Flight 182

17. Contributing Causes

18. Recommendations

19. Concluding Comment

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

1. Air India Flight 182

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.

Wiring/cargo door/explosive decompression explanation: Mechanical explanation for the inflight breakup of Air India Flight 182 and three other Boeing 747s 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.

Formatting Style:

There are two Aircraft Accident Reports specifically referenced in Section 1 regarding Air India Flight 182; the Indian Kirpal Report and the Canadian Aviation Occurrence Report. Conclusions made by an independent accident investigator must be supported by the best evidence available and documented for immediate confirmation by the reviewer; therefore, quotes and section numbers from the actual official reports are given after the discussion by the investigator. The format is to first give a premise explanation, its proponent, an analysis, a discussion of the explanation, and the conclusion; immediately followed by the indented excerpts of the official corroborative statements to support or mitigate against the premise explanation, if appropriate. The first report quoted is always the Canadian Aviation Occurrence Report followed by the Indian Kirpal Report. Any identical duplicated material from both reports is only stated once in a premise explanation but may be repeated in other premises if relevant.

Thus the premise explanation and its proponents is stated, discussion and analysis are made, and then each official report is quoted in sequence to support or mitigate against that explanation. All quotes from the two official Air India Flight 182 reports are indented and followed by the introduction: 'From the Canadian Aviation Occurrence Report:' or 'From the Indian Kirpal Report' and followed by the statements.

Introduction:



There was unanimous official opinion among authorities that an inflight breakup caused by an explosion in the forward cargo compartment occurred in Air India Flight 182 on 23 June 1985 at 0714Z, one hundred fifteen miles west of Ireland while proceeding normally at 31,000 feet above sea level. The information concerning meteorological conditions, crew, flight, aircraft, aids to navigation, communication, and search and rescue as reported by the Indians and Canadians in their reports is stipulated to be correct.

This report examines some the information available to the public with respect to the circumstances surrounding the Air India Flight 182 accident which has been published in public documents reporting conclusions and findings. The sources of information include information made public by the Indian and Canadian inquiries as a result of the RCMP investigation; the flight data recorder (FDR), cockpit voice recorder (CVR) and Shannon ATC tape recording analyses by Canadian, United Kingdom, and Indian authorities; the medical evidence obtained from the pathologist of the Air Accidents Investigations Branch of the United Kingdom; evidence obtained by photographic examination of the wreckage recovered, the wreckage distribution pattern, and evaluations of photographs and videotapes of the wreckage on the ocean bottom. In addition, this report evaluates the evidence and conclusions in other aircraft accident reports which support the conclusion by this investigator for the probable cause of the Air India Flight 182 accident as an inflight breakup caused by a wiring/cargo door/explosive decompression sequence of events.

The tangible and direct evidence to support the conclusion of an inflight breakup by explosion in the forward cargo compartment exists in the CVR, the ATC tape recording, the DFDR, the wreckage distribution, the inflight damage to the airframe, the medical evidence, and the engines. There was no dispute among investigating authorities that a breakup of Air India Flight 182 occurred suddenly and catastrophically in flight and the cause was an explosion in the forward cargo compartment.

There was some circumstantial evidence in 1985 that a bomb caused that explosion; however, based upon similar circumstances to similar aircraft leaving similar evidence in the subsequent sixteen years, new facts and circumstantial evidence sustain the premise explanation by this investigator that the cause of the explosion in the Air India Flight 182 forward cargo compartment was not the result of a conspiracy to detonate a bomb but a mechanical explanation as caused by an explosion in the forward cargo compartment of explosive decompression when the forward cargo door ruptured 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.

Section 2 of this report establishes that Air India Flight 182 did suffer an explosion in the forward cargo door compartment on the starboard side that led to the total breakup of the aircraft in flight and the explosion cause was not a bomb. Section 3 establishes that the cause of the explosion in Air India Flight 182 was an explosive decompression when the forward cargo door ruptured open in flight probably at one or both of the midspan latches and probably caused by faulty wiring.

2. Premise Explanations for Air India Flight 182:

The main questions presented to the investigators in 1985/1986 for the cause of the inflight breakup for Air India Flight 182 were, 'What kind of explosion and where did it occur?' Six premises will be examined:

2.1 Premise Explanation: Explosion in flight for Air India Flight 182 in the forward cargo compartment.

Proponents: Indian Government in its Kirpal Report, CASB, Canadian Aviation Safety Board, now TSB, Transportation Safety Board, of Canada, in its Canadian Aviation Occurrence Report, UK AAIB, United Kingdom Air Accidents Investigation Branch Farnborough, U.K by its representative, NTSB USA, National Transportation Safety Board, United States of America, by its representative

2.2. Premise Explanation: Explosion of a bomb in the aft cargo compartment of Air India Flight 182, a bomb which was first loaded at Vancouver B.C, Canada onto CP Flight 060 on 22 June, 1985.

No proponent but considered, evaluated, and rejected by the Indian Kirpal Report and the Canadian Aviation Occurrence Report, and the AAIB representative

2.3 Premise Explanation: Explosion in the forward cargo compartment with its cause unstated:

Proponent: Canadian CASB (TSB),

2.4 Premise Explanation: Explosion in the forward cargo compartment on the starboard side, inclusive of a bomb detonation.

Proponent: Indian Kirpal Report,

2.5 Premise Explanation: Explosion in the forward cargo compartment caused by explosive decompression of undetermined cause, exclusive of a bomb detonation:

Proponent: Mr. Roy Davis of AAIB, as described in the Canadian Aviation Occurrence Report and the Indian Kirpal Report

2.6 Premise Explanation described in Section 3: Explosion in the forward cargo compartment caused by 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:
Proponent: John Barry Smith

This report shall analyze all the explanations, their proponents, their reasons, and their likelihood of being the most correct.

2.1. Premise Explanation: Explosion in flight in the forward cargo compartment .

2.1.1 Proponents: Indian Government in its Kirpal Report, CASB, Canadian Aviation Safety Board, now TSB, Transportation Safety Board, of Canada, in its Canadian Aviation Occurrence Report, UK AAIB, United Kingdom Air Accidents Investigation Branch Farnborough, U.K., by its representative, NTSB USA, National Transportation Safety Board, United States of America, by its representative

2.1.2 Analysis: The unanimous conclusion by authorities of a sudden inflight breakup implies an explosion of explosive decompression since the hull of Air India Flight 182 was pressurized to a 8.9 pounds per square inch differential between inside and outside air at 31000 feet above sea level. Explosive decompression is a symptom of a sudden hull breakup, not the cause. If the hull is not compromised by a break 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 inflight breakup and subsequent explosive decompression. Some of the investigators in the two reports seem to imply that if a bomb had detonated, then that would rule out explosive decompression occurring and vice versa; however, 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 in the past, depending on the size of the bomb, the skin tear, or the 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 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.

The unanimous conclusion by authorities of an inflight breakup by explosion in the forward cargo compartment for Air India Flight 182 can be summarized by the Canadian Aviation Bureau Aviation Occurrence Report findings and an excerpt from the Indian Kirpal Report which also illustrates the conflict in the specifics:

From the Canadian Aviation Occurrence Report:
4.0 CONCLUSIONS: The Canadian Aviation Safety Board respectfully submits as follows: 4.1 Cause-Related Findings
5. There is considerable circumstantial and other evidence to indicate that the initial event was an explosion occurring in the forward cargo compartment. This evidence is not conclusive. However, the evidence does not support any other conclusion.

From the Indian Kirpal Report:

1. 4.10 After going through the entire record we find that there is circumstantial as well as direct evidence which directly points to the cause of the accident as being that of an explosion of a bomb in the forward cargo hold of the aircraft;
2. 3.4.6.60: The only conclusion which can, however, be arrived at is that the aircraft had broken in midair and that there has been a rapid decompression in the aircraft.

An inflight breakup is agreed upon by the Canadian and Indian authorities and the cause is given as an explosion; however, the Canadians decline to give a cause of the explosion and leave it unstated. The Indians state the cause of the explosion was a 'bomb.' The Canadian finding specifically omits a possible cause of the explosion such as 'bomb,' or 'explosive decompression'. The location of the explosion is identified and agreed by both authorities as the forward cargo compartment.

The tangible and circumstantial evidence upon which the unanimous conclusion of inflight breakup by explosion in the forward cargo compartment was reached can be summarized as thus:

- A. The cockpit audio tapes and the digital flight recorder were normal until a sudden audible loud sound occurred and the power was abruptly cut to the recorders.
- B. Passengers suffered explosion type injuries.
- C. Metal skin of the fuselage was peeled outward and curled.
- D. Metal skin suffered explosion type impacts from inside the aircraft.
- E. The main pieces of wreckage on the surface were far apart from each other as well as the wide scatter of the victims.
- F. An explosion in the forward cargo compartment explained the abrupt cessation of the recorders and the sudden loud audible sound on the voice recorder.
- G. The inflight damage could have occurred only if objects had been ejected from the front portion of the aircraft when it was still in the air.

2.1.3 **Conclusion:** There was an explosion in flight in Air India Flight 182 in the forward cargo compartment.

Excerpts of official corroborative statements supporting the breakup in flight of Air India Flight 182 as caused by an explosion in the forward cargo compartment:

From the Canadian Aviation Occurrence Report:

3.1 Initial Event From the correlation of the recordings of the DFDR, CVR and Shannon ATC tape, the unusual sounds heard on the ATC tape started shortly after the flight recorders stopped recording. The conversations in the cockpit were normal, and there was no indication of an emergency situation prior to the loud noise heard on the CVR a fraction of a second before it stopped recording. The DFDR showed no abnormal variations in parameters recorded before it stopped functioning. The other possibility for the irregular signals on the DFDR is that they were caused by a disturbance to the Flight Data Acquisition Unit in the main electronics bay. Since there was an almost simultaneous loss of the transponder signal, this indicates the possibility of an abrupt aircraft electrical failure. The abrupt cessation of the data recorder could be caused by airframe structural failure or the detonation of an explosive device as the initial event.

3.3 Aircraft Break-up Sequence The medical evidence showed a proportion of the passengers with indications of hypoxia, decompression, flail injuries and loss of clothing. The incidence of hypoxia and decompression indicates that the aircraft experienced a decompression at a high altitude. The flail injuries and loss of clothing indicate a proportion of the passengers were ejected from the aircraft before water impact. Hence, it is likely that the aft portion of the aircraft separated from the forward portion before striking the water.

3.4 Aircraft Structural Integrity As described earlier, the sudden nature of the occurrence indicates the possibility of a massive airframe structural failure or the detonation of an explosive device.

3.4.4 Structural Failure The initial event has been established as sudden and without warning. The abrupt cessation of the flight recorders indicates the possibility of a massive and sudden failure of primary structure; however, there is evidence to suggest that there were ruptures in the forward and aft cargo compartments prior to any failure of the primary structure in flight. An explosion in the forward cargo compartment would explain the loss of the DFDR, CVR and transponder signal as the electronics bay is immediately ahead of the cargo compartment.

Excerpts of official corroborative statements supporting the breakup in flight of Air India Flight 182 as caused by an explosion in the forward cargo compartment:

From the Indian Kirpal Report:

3.1.6 In his testimony in Court, Wing Commander Dr. I.R. Hill further stated that the significance of flail injuries being suffered by some of the passengers was that it indicated that the aircraft had broken in mid-air at an altitude and that the victims had come out of the aeroplane at an altitude.

3.2.11.42 a. Taking the scatter of the wreckage and bodies into consideration and the condition of the limited wreckage recovered indicates that the aircraft had broken up in flight before impact with the sea.

3.4.6.60: The only conclusion which can, however, be arrived at is that the aircraft had broken in midair and that there has been a rapid decompression in the aircraft.

E. Damage in air: The examination of the floating and the other wreckage shows that the right hand wing leading edge, the No. 3 engine fan cowl, right hand inboard mid flap leading edge and the leading edge of the right hand stabilizer were damaged in flight. This damage could have occurred only if objects had been ejected from the front portion of the aircraft when it was still in the air. The cargo door of the front cargo compartment was also found ruptured from above. This also indicates that the explosion perhaps occurred in the forward cargo compartment causing the objects to come out and thereby damaging the components on the right hand side.

I. Metallurgical Examination Results : A metallurgical examination, especially of Targets 362 and 399, clearly confirms that there was an explosion in the forward cargo compartment.

2.2 Premise Explanation: Explosion of a bomb in the aft cargo compartment, a bomb which was first loaded at Vancouver B.C, Canada onto CP Flight 060 on 22 June, 1985.

2.2.1 **No proponent** for this explanation but it was considered, evaluated, and rejected in the Indian Kirpal Report, the Canadian Aviation Occurrence Report: by the AAIB representative,

and the NTSB representative. However, there exists a recent report entitled "Aircraft Occurrence Investigation Report" dated 16 March 2001, by John H. Garstang, an official assigned to the Royal Canadian Mounted Police (RCMP) Air India Task Force (AITF). The report shall be referred to as the 'Garstang Report.'

Observations about the author of the Garstang Report: John H. Garstang, is an official assigned to the Royal Canadian Mounted Police (RCMP) Air India Task Force (AITF). Mr. Garstang is apparently not currently assigned to the Transportation Safety Board (TSB) of Canada. His report carries his signature without title. He has been assigned to the RCMP AITF since 1988 and therefore represents official RCMP opinion regarding the probable cause of Air India Flight 182. He calls his work for the RCMP as "independent."

Current government agency opinions about the probable cause for the inflight breakup of Air India Flight 182:

A. RCMP opinion about the probable cause for Air India 182 is an explosion of a bomb in the forward cargo compartment.

B. Unless updated with a supplemental conclusion by the TSB, the Canadian Aviation Safety Board (Canadian Aviation Occurrence Report) conclusions as stated in their 1986 Aviation Occurrence Report of an explosion, cause unstated, in the forward cargo compartment was the probable cause for the breakup of Air India Flight 182 is the current position of Canadian aircraft accident investigation authorities.

C. Unless updated by the Indian government, the Kirpal Report findings of an explosion by a bomb in the forward cargo compartment is the current position of the Indian government.

2.2.2 Analysis: There was consideration of the explosion of a bomb, or any other source of an explosion, in the aft cargo compartment of Air India Flight 182 instead of an explosion in the forward cargo compartment, to explain the breakup in flight amidships. Both the Indian Kirpal Report and the Canadian Aviation Occurrence Report had good cause to suspect a failure in the aft section of Air India Flight 182 and therefore examined and evaluated extensively the possibility of an aft pressure bulkhead failure or an aft cargo door inadvertent opening.

Just five weeks after Air India Flight 182, a Japan Air Lines Boeing 747, JAL Flight 123, had an aft pressure bulkhead fail in flight and the subsequent explosive decompression tore off the vertical stabilizer which rendered the aircraft uncontrollable leading to its fatal crash. Wreckage of Air India Flight 182 was then attempted to be retrieved by the US Navy to rule in or rule out such a similar probable cause.

Corroborative official statements supporting the reasons and results of the close examination of the aft pressure bulkhead for evidence of preexisting failure in flight.

From the Canadian Aviation Occurrence Report

3.4.2 Aft Pressure Bulkhead

The localized impact mark found on the leading edge of the right horizontal root leading edge is indicative of an object striking the stabilizer in flight before water impact. This suggests that the loss of the tail plane was not the first event. The horizontal and vertical stabilizers were found separated and each was intact and in good condition. Items from the aft cargo compartment were found further to the west of the tail plane. The absence of the type of damage to the tail plane as was found in the Japan Airlines (JAL) Boeing 747 accident where the aft pressure bulkhead failed and which took place shortly after this occurrence, and the rupture

of the aft cargo compartment before the loss of the tail indicate that there was not an in-flight failure of the aft pressure bulkhead. In addition, examination of the recovered portions of the bulkhead shows evidence of overload failures from the rear to front only and no evidence of any pre-existing defect, premature cracking or pre-impact corrosion damage.

From the Indian Kirpal Report

1.4.6 The Court also had the advantage of being able to meet members of the team investigating into the Japan Airlines Flight JL 123 accident which had occurred near Tokyo on 12th August, 1985. Similarities and dissimilarities between the two accidents were, to some extent, noticed and some information was exchanged.

3.2.10.5 Subsequent to the accident to Japan Airlines Boeing 747 aircraft, suspected to have been caused by failure of the repair to the rear pressure bulkhead, NTSB and FAA decided to fund the U.S. Navy for a two week operation over the seas for recovery of significant pieces of wreckage.

In addition, the aft cargo door stops of Air India Flight 182 had been removed and reinstalled by authorized personnel just before the Air India Flight 182 fatal flight to make room for parts of an engine being shipped back to India for repair.

Corroborative official statements supporting the reasons and results of the close examination of the aft cargo door for preexisting failure in flight.

From the Canadian Aviation Occurrence Report

2.1.20 The pre-loaded four pallets and one container were brought to the aircraft by M/s Mega International personnel from their warehouse in the afternoon of 22nd June for loading them into the aircraft cargo compartment at positions assigned by the Air Canada load agent. Difficulty was experienced while loading one of the pallets having inlet cowl of the pod engine. To enable loading of the cowl, Air Canada engineering/maintenance personnel removed door stop fitting from the aft cargo compartment door cut-out. After removal of the fittings, the cowl could be loaded. All the removed fittings were then reinstalled.

From the Indian Kirpal Report

2.4.3.5 Some difficulty was experienced while loading one of the pallets having inlet cowl of the pod engine. To enable loading of the cowl, Air Canada engineering/maintenance personnel removed door stop fittings from the aft cargo compartment door cut-out. After removal of the fittings, the pallet could be loaded. All the removed fittings were then re-installed. Removal and installation of the fittings was certified by Mr. Rajendra.

2.4.3.6 A question arose whether removal of the door stop fittings could have caused some difficulty in flight. From the video films of the wreckage it was found that the complete aft cargo door was intact and in its position except that it had come adrift slightly. The door was found latched at the bottom. The door was found lying along with the wreckage of the aft portion of the aircraft. This indicates that the door remained in position and did not cause any problem in flight.

The investigators carefully examined all pieces of wreckage in and around the aft pressure bulkhead and aft cargo compartment for evidence of any type of failure of structure and for any

type of explosion, such as explosive decompression or a bomb. They found none.

Excerpts of official corroborative statements in support that no evidence of an explosion in the aft cargo compartment was found.

2.11.6.5 Target 47 - Aft Cargo Compartment

This portion of the aft cargo compartment roller floor was located between BS 1600 and BS 1760. Based on the direction of cleat rotation on the skin panel (target 7) and the crossbeam displacement on this structure, target 47 moved aft in relation to the lower skin panel when it was detached from the lower skin. No other significant observation was noted. There was no evidence to indicate characteristics of an explosion emanating from the aft cargo compartment.

Investigators on the scene found that the type of damage that would have occurred with an aft pressure bulkhead failure such as the loss of the vertical stabilizer did not occur to Air India Flight 182; they found that the aft cargo compartment ruptured before, not after, the loss of the entire tailplane, and they found that the overload failures from the rear to front only instead of from front to rear if the aft pressure bulkhead had failed as an initial event.

They found that the aft cargo door was discovered intact and in position and did not cause any problem in flight. It was latched at the bottom. They found there was no evidence to indicate characteristics of an explosion of any type emanating from the aft cargo compartment.

Therefore, after an extensive examination and evaluation by the Canadian and Indian authorities of the possibility of an explosion of any type in the aft section or in the aft cargo compartment based upon visual examination of the actual aft pressure bulkhead, aft cargo door, aft cargo compartment floor and skin; they concluded that the occurrence of an explosion or any type in the aft cargo compartment was ruled out as well as a failure of the aft pressure bulkhead or involvement by the aft cargo door. The rupture that occurred in the aft cargo compartment was after the initial events, was a result of the overpressures and overload experienced by that part of the aircraft and consistent with an airframe disintegrating after an inflight breakup caused by the confirmed explosion in the forward cargo compartment.

The tangible and direct evidence to support the conclusions by authorities of an inflight breakup by explosion in the forward cargo compartment exists in the CVR, the ATC tape recording, the DFDR, the wreckage distribution, the inflight damage to the airframe, the medical evidence, and the engines.

A confirmed alternative exists to a bomb explosion in the aft cargo compartment of Air India Flight 182 to explain its inflight breakup and that is an explosion in the forward cargo compartment. That conclusion was and remains unanimous among the aircraft accident investigative authorities and was based upon the evidence and lack of evidence.

There exist certain characteristics of an explosion by bomb such as evidence in the metal itself or in the wreckage such as: Pitting, cratering, hot gas, washing, holes, punctures, shrapnel, explosive residue, burn injuries to passengers sitting in the cabin, sooted metal, timer, fuze, bomb explosion sound on the cockpit voice recorder, and staggered power cuts to the aft and forward data recorders (the transponder is located forward and the CVR and DFDR are located aft.)

Summary of evidence required to support a conclusion of an explosion of any type in the aft cargo compartment of Air India Flight 182 and its presence or absence:

- A. Pitting: Absent
- B. Cratering: Absent
- C. Hot gas washing: Absent
- D. Holes: Absent
- E. Punctures: Absent
- F. Shrapnel: Absent
- G. Explosive residue: Absent
- H. Burn injuries to passengers sitting in the cabin: Absent
- I. Sooted metal: Absent
- J. Timer: Absent
- K. Fuze: Absent
- L. Bomb explosion sound on the cockpit voice recorder: Absent
- M. Staggered power cuts to the aft and forward data recorders: Absent

Summary of evidence that refutes the assertion that an explosion of any type occurred in the aft cargo compartment as an initial event or at any other time.

- A. Absence of required corroborative evidence to support the assertion.
- B. Transponder off simultaneously as FDR and CVR
- C. Inflight damage by flying debris to pieces of airframe well forward of the aft cargo compartment such as leading edge of wing and engines.
- D. Overpressures in both cargo compartments, not just the aft.
- E. Intact aft and bulk cargo doors.
- F. Much straight and undamaged fuselage skin in the aft section.
- G. Conclusive evidence of an explosion in the forward cargo compartment to explain the inflight breakup of Air India Flight 182.
- H. General trajectory patterns from wreckage debris locations that match two other early model Boeing 747s, Pan Am Flight 103 and Trans World Airlines Flight 800, that experienced inflight breakups amidships from an explosion in or near the forward cargo compartment, not the aft cargo compartment as confirmed by the aircraft accident investigation authorities of the UK AAIB, and the USA NTSB.

An evaluation of the independent accident report by Mr. Garstang follows:

The overall appraisal by this independent investigator of Mr. Garstang's report is that the data shows in some manner what happens to sections 46 and 48 of an early model Boeing 747 that has broken apart amidships from an explosion in the forward cargo compartment and is in the process of disintegrating as it falls and drifts from 31000 feet to the sea, after which it drifts and sinks another 6700 feet to the bottom.

upon itself and fails in a different mode (shear) Looks entirely different than a tensile crack

Overpressure: the pressure hull experienced a higher pressure than the design pressure."

The airframe was disintegrating and rapidly redistributing its design loads. This redistribution leads to a lot of local overloading on airframe/ pressure hull metal. It tore itself apart."

The Garstang Report makes an unsubstantiated statement that is in contradiction to the Indian Kirpal Report and the Canadian Aviation Occurrence Report in which Mr. Garstang states on page 7, referring to the "Forward Half of the Aircraft Fuselage (Sections 41, 42, 44), "The fracture patterns examined were all consistent with an overload mode of failure." The Indian Kirpal Report and the Canadian Aviation Occurrence Report found conclusive evidence of an explosion in the forward half of the fuselage forward of the wing on the right side in the forward cargo compartment that was not the result of an overload mode of failure but was the result of an explosion. They also found many, not 'all', fractures that were of an overload type as both the aft and forward cargo compartments ruptured and were disintegrating in flight.

The Garstang Report devotes a scant one page to the breakup of the forward half of Air India Flight 182 whereas the actual investigators in the Indian Kirpal Report and Canadian Aviation Occurrence Report inquiries concentrated most of their retrieval and evaluation efforts in that area based upon the tangible evidence discovered which conclusively proved an explosion had occurred in the forward cargo compartment and there was no explosion of any type in the aft compartment. The Garstang Report declines to address that evidence.

The Garstang Report devotes most of its fourteen pages of analysis to the 'Rear Half of the Aircraft Fuselage' which had fractured into smaller pieces and lay isolated from one another on the ocean floor. He implies that observation is evidence of an explosion in the aft cargo compartment but, in fact, is evidence of an inflight breakup and disintegrating fuselage which lay scattered in a very long trail of debris.

The Garstang Report reports that the breakup location is at the Section 44 and Section 46 joint which is to be expected with an inflight breakup since that is where the sections are mated in construction, but not expected if a powerful bomb were to explode in the aft cargo compartment which would have split and shattered the fuselage in the middle of Section 46 leaving much obvious evidence of the bomb explosion.



Above picture is of a Boeing 747 during construction and shows the sections being mated. Section 41 has already been mated to Section 42. The unjoined joint on the left is the Section 44/Section 46 joint.

When a real bomb the size of the alleged bomb by the Garstang Report is detonated in the

aft cargo compartment of a Boeing 747, much real evidence is created.



Above is a picture of the staged bombing of a Boeing 747 at Bruntingthorpe in 1997.

The aft section evidence which resulted from the real bomb explosion above does not match the aft section evidence examined for Air India Flight 182 which had undeformed, straight fuselage skin and intact cargo doors. If the above bomb type explosion had occurred in Air India Flight 182, the Canadian and Indian and UK investigative authorities in 1985/1986 would most certainly have detected it because of the obvious 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.

None of the tell tale characteristics of a bomb explosion pieces of evidence was found on Air India Flight 182. In addition there was much evidence to rule out any type of explosion in the aft compartment.

The reason for ruling out a bomb explosion anywhere in Air India Flight 182 is the same reason used to rule out a bomb explosion anywhere in Trans World Airlines Flight 800, another early model Boeing 747 that was seriously evaluated for a bomb explosion after experiencing an inflight breakup caused by an explosion that was not in the aft cargo compartment. That reason is a lack of corroborating evidence even after some ambiguous evidence of overpressures and overloading was discovered.

The Garstang Report describes, in 'Aft Cargo and Bulk Cargo Compartments' a large piece of belly skin, Target 7, which was not grossly deformed, bent, twisted, or crushed, missing evidence which might be expected within the range of a powerful bomb explosion. The report describes the separations of the skin from the floor assembly in terms of overload and overpressure but not by hot gas pitting, shrapnel, cratering or punctures which would support the assertion of an explosion by bomb.

The Garstang Report makes another undocumented statement that a piece of skin is 'similar' to a piece of skin in the Bruntingthorpe staged bomb explosion but provides no photographs of either piece of metal. It is reasonable to expect that among thousands of different shapes of pieces of wreckage there might be one that are 'similar' to another among thousands of pieces in a staged bomb explosion.

The Garstang Report describes in detail the overpressures and overloads of pieces of the aft section of Air India Flight 182 (Targets 7, 8, 47, 307, 287, 658, 26, 369, 321, 71, and 282) but offers no evidence of an explosion, only of aerodynamic forces consistent with a fuselage disintegrating as it falls from five miles high.

Whenever there is evidence offered in pieces of metal in 'deformation', there is also the qualifier that the deformation could have occurred by aerodynamic forces or water impact. Deformation on pieces of metal in the aft section, as are overpressures and overloads, are not confirmations of an explosion by bomb but are confirmations of a section of aircraft disintegrating as it falls after an inflight breakup amidships from a confirmed explosion in the forward cargo compartment.

The Garstang Report equated on page 13 that a bomb is an improvised explosive device when it states: "Detonation of a bomb (improvised explosive device)...", a synonym which is misleading. There are many devices which may become an improvised explosive device such as firecrackers, fireworks, blasting caps, and other incendiary devices which were never intended to become bombs but did by circumstances. If there were any device created that was not improvised to be explosive, but very, very calculated, it would be a 'bomb' which is a most carefully thought out explosive device. On the other hand, fireworks do detonate inadvertently and cause explosions often leading to fatalities.

The Garstang Report summarizes the 'Structural Breakup' by stating: " Analysis indicated that the aft cargo and bulk cargo compartments failed due to a large, internal, overpressure load(s)."

To use the overpressures and overloads on beam, fuselage skin, skin panels, and trunnions as conclusive evidence of an explosion is faulty logic as both cargo compartments had such evidence. Those overpressure failures are consistent with aerodynamic and water impact forces acting on a compromised fuselage disintegrating as it falls to the sea, an opinion shared and stated by the Indian Kirpal Report and Canadian Aviation Occurrence Report investigators in 1985/1986 who carefully examined and evaluated all wreckage in the aft area of Air India Flight 182 and is also the current opinion of a senior metals engineer in 2001.

Without any corroborative tangible evidence which would have been present of a bomb explosion, or evidence of any type of explosion, the next statement by Mr. Garstang lacks credibility and carries little weight: "The only plausible way to do this rapidly, and in the manner previously described, is by the detonation of a bomb, (improvised explosive device)."

As explained above, there is a plausible way to explain the overpressures in the aft compartment as well as the overpressures discovered in the forward compartment: Aerodynamic and water impact forces acting upon both cargo compartments in the fuselage as it disintegrates and falls to the sea after experiencing an inflight breakup amidships from the confirmed explosion in the forward cargo compartment. This plausible way to explain the overpressure evidence is currently agreed upon by official accident investigators of three countries, a metal engineer, and this independent aircraft accident investigator.

The Garstang Report section on 'Trajectory Analysis' opens with a broad disclaimer that a breakup of an aircraft in flight is a complex affair composed of random actions because various pieces of wreckage have different weights, sizes, and shapes and the trajectory of these pieces through the air can not be precisely determined because of the unknown winds and currents affect

the drift pattern of the piece through the five miles of air to the bottom of the ocean.

There are other factors which limit the validity of trajectory studies as stated by the Canadians in their aviation occurrence report, "The depth of the wreckage varies between about 6000 and 7000 feet, and the effect of the ocean current, tides and the way objects may have descended to the sea bed was not determined, thus some distortion of an object's relationship from time of water entry to its location on the bottom cannot be discounted. In general, the items found east of long 12^o43.00'W are small, lightweight and often made of a structure which traps air. These items may have taken considerable time to sink and may have moved horizontally in sea currents before settling on the bottom. Marks left on the sea bed beside some wreckage does indicate horizontal movement of the wreckage as it settled."

The Garstang Report plots the location of the pieces of wreckage in three appendices, G, H, and I. The specific locations of the pieces of wreckage as retrieved are given in latitude and longitude (lat/long) in the Indian Kirpal Report and in the appendices of the Garstang Report which is consistent with wreckage retrieval procedures. The Indian Kirpal Report, as well as the Trans World Airlines Flight 800 NTSB report of AAR 00/03, plots the wreckage items on a grid using a north arrow and distance in nautical miles from a reference point, which is consistent with official aircraft accident reports.

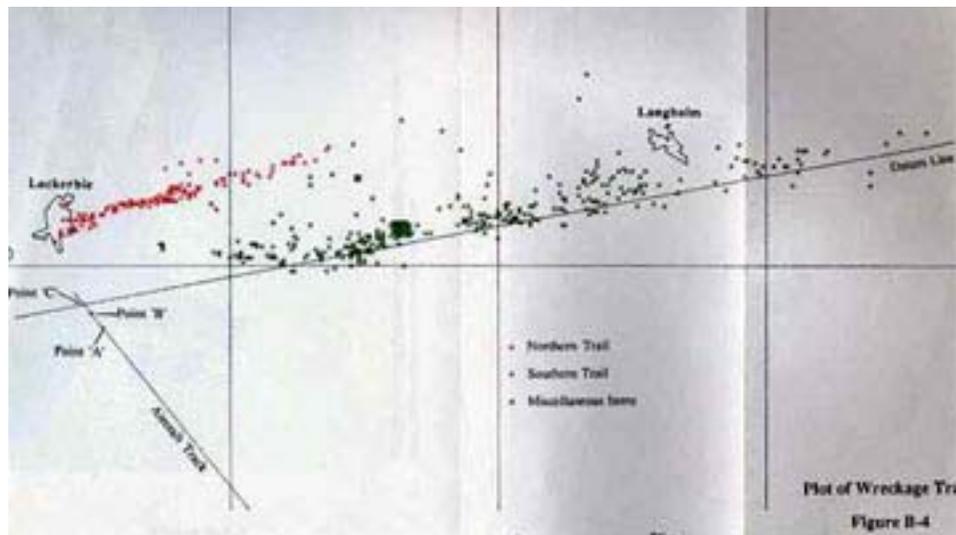
The Garstang Report, however, plots the wreckage items in "Universal Mercator Projection", omits the north arrow, and has no reference point.

Specifically, the Garstang Report narrative gives the lat/long position for only one piece of wreckage, a torn suitcase. In the official accident reports of the Indians and Canadians for Air India Flight 182, and the USA NTSB for TWA 800, the broad wreckage patterns as well as the individual pieces are given in lat/long.

Only a generalized appraisal of large sections of wreckage is possible and that was done in the Garstang Report as well as the official reports. A general plot of large sections of wreckage may be plotted and a theory of which sections left the aircraft first based upon the assumption they would land closest to the initial event location. This is done on all in flight breakups, such as Pan Am Flight 103 and Trans World Airlines Flight 800, two additional early model Boeing 747s that suffered breakups amidships in flight and left similar debris patterns. Specifically, the nose section was in a dense localized area, the area of initial breakup just forward of the wing was in a scattered area, and then the long loose trail of the aft section as it scatters widely the pieces of the disintegrating fuselage.

All three flights, Air India Flight 182, Pan Am Flight 103, and Trans World Airlines Flight 800, exhibited this matching debris pattern. All three flights have conclusive evidence which is reported in detail in the official accident reports of having suffered breakups in flight from explosions in or adjacent to the forward cargo compartment, conclusions which are supported by trajectory studies, wreckage reconstructions, and reconstruction drawings. All three official accident reports conclusively ruled out explosions of any type in the aft cargo compartment.

The Garstang Report states on page 16: "It is significant to note that the wreckage trail patterns bear a very strong resemblance to a known case involving the same type of aircraft, at essentially the same altitude and speed, which was proceeding normally when, without warning, something sudden and catastrophic occurred." "The case I [Garstang] am referring to is the Pan Am Flight 103 occurrence..."



Above drawing shows wreckage trails for Pan Am Flight 103 from the AAIB AAR 2/90

The debris patterns of Air India Flight 182 and Pan Am 103 do match. Both events were carefully examined for the location of the explosion that broke the aircraft apart amidships. Both events have conclusive evidence of an explosion in the forward cargo compartment to explain the breakup. Both events had none of the evidence to support an assertion of an explosion from any source in the aft cargo compartment. The matching debris patterns of both events confirm the conclusions of the British, Indian, and Canadian investigators who stated in their respective aircraft accident reports that the explosion in each aircraft occurred in the forward cargo compartment and did not occur in the aft compartment.

The concluding assertion on the trajectory analysis of The Garstang Report which states, "The distinction is that the wreckage trail patterns indicate that the lead Air India Flight 182 breakup event occurred in the rear of the aircraft, as opposed to the front of the Pan Am 103 case," contradicts the physical laws of aerodynamics, gravity, chemistry, and metallurgy. It insults the detailed concerted efforts of aviation accident investigators of three countries to precisely determine the location of the explosion and who all concluded it was in the forward section and was not in the aft cargo compartment.

Summary of evidence that suggests there was an explosion of any type in the aft cargo compartment of Air India Flight 182 as indicated by the Garstang Report:

- A. Overpressures and overloads on a few pieces of the aft section of Air India Flight 182 (Targets 7, 8, 47, 307, 287, 658, 26, 369, 321, 71, and 282)
- B. Quilting pattern on a few pieces of wreckage.
- C. One piece of wreckage fuselage skin that is 'similar' to another piece of metal from wreckage from a staged aircraft bombing.
- D. Trajectory studies that imply that the specific first pieces to leave Air India Flight 182 came from the aft cargo compartment.

Summary of reasonable alternative explanations to explain the evidence offered by the Garstang Report for an explosion in the aft cargo compartment.

- A. Over pressures and overloads on a few pieces of fuselage skin, beams, and

trunnions occur during any fuselage breakup, with or without an explosion source.

B. Quilting patterns on fuselage skin occurs upon water impact and did so on Trans World Airlines Flight 800 and Pan Am Flight 103.

C. A strangely shaped piece of metal can occur when a fuselage disintegrates from an inflight breakup at 296 knots which can be similar to a strangely shaped of a piece of metal that occurs after a staged aircraft bombing.

D. Trajectories can be widely variable for specific pieces of falling wreckage based upon shape, size, and weight of the object.

To review the evaluation of the Garstang Report regarding Air India Flight 182:

A. It offers no new evidence to contradict the conclusions of the Canadians and the Indians.

B. It offers no new insight into the previous investigations.

C. It omits and refuses to address the conclusive tangible evidence which refutes its assertions, such as

1. Cockpit voice recorder data,
2. Inflight damage to engines, wing leading edge and right horizontal stabilizer. straight and undamaged skin panels in the aft cargo compartment,
3. The large undeformed sheets of fuselage skin,
4. The intact aft and bulk cargo doors,
5. The loss of the tailplane was not the first event and would have been if a bomb explosion had occurred in the aft cargo compartment.

6. The power was cut to three pieces of electronic equipment, two of which are located in the aft area, and one in the main equipment compartment adjacent to the forward cargo compartment. If an explosion occurred in the aft cargo compartment, the two recorders might have stopped recording but not the transponder which would have continued on for some time. The simultaneous stopping of all three indicates the explosion was in the forward cargo compartment.

D. It offers no corroborative evidence of a bomb explosion in the aft cargo compartment such as:

1. Pitting: Absent
2. Cratering: Absent
3. Hot gas washing: Absent
4. Holes: Absent
5. Punctures: Absent
6. Shrapnel: Absent
7. Explosive residue: Absent
8. Burn injuries to passengers sitting in the cabin: Absent
9. Sooted metal: Absent
10. Timer: Absent
11. Fuze: Absent
12. Bomb explosion sound on the cockpit voice recorder: Absent
13. Staggered power cuts to the aft and forward data recorders: Absent

E. It offers as proof of an explosion in the aft compartment ambiguous evidence which is common to both compartments such as overloads, overpressures, and quilting patterns, all of which have alternative explanations such as aerodynamics and water impact, and are evident in both cargo compartments of Air India Flight 182 and evident in Pan Am Flight 103 and Trans World Airlines Flight 800, two additional Boeing 747 inflight breakups that were not caused by explosions in the aft cargo compartment.

F. It offers a trajectory study in which:

1. Essential chart details are omitted,
2. Ballistic trajectory charts are missing which are included in other accident reports which contain trajectory studies.
3. Specific conclusions about locations of pieces of wreckage are made which were prone to error from errant winds, currents, and aerodynamics of random shaped pieces of wreckage,

To summarize the assertions in the Garstang Report that an explosion of a bomb in the aft cargo compartment caused the inflight breakup of Air India Flight 182:

- A. There is no old or new evidence offered to sustain such an assertion.
- B. The methodology is unorthodox.
- C. Statements are made which contradict the established facts, data, and evidence.
- D. Conclusions are drawn which are unsubstantiated, not logical, or have plausible alternative explanations.

2.2.3 Conclusions:

There never was and is not now any official assertion by any recognized aviation accident investigating authority that the explosions in Trans World Airlines Flight 800, Pan Am Flight 103, and Air India Flight 182 did not occur in or near the forward cargo compartment and there never was and is not now any assertion by an recognized aviation accident investigating authority of any country that an explosion of any type occurred in the aft cargo compartment of their respective aircraft.

To put it another way, there has been and there is now total agreement by all aviation accident investigating authorities of four countries, Canada, UK, USA, and India, that the explosions in Trans World Airlines Flight 800, Pan Am Flight 103, and Air India Flight 182 occurred in or near the forward cargo compartment. There has been and there is now total agreement by all aviation accident investigating authorities of those same countries, that the explosion in Trans World Airlines Flight 800, Pan Am Flight 103, and Air India Flight 182 did not occur in the aft cargo compartment.

- A. There was no bomb explosion, nor any other type of explosion, in the aft cargo compartment of Air India Flight 182.
- B. There was an explosion in the forward cargo compartment of Air India Flight 182.

Excerpts of official corroborative statements mitigating against a breakup in flight of Air India Flight 182 caused by an explosion of a bomb in the aft cargo compartment.

From the Canadian Aviation Occurrence Report:

2.11.4.9 The aft cargo and bulk cargo doors were found in place and intact, and 5L, 5R and 4R entry doors were identified.

3.4.2 Aft Pressure Bulkhead The localized impact mark found on the leading edge of the right horizontal root leading edge is indicative of an object striking the stabilizer in flight before water impact. This suggests that the loss of the tail plane was not the first event.

3.4.4 Structural Failure The abrupt cessation of the flight recorders indicates the possibility of a massive and sudden failure of primary structure; however, there is evidence to suggest that there were ruptures in the forward and aft cargo compartments prior to any failure of the primary structure in flight.

3.4.5 Explosive Device-Target 47, which is a portion of the aft cargo compartment roller floor, shows no indications characteristic of an explosion emanating from the aft cargo compartment.

From the Indian Kirpal Report:

2.4.3.6 A question arose whether removal of the door stop fittings could have caused some difficulty in flight. From the video films of the wreckage it was found that the complete aft cargo door was intact and in its position except that it had come adrift slightly. The door was found latched at the bottom. The door was found lying along with the wreckage of the aft portion of the aircraft. This indicates that the door remained in position and did not cause any problem in flight.

3.2.11.19 Target 47 - Aft Cargo Floor Structure This portion of the aft cargo compartment was located between B S 1600 and B S 1760. No significant observation was noted. There was no evidence to indicate characteristics of an explosion emanating from the aft cargo compartment.

G. Holes in the front cargo hold panels While the skin panels of the aft cargo compartment are fairly straight and undamaged, the panels of the front cargo compartment are ruptured and have a large number of holes. This shows that there was occurrence of an event in the front cargo compartment and not in the aft cargo compartment.

E. Damage in air: The examination of the floating and the other wreckage shows that the right hand wing leading edge, the No. 3 engine fan cowl, right hand inboard mid flap leading edge and the leading edge of the right hand stabilizer were damaged in flight. This damage could have occurred only if objects had been ejected from the front portion of the aircraft when it was still in the air. The cargo door of the front cargo compartment was also found ruptured from above. This also indicates that the explosion perhaps occurred in the forward cargo compartment causing the objects to come out and thereby damaging the components on the right hand side.

3.4.4 Structural Failure The initial event has been established as sudden and without warning. The abrupt cessation of the flight recorders indicates the possibility of a massive and sudden failure of primary structure; however, there is evidence to suggest that there were ruptures in the forward and aft cargo compartments prior to any failure of the primary structure in flight. An explosion in the forward cargo compartment would explain the loss of the DFDR, CVR and transponder signal as the electronics bay is immediately ahead of the cargo compartment.

3.4.6.60: The only conclusion which can, however, be arrived at is that the aircraft had broken in midair and that there has been a rapid decompression in the aircraft.

E. Damage in air: The examination of the floating and the other wreckage shows that the right hand wing leading edge, the No. 3 engine fan cowl, right hand inboard mid flap leading edge and the leading edge of the right hand stabilizer were damaged in flight. This damage could have occurred only if objects had been ejected from the front portion of the aircraft when it was still in the air. The cargo door of the front cargo compartment was also found ruptured from above. This also indicates that the explosion perhaps occurred in the forward cargo compartment causing the objects to come out and thereby damaging the components on the right hand side.

j. There was no significant fire or explosion in the flight deck, first and tourist passenger cabin including several lavatories and the rear bulk cargo hold.

2.11.3 Wreckage Distribution

The wreckage distribution as determined by the mapping of the sea bed provided some distinct distribution patterns. The depth of the wreckage varies between about 6000 and 7000 feet, and the effect of the ocean current, tides and the way objects may have descended to the sea bed was not determined, thus some distortion of an object's relationship from time of water entry to its location on the bottom cannot be discounted. In general, the items found east of long 12^o43.00'W are small, lightweight and often made of a structure which traps air. These items may have taken considerable time to sink and may have moved horizontally in sea currents before settling on the bottom. Marks left on the sea bed beside some wreckage does indicate horizontal movement of the wreckage as it settled.

2.3 Premise Explanation: Explosion in the forward cargo compartment with its cause unstated:

2.3.1 Proponents: CASB, Canadian Aviation Safety Board in its Canadian Aviation Occurrence Report

2.3.2 Analysis: The CASB explanation for the breakup was to state there was an explosion in the forward cargo compartment but omit the cause of the explosion. This was the prudent choice of the CASB based on evidence and experience available to them in 1985/1986. CASB concluded in their report that the evidence supported an 'explosion' in the forward cargo compartment but that the evidence did not support the determination of the cause of that explosion. They specifically omitted a cause of bomb, structural failure, or open door. The CASB most certainly knew the focus of attention would be on the cause of the explosion and did not omit the cause as an administrative oversight. They certainly knew the Indians believed it was a bomb explosion and the AAIB representative had rejected that cause and stated the explosion was from an explosive decompression by a cause yet to be determined.

The CASB decided to just state the explosion occurred in the forward cargo department and declined to state the cause as a bomb detonation or explosive decompression. This decision by the Canadians to be cautious was later proven correct by subsequent similar accidents discussed in Section 3 which finally determined the cause of the explosion not from a bomb explosion but an explosive decompression when the forward cargo door ruptured open in flight.

2.3.3 Conclusion: There was an explosion in the forward cargo compartment with cause unstated based upon knowledge available in 1985/1986 to the Canadian accident investigators.

Excerpts of official corroborative statements to support the breakup in flight of Air India Flight 182 as caused by an explosion in the forward cargo compartment with its cause unstated.

From the Canadian Aviation Occurrence Report:

4.0 CONCLUSIONS The Canadian Aviation Safety Board respectfully submits as follows:

4.1 Cause-Related Findings

5. There is considerable circumstantial and other evidence to indicate that the initial

event was an explosion occurring in the forward cargo compartment. This evidence is not conclusive. However, the evidence does not support any other conclusion.

2.4 Premise Explanation: Explosion of a bomb in the forward cargo compartment on the starboard side, inclusive of a bomb detonation, a bomb which was first loaded at Vancouver B.C, Canada onto CP Flight 060 on 22 June, 1985.

2.4.1 **Proponent:** The Indian Kirpal Report.

2.4.2 **Analysis:** Another explanation for the explosion was a 'bomb' in the forward cargo compartment on the starboard side which caused the breakup of Air India Flight 182 in flight and was presented by the Indian Kirpal Report which concludes in a finding: ' 4.10 After going through the entire record we find that there is circumstantial as well as direct evidence which directly points to the cause of the accident as being that of an explosion of a bomb in the forward cargo hold of the aircraft.'

The bomb explosion in the forward cargo compartment finding by the Indians was based on meager circumstantial and tangible evidence. The circumstantial evidence of 'bomb' detonation lies in two areas, the ticketing and switching of tickets by one or two mysterious men in Vancouver, B. C. Canada and an explosion at Narita Airport, Tokyo, Japan within the hour of the explosion of Air India Flight 182 off Ireland.

It is not unusual for passengers to manipulate ticket fares and baggage destinations when flying into and through Canada: From the Kirpal Report: '2.2 It should be noted that some passengers from India book flights to Montreal with their intended destination being Toronto. The reason is that the fare to Montreal is cheaper and therefore some passengers get off the flight in Toronto, claim their luggage and leave without reporting a cancellation of the trip to Montreal.'

The ticketing by airline agents of the two men allegedly named 'Singh' is described in the report; however, the supporting documentation is missing. There are no interview notes or audio tapes available of the actual transactions. The ticketing procedures as described conflict with established procedures by the airlines. The names offered should have been rejected on site as inadequate for security reasons. It is not unusual for passengers to switch flights. The entire ticketing sequence used as important circumstantial evidence for a 'bomb' being loaded upon CP 060 in Vancouver is uncorroborated, unsubstantiated, conflicts with normal procedures, and lacks tangible evidence of tickets, suitcases, money, voice, or handwritten notes.

The second circumstantial event offered as proof of a 'bomb' explosion on Air India Flight 182 is the Narita episode of an explosion on a baggage cart which happened thousands of miles away in a enormously busy airport which had suffered fatal terrorist attacks before and after which were unrelated to any Air India flights. The airport was controversial in that in September, 1971, after a second compulsory execution of the land expropriation by proxy, three policemen were killed in a conflict during expropriation. In May, 1977, the removal of the obstructing steel tower resulted in the death of one the supporters of the opposition group during the protest rally. In March, 1978, extremists attacked the control tower with subsequent destruction of most of the equipment resulting in the opening of the airport being postponed. In September, 1988, the Chairman of the Chiba Prefecture Land Expropriation Committee was seriously injured in an attack of terrorism. All members of the committee resigned.

The details supporting the Narita 'bomb' explosion evidence are omitted from the Indian Kirpal Report as well as the details on yet another Boeing 747 aircraft, CP 003, carrying a 'bomb'

which does not detonate during the flight. For the Narita event to be connected to Air India Flight 182 in any meaningful manner, the details as to security for CP 003 and the baggage cart explosion must be investigated and stated in the same degree of attention to detail as the security status for CP 060 and Air India Flight 181/182.

The four flights of three different aircraft through four airports in two countries which had the two 'bombs' on board had many delays enroute and to connect the event of Narita and the event of Air India by timing because they happened within the hour thousands of miles apart as circumstantial proof of a relationship indicating both were 'bombs' is not logical nor credible.

The Indian Kirpal report states in the finding:

'A. Connection with an explosion at Narita Airport : On 23rd June, 1985 there was an explosion at the Narita Airport. The explosion occurred when a bomb exploded in a suitcase which was to be interlined to Air India's Flight No. 301 from Tokyo to Bangkok. CPA 003 arrived Narita Airport, Tokyo. Arrived 14 minutes early 0541 Baggage cart explodes in transit area. 2 killed, 4 injured' 'Similarly, a suitcase was interlined unaccompanied on CP Air Flight 003 from Vancouver to Tokyo to be placed on Air India Flight 301 to Bangkok. The explosion of a bag from CP 003 at Narita Airport, Tokyo, took place 55 minutes before the AI 182 accident. Therefore, the nature of the link between the two occurrences raises the possibility that the suitcase which was unaccompanied on AI 182 contained an explosive device.' 'At 0541 GMT, 23 June 1985, CP Air Flight 003 arrived at Narita Airport, Tokyo, Japan, from Vancouver. At 0619 GMT a bag from this flight exploded on a baggage cart in the transit area of the airport within an hour of the Air India occurrence. Two persons were killed and four were injured. From the day of the occurrences, there have been questions about a possible linkage between the events.' 'The interlined baggage exploded at Narita Airport and there is strong probability that the suitcase from Vancouver, which was interlined to AI 182, contained a device similar to the one which had exploded at Narita Airport on 23 June, 1985.' 'As it was suspected that there may be a link between the blast which had taken place at Narita Airport on 23rd June, 1985 and the accident to Air India's flight 182, it was felt necessary to inspect the site of the bomb blast at Narita Airport. On the aforesaid visit to Tokyo, the site where the blast had taken place was inspected which gave some, though very vague, idea of the detonating power of the blast.'

Note there is no evidentiary connection between 'an interlined bag' and 'a bag from this flight'. There is no support documentation for a 'bomb' explosion on the baggage cart, no documentation support for which suitcase and from which flight the bag came from and the only statement by the Court is very vague about details even though he personally visited the site.

When the Indian judicial authority alleges that Air India Flight 182 was blown out of the sky by a 'bomb' explosion in the forward cargo compartment on the starboard side in its official report, then the following sequence of allegations must be believed:

Two bombs were somehow surreptitiously placed on two Boeing 747s at Vancouver airport on or about 22 June 1985. This was done although there was much security in place to prevent such heinous crimes. One 'bomb' loaded on CP 003 flew to Tokyo with the 'bomb' refusing to detonate either through a altimeter fuze or a timing fuze. This 'bomb' was then unloaded in a busy airport, put on a

baggage cart which was wheeled through a 'transit' area with many other bags from many other flights, and only then the 'bomb' detonated, not from an altimeter fuze but from a timing fuze which went off when it was not supposed to. No fuze or parts of any bomb or the suitcase were reported to have been discovered. At the same time this premature 'bomb' was loaded at Vancouver onto CP 003, the other 'bomb' was loaded onto CP 060, also in Vancouver, and successfully slipped past the extensive security of men, dogs, and machines. CP 060 then flew to Toronto without the bomb going off by timer or altimeter fuse. At Toronto, the 'bomb' was then off loaded from CP 060 and sent, along with some passengers, to a different aircraft, a Boeing 747 which was Flight 181 which, after another flight to Montreal, would change to Flight 182. At Toronto, all the baggage from CP 060, including the 'bomb', was placed in the aft cargo hold of the Boeing 747 that was to become Air India Flight 182. The aircraft, now called Flight 181, took off and flew to Montreal with the 'bomb' still not detonating by altimeter or timing fuze. After the Boeing 747 landed in Montreal with the 'bomb' still in the aft cargo hold, the flight number changed to Air India Flight 182, more passengers and baggage were put on board, with all their baggage, and a new 'bomb', loaded into the forward cargo compartment. There were many delays involved with loading parts of a large engine into the aft cargo compartment which did not set off the 'bomb' in that compartment. Finally, the aft and forward cargo compartment 'bomb' laden Boeing 747 called Air India Flight 182 took off for its third flight in about twelve hours, flew for five hours and then a fuze for an entirely new Montreal 'bomb' decided to activate and a 'bomb' exploded in the forward cargo compartment, not by an altimeter fuze because the aircraft was level at 31000 feet and had been so for hours, but by a timer fuze. The Vancouver 'bomb', first loaded in Vancouver and transferred to the aft cargo compartment of the doomed aircraft in Toronto, is presumed to have fallen harmlessly to the sea and remained hidden from the robotic search vehicles with video and still cameras.

To further clarify the impossibility of the 'bomb' assertions in the Indian Kirpal report: The bomb explosion explanation for a bomb loaded first in Vancouver is impossible because if the first placement of the bomb in an aircraft is stated to have occurred in Vancouver for flights CP 003 and CP 060, then the mystery suitcase with a bomb inside from Vancouver on CP 060, as was all baggage, was loaded from CP 060 into the aft cargo compartment of Air India Flight 181/182 in Toronto and thus unable to explode in the forward cargo compartment two flights later as only the Indian Kirpal Report alleges. One section of the Indian Kirpal Reports states that the cargo compartment into which the suitcase carrying the alleged bomb was loaded could not be determined, but in another section of the same report, it clearly states that all the baggage from CP 060 was loaded into the aft cargo compartment of Air India Flight 181/182 in Toronto and all the baggage for the Montreal passengers was loaded into the forward compartment. [2.4.3.6 The entire baggage of passengers ex-Montreal was loaded in containers at positions 12R, 21R, 22R, 23R and 24R in the front cargo compartment. 2.4.3.7 All the baggage and engine parts in the aft and bulk cargo compartments were loaded at Toronto.] The unsure statement by one investigator versus the clear statement and the logic of common sense of efficient baggage loading indicates that all baggage from CP 060 from Vancouver went into the aft cargo compartment, not the forward, and all baggage for the Montreal passengers went into the forward cargo compartment, not the aft, of Air India Flight 181/182.

If there were conclusive evidence of a bomb explosion in the forward cargo compartment of Air India Flight 182, and there is not even scant evidence of a bomb explosion in either compartment, the suitcase containing the 'bomb' would have come from Montreal ticketed

passengers.

The confusion among authorities over the three 'bombs' as to where they came from, where they were going, what aircraft was targeted, and where they were located in the various aircraft is understandable because the 'bombs' are phantoms. There were no bombs. The phantom 'bombs' existed only in the minds of those who wished them to exist.

The Tokyo airport is one of the busiest in the world; lost and misplaced baggage is common at all airports; this airport was the target of unrelated terrorist acts before and since; there is no documentation to support the vague conjecture of a connection to an event thousands of miles away which took place within the hour although the many flights involved had many delays; security details were omitted on yet another bomb placed into a Boeing 747; and details on type of bomb and security arrangements at Narita Airport were omitted.

The circumstantial connections to passengers switching flights and events on baggage carts thousands of miles away have little, if any, connection to an airplane accident at 31000 feet. Any connection of those two circumstances is very unlikely and lacks any real evidence to support the claim the events are circumstantial proof of a bombing in an airliner such as Air India Flight 182.

The entire premise of 'bomb explosion' for Air India Flight 182 from circumstantial evidence is not realistic when the actual details are examined and impossible if the 'bomb' is asserted to have been loaded in Vancouver, B.C. Canada. At first blush it appears plausible, and even exciting, but the reality of the evidence rules it out. The bomb theory lacks credibility, reason, or logic. It assumes inefficient ticketing agents, dull-witted security forces, and malfunctioning X ray machines in four large metropolitan airports in two industrialized nations. It assumes incompetent terrorists who can't set a 'bomb' to go off on time. It assumes a quiet 'bomb' in an aircraft that makes no sound when it goes off, and three stealthy 'bombs' that managed to slip through sniffing dogs, portable metal detectors, X-Ray machines, private security teams, and yet leave no trace of their fuzes, timers, explosive material, or containers.

The conclusion of a 'bomb' explosion in Air India Flight 182 is based mainly on weak circumstantial evidence since little tangible evidence of a bomb explosion was discovered. The circumstantial evidence of a 'bomb' explosion is unsubstantiated and can be summed up as very vague. Now that a reasonable, mechanical alternative with precedent for the explosion on Air India Flight 182 has emerged, detailed in Section 3 of this report, the finding of 'bomb explosion' becomes even less credible.

The tangible evidence for and against a bomb placed anywhere on Air India Flight 182 can be summarized as thus:

Summary of evidence for a bomb explosion:

- A. Blackened erosion on some seat cushions.
- B. Cabinet had dent in it.
- C. Minor fire and explosive damage in cabin.
- D. Sudden and massive structural failure.
- E. The lining in one suitcase was severely tattered;
- F. Although the wooden spares box was burned, this could have happened after the occurrence;
- G. Although pieces of an overhead locker were damaged by fire, it is not known if the burning happened at the time of the occurrence;
- H. Although the pieces of U-section alloy clearly indicated evidence of an

explosion, it is quite possible that these pieces were not associated with the aircraft;

- I. The bottoms of some seat cushions show indications of a possible explosion;
- J. The inside of the right wing root fillet appears to have been scorched; and
- K. The deformation of the floor of the upper deck storage cabinet might have been caused by an explosive shock wave generated below the cabin floor and inboard from the cabinet.
- L. Damage to the floor station and the presence of the fragments.
- M. Targets 362/396 and 399 which contain some evidence that an explosion emanated from the forward cargo compartment.
- N. Curling, cork-screwing, and saw tooth edges may also be indicative of an explosion though such fractures by themselves may not be conclusive evidence that an explosion was involved.
- O. The bang could have been caused by a rapid decompression but it could also have been caused by an explosive device.
- P. Marked similarities between the spectra of Indian Airlines 737 and Air India's Kanishka CVR.
- Q. Twinning on fragments of wreckage.

Summary of evidence against a bomb explosion:

- R. Wooden boxes were found broken apart exhibiting no burn marks.
- S. An electronic device was found among some floating wreckage and was not modified as a detonating device.
- T. There was no evidence to indicate characteristics of an explosion emanating from the aft cargo compartment.
- U. No part of an explosive device, its detonator or timing mechanism was recovered.
- V. Certain characteristics of the noise indicate the possibility that the noise was the result of an explosive decompression.
- W. From the examination of the wreckage recovered and wreckage on the bottom, there is no indication that a fire or explosion emanated from the cabin or flight deck areas.
- X. The medical examination of the bodies also showed no fire or explosion type injuries.
- Y. A portion of the aft cargo compartment roller floor shows no indications characteristic of an explosion emanating from the aft cargo compartment.
- Z. No evidence of fire burns or explosive material could be found.
- AA. The floating wreckage recovered and showed there was no evidence of fire internal or external.
- AB. Examination of clothing from the bodies did not show any explosive fractures or any signs of burning.
- AC. The seat cushions and head cushions also did not show any explosive characteristics.
- AD. A number of lavatory doors and structure also did not show any damage consistent with explosion. The flight deck door showed no explosion damage inside or outside.
- AE. There was no significant fire or explosion in the flight deck, first and tourist passenger cabin including several lavatories and the rear bulk cargo hold.
- AF. The bang could have been caused by a rapid decompression and no sound of a 'bomb' preceded the bang.
- AG. The only conclusion which can, however, be arrived at by the Court is that the aircraft had broken in midair and that there has been a rapid decompression in the aircraft.
- AH. Twinning evidence is unreliable because of poor examining conditions and a

powerful explosive decompression can be the cause of it.

An article in a magazine by Mr. Eric Newton, a retired expert in aviation sabotage, to describe a phenomenon called, 'twinning' is referred to by Judge Kirpal as support for a bomb explosion.

Judge Kirpal quotes Mr. Newton who writes:

"In some metals such as copper, iron and steel, deformation in the crystals of the metal takes place by 'twinning', that is to say by parallel lines or cracks cutting across the crystal. Such a phenomenon can occur only if the specimen has been subjected to extreme shock wave loading at velocities in the order of 8000 m/sec. Such specimens, usually distorted must be selected with care, prepared in a metallurgical laboratory, polished, mounted and microscopically examined."

Judge Kirpal then states in his report, 3.2.11.58: 'The metallurgical report indicates that the microscopic examination (conducted by them) discloses such features being present which had been described as positive signatures of the detonation of an explosive device in an aircraft by Mr. Newton.' Judge Kirpal does not identify the authors of the 'metallurgical report' who conducted the actual microscopic examination of the few fragments from Air India Flight 182 that exhibited twinning but it is possible that the fragments of aluminum found at the bottom of the ocean might not have been copper, iron, or steel, and having been immersed for days, had not been selected with care and prepared in a metallurgical laboratory and thus any results are highly suspect. For twinning to be reliable as an indicator of the type of explosion, a comparative piece of similar metal with the same amount of pressure cycles must be used to compare against the twinned fragment. The actual results of the metallurgical report for Air India Flight 182 are not given, only vague references to 'such results' and 'explosive fracture' which could come from any explosive source, such as an explosive decompression.

In recent correspondence with Gordon E. Smith, Senior Materials Engineer, Mr. Smith (no relation) reports to this investigator that twinning can be produced any time metal is separated fast enough, about 25,000 feet/Sec speed, which includes such events as bomb explosion, aviation fuel explosion, and powerful explosive decompressions. An aviation fuel explosion can create twinning only by concentrating its force and tearing the metal. Twins will be found adjacent to tears but not several feet away from tears. In an explosive decompression, the twin population and size distribution will be related to the force of the explosion experience by that piece. Metal grain twinning from age/cycles will be distributed in areas of high stresses from pressure cycles. i.e. door frames, bulkheads. The twin characteristics will be a function of the total force available and the rate of application of that force. For twinning to be reliable as an indicator of the type of explosion, a comparative piece of similar metal with the same amount of pressure cycles must be used to compare against the twinned fragment. The Reference sample must be from the same numbered part on an aircraft with similar numbers of pressure cycles. A new part will not have any metal crystal twins that might have been formed by in service stresses.

When Mr. Newton personally inspected the pieces and the fragments of pieces of wreckage and made his report to the Court, he makes no mention of 'twinning' but he does seem to rule in an explosion but rules out sabotage by bomb explosion.

Excerpts of official corroborative statements to support the absence of fire or bomb explosion evidence by personal inspection by Mr. Newton.

From the Kirpal Report:

3.2.11.42 The floating wreckage recovered was initially examined at Cork. On 25th June, Mr. Eric Newton a retired investigator of AIB, UK, was requested to examine the floating wreckage recovered and other materials with specific reference to the possibility of explosive sabotage having taken place. Mr. Newton examined the floating wreckage, passenger clothings and the other materials recovered from the crash victims. The findings of Mr. Newton on the material available at that time are summarised below:

- a. Taking the scatter of the wreckage and bodies into consideration and the condition of the limited wreckage recovered indicates that the aircraft had broken up in flight before impact with the sea.
- b. Detailed examination of the structural wreckage recovered did not reveal any evidence of collision with another aircraft. Nothing was found suggestive of an external missile attack.
- c. There was no evidence of fire internal or external.
- d. There was no evidence of lightning strike.
- e. Examination of all available structural parts recovered, did not reveal any evidence of significant corrosion, metal fatigue or other material defects. All fractures and failures were consistent with overstressing material and crash impact forces.
- f. Examination of clothing from the bodies did not show any explosive fractures or any signs of burning. The seat cushions and head cushions also did not show any explosive characteristics.
- g. The damage to the suitcases (14 large and 29 small) which were examined was due to impact crash forces. The presence of 14 large suitcases could, however, indicate that one of the baggage containers had been broken to permit these suitcases to escape.
- h. A number of lavatory doors and structure also did not show any damage consistent with explosion. The flight deck door showed no explosion damage inside or outside.
- i. The circumstantial evidence strongly suggests a sudden and unexpected disaster occurred in flight.
- j. There was no significant fire or explosion in the flight deck, first and tourist passenger cabin including several lavatories and the rear bulk cargo hold.

Microscopic examination of crystals on fragments of pieces of metal from Air India Flight 182 which were not selected with care, not the proper metal, not prepared in a metallurgical laboratory, retrieved in poor condition, and which gives vague results which may or may not have been caused by a high explosive device is not a very reliable and valid basis upon which to make the finding of the detonation of a high explosive device in the forward cargo compartment of Air India Flight 182 as Judge Kirpal had done. Even if some 'twinning' was discovered, the cause of it may not have been a bomb explosion; it could have been an explosive decompression. Other corroborative evidence was needed to determine the cause of the twinning but it was not found.

In regard to 'twinning' as a reliable indicator of a bomb explosion in Air India Flight 182, the Canadians decline to even discuss 'twinning' and do not refer to it in their report at all. For Trans World Airlines Flight 800, a similar event for which the cause was suspected as being a bomb explosion for seventeen months and underwent intense scrutiny to confirm the bomb explanation, 'twinning' was not considered or mentioned at all in its aircraft accident report, NTSB AAR 00/03. The legitimate corroborating evidence sought for a bomb explosion in Trans World Airlines Flight 800, such as severe pitting, cratering, petalling, or hot gas washing, was discussed in the report. The investigation into Pan Am Flight 103 which has attempted for years to confirm a

bomb explosion also neglected to consider 'twinning' as a reliable indicator of a bomb explosion and omits any reference to it in its report of AAIB 9/90. Contrary to Judge Kirpal's assertion, twinning is not a positive indicator of a specific type of explosion, such as a bomb explosion, exclusive of other types of explosions.

The reasons for ruling out a bomb explosion for Trans World Airlines Flight 800 are the same reasons for ruling out a bomb explosion for Air India Flight 182 and that is a lack of corroborating evidence even after some minute ambiguous tangible evidence was discovered.

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 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.

Judge Kirpal was only forceful for one explanation for the Air India Flight 182 event in which he stated in his report: 3.4.6.60 The only conclusion which can, however, be arrived at is that the aircraft had broken in midair and that there has been a rapid decompression in the aircraft.

The ambiguity and conflicts from within the investigators may be summarized by their finding and conclusion where Judge Kirpal finds for a bomb explosion and the Canadian aircraft accident investigators conclude an explosion but decline to state the cause.

There was much evidence of an explosion on the starboard side of the forward cargo compartment in Air India Flight 182 but of the circumstantial and tangible evidence for a bomb explosion there is precious little of actual physical evidence and when that evidence is offered, it is usually accompanied by a disclaimer with an alternative benign explanation. When opinions for a bomb explosion are stated, they are often unsubstantiated, confusing and self contradictory. Determined efforts were made at great expense and time to confirm an explosive device with every possible bit of metal examined closely for the characteristics of a bomb such as fuze, timer, residue, container, but none of a conclusive nature was found. On the other hand, evidence given against an explosive device in Air India Flight 182 is clearly stated and unequivocal.

The circumstantial evidence for a bomb explosion relies on flawed logic, unrelated events, and irrelevant facts while omitting crucial details necessary to sustain the premise. The explanation for the explosion which caused the breakup in flight based on the circumstantial and tangible evidence as caused by a bomb explosion in the forward cargo compartment is poorly documented, mostly unsubstantiated, unreasonably circumstantial, and therefore very unlikely, and probably impossible.

The Canadian professional aircraft accident investigators understood the evidence and the significance of the lack of it and refused to conclude a bomb was the cause of the explosion but agreed there was an explosion in the forward cargo compartment on the starboard side. When the illogical circumstantial evidence and the dearth of physical evidence of a 'bomb' explosion on Air India Flight 182 is considered, it is clear why the Canadian aircraft accident investigators chose to leave the cause of the explosion as unknown and unstated. The Indian government was not so prudent.

The Indian investigation was conducted and written by Honorable Mr. Justice B. N. Kirpal, Judge, High Court of Delhi Assessors, not an aircraft accident investigator. Although the Court held that it would not go into the question as to who was responsible for the accident, the Indian Kirpal Report devotes many dozens of pages describing the thousands of investigative hours in three countries to do exactly that by accepting hearsay evidence and uncorroborated testimony on the unsubstantiated assumption of a 'bomb explosion'.

The Indian aviation accident investigator originally assigned, Mr. Khola, Director of Air Safety, Civil Aviation Department, New Delhi, was quickly taken off the case and input from Indian aircraft accidents investigators was muted thereafter. The tone of the Indian Kirpal Report was shifted from the science to the political, while the Canadian Report stays firmly neutral and scientific. Because of the shift of emphasis from accident investigation to criminal investigation a presumption was made that a person or persons unknown committed the act and much effort was directed in confirming that a crime had occurred so that the persons could be apprehended.

In the case of Air India Flight 182, however, the evidence showed there was no bomb explosion but a mechanical accident, and thus no crime, and thus no criminals, except possibly for unintentional lapses of responsibility or negligence. The Canadian aircraft accident investigators understood the mechanical possibility and stated the cause of the airplane crash in scientific conclusions and not criminal findings.

Analysis of the then and now tangible, direct and circumstantial evidence for the conclusion by this investigator of a mechanical probable cause of the explosion as caused by wiring/cargo door/explosive decompression sequence of events is given in Section 3 of this report.

2.4.3 Conclusions: Conclusions regarding the premise of an explosion in flight of a bomb on the starboard side in the forward cargo compartment of Air India Flight 182, inclusive of a bomb detonation, a bomb which was first loaded at Vancouver B.C, Canada onto CP Flight 060 on 22 June, 1985.

- A. There was an explosion on the starboard side of the forward cargo compartment.
- B. There was no bomb explosion in the forward cargo compartment from any baggage loaded in Vancouver B.C onto CP 060.
- C. There was no bomb explosion, nor any other kind of explosion, in the aft compartment.
- D. There was no bomb explosion in any compartment, although there was an explosion in the forward cargo compartment on the starboard side. (Type of explosion detailed in Section 3)

Excerpts of official corroborative statements to support the identification of the Indian official in charge of the investigation for Air India Flight 182.

From the Indian Kirpal Report.

Initial Action Taken by the Government of India

1.2.1 Initial intimation of the accident was received by Air India who, in turn, communicated the same to Mr. H.S. Khola, Director of Air Safety, Civil Aviation Department, New Delhi. The Accident Investigation Branch of United Kingdom also sent information to the Director General of Civil Aviation, New Delhi to the effect that the accident had taken place on international waters and as such it was India which was the authority to investigate the accident in accordance with the provisions of ICAO Annex 13.

1.2.2 Thereupon Order No. AV.15013/8/85-AS dated 23rd June, 1985 was

issued by the Director General of Civil Aviation whereby Mr. H.S.Khola was appointed Inspector of Accidents for the purpose of carrying out the investigation into the aforesaid air accident. This appointment was made under Rule 71 of the Aircraft Rules, 1937.

1.2.12 The Government of India, in exercise of the powers conferred by Rule 75 of the Aircraft Rules, 1937 vide Notification No. AV.15013/10/85-A, dated 13th July, 1985, directed that a formal investigation of the accident be carried out. Mr Justice B.N. Kirpal, Judge of the Delhi High Court, was appointed as the Court to hold the said investigation.

1.5.28 By the order dated 4th February, 1986, it was made clear that it was not the intention of the investigation to apportion blame if any lapse had been committed and, therefore, the Court would ignore any written submissions which tended to apportion blame or responsibility for any lapse of any participants. The Court had then held that it will not go into the question as to who was responsible for the accident. It was in view of this order that no evidence was led by any of the parties on the question as to who may have been responsible for any possible lapse which could have led to this accident.

Excerpts of official corroborative statements in support of the breakup in flight of Air India Flight 182 as caused by an explosion in the forward cargo compartment, inclusive of a bomb detonation.

From the Canadian Aviation Occurrence Report:

3.2 Passenger/Flight Deck Area There was blackened erosion damage to the bottoms of some seat cushions, showing damage possibly from an explosive device, and the upper deck storage cabinet had a large rounded dent in the bottom inboard edge which might have been caused by an explosive shock wave generated below the cabin floor and inboard from the cabinet. It should be noted that the pieces of the overhead locker were found on the Welsh shore some time after the accident, and it is not known if the pieces were subjected to a fire after the accident. Also, it is not known if the damage to the seat cushions and the upper deck storage cabinet could have been caused by other means. Nevertheless, the above evidence suggests that some areas of the passenger cabin may have been subjected to minor fire and explosive damage possibly emanating from below the cabin floor.

3.4 Aircraft Structural Integrity As described earlier, the sudden nature of the occurrence indicates the possibility of a massive airframe structural failure or the detonation of an explosive device.

3.4.5 Explosive Device Of the floating wreckage, there is little to indicate the possibility of an explosion:

the lining in one suitcase was severely tattered; although the wooden spares box was burned, this could have happened after the occurrence; although pieces of an overhead locker were damaged by fire, it is not known if the burning happened at the time of the occurrence; although the pieces of U-section alloy clearly indicated evidence of an explosion, it is quite possible that these pieces were not associated with the aircraft; the bottoms of some seat cushions show indications of a possible explosion; the inside of the right wing root fillet appears to have been scorched; and the deformation of the floor of the upper deck storage cabinet might have been caused by an explosive shock wave generated below the cabin floor and inboard from the cabinet. It is not known if the suitcase came from the aft or forward cargo compartment, and the location of the seats from which the cushions came is also unknown. The scorching of the right wing root fillet and the damage to the upper

deck cabinet suggest, if there was an explosion, it emanated from the forward cargo compartment.

Target 399, consisting of a piece of the skin and stringers on the right side in the area of the forward cargo compartment contained holes and several hundred metal fragments. The damage to the floor station and the presence of the fragments are consistent with an explosion. The examination of the recovered wreckage contains no evidence of an explosion except for targets 362/396 and 399 which contain some evidence that an explosion emanated from the forward cargo compartment.

An explosion in the forward cargo compartment would explain the loss of the DFDR, CVR and transponder signal as the electronics bay is immediately ahead of the cargo compartment.

3.5 Security Aspects There is a considerable amount of circumstantial and other evidence that an explosive device caused the occurrence

3.5 The evidence indicates that if there was an explosion, it most likely occurred in the forward cargo hold, not the passenger and flight deck areas or exterior to the fuselage. Although an explosive device could have been placed in a cargo hold in a number of ways, the available evidence points to the events involving the checked baggage of M. and L. Singh in Vancouver. The investigation determined that a suitcase was interlined unaccompanied from Vancouver via CP Air Flight 060 to Toronto. In Toronto, there is nothing to suggest that the suitcase was not transferred to Terminal 2 and placed on board Air India Flight 181/182 in accordance with normal practice.

3.5.2 Once loaded on the aircraft, the suitcase would have been placed in container 11L and 12L (see Appendix B) if in the forward cargo compartment, in container 44L or 44R if in the aft cargo compartment, or in position 52 if in the bulk cargo compartment. It could not be determined in which cargo compartment the suitcase was loaded. Therefore, although the procedures were in place to prevent an explosive device from being placed on board the aircraft in checked-in baggage, there was a breakdown in the X-ray machine used to screen baggage, and there are indications that the PD-4 sniffer was inadequate. Also, the security numbering system used in Toronto was ineffective in preventing unaccompanied interlined baggage from being placed on board the aircraft.

Excerpts of official corroborative statements in support of the breakup in flight of Air India Flight 182 as caused by an explosion in the forward cargo compartment inclusive of a bomb detonation.

From the Indian Kirpal Report:

1.2.8 It was also being speculated that the accident may have occurred due to an explosion on board the aircraft. In order to see whether there was any evidence of an explosion which could be gathered from the floating wreckage which was being salvaged, the Government of India requisitioned the services of Mr. Eric Newton, a Specialist in the detection of explosives sabotage in aircraft wreckage.

3.2.11.56 Mr. Newton has also observed that curling, cork-screwing, and saw tooth edges may also be indicative of an explosion though such fractures by themselves may not be conclusive evidence that an explosion was involved.

3.2.11.57 Mr. Newton also refers to the positive explosive signatures which remain on a detonation in an aircraft. These positive signatures, according to him, are as follows:

"(a) The formation of distinctive surface effects such as pitting or very small craters formed in metal surfaces, caused by extremely high velocity impacts from small

particles of explosive material. Such craters, when viewed under the microscope, have raised and rolled over edges and often have explosive residue in the bottom of the crater.

"(b) Small fragments of metal, some less than 1 mm in diameter, which, under the scanning electron microscope, reveal features such as rolled edges, hot gas washing (orange peel effect, surface melting and pitting and general evidence of heat; such features have been proved and observed following explosive experiments with known explosives). Supporting strong evidence would be if such fragments (normally found embedded in structures, furnishing or suitcases) were found embedded in a body where evidence of burning of tissue is present at the puncture entry and where the fragment came to rest.

"(c) As well as surface effects on metal fragments produced by explosives there are deformation mechanisms which are peculiar to high rates of strain at normal temperature. At normal rates of strain metals deform by usual mechanism associated with dislocation movement. However, because this process in an explosion is thermally activated at very high rates of strain, there is insufficient time for the normal process to occur. In some metals such as copper, iron and steel, deformation in the crystals of the metal takes place by 'twinning', that is to say by parallel lines or cracks cutting across the crystal. Such a phenomenon can occur only if the specimen has been subjected to extreme shock wave loading at velocities in the order of 8000 m/sec. Such specimens, usually distorted must be selected with care, prepared in a metallurgical laboratory, polished, mounted and microscopically examined. Where such twinning of the crystals is found it establishes (a) that the specimen was close to the seat of the explosion and (b) that a military type explosive had been used with a detonating velocity of 8000 m/sec or more. Twinning is rarely produced when shock impact loadings are below 8000 m/sec. The above features, singly or combined, are considered to be proof positive evidence of a detonation of a high explosive; they could not be produced in any other way.

3.2.11.58 The metallurgical report indicates that the microscopic examination (conducted by them) discloses such features being present which had been described as positive signatures of the detonation of an explosive device in an aircraft by Mr. Newton. Furthermore, twinning effect has also been noticed at a number of places - around holes and in fragments. These have been categorised by Mr. Newton as positive signature of an explosion.

3.2.11.59 In the primary zone of explosion, metallic structures disintegrate into numerous tiny fragments and usually these fragments contain the above mentioned distinct signatures of explosion. In the present case the explosive damage had occurred at an altitude of 31000 feet when the aircraft was flying over the ocean. The fragments that formed due to explosion must have been scattered over a wide area and it is impossible to locate and recover all of them from the ocean bed. Nevertheless, some of the fragments which were recovered along with the targets 362 and 399 do contain signatures of explosive fracture.

3.2.11.60 From the aforesaid discussion it would, therefore, be safe to conclude that the examination of targets 362 and 399 clearly reveals that there had been a detonation of an explosive device on the Kanishka aircraft and that detonation has taken place not too far away from where these targets had been located.

3.4.6.51 It may be that the frequency spectrum of Kanishka CVR did not contain low frequencies but, as has been admitted by Mr. Davis himself in answer to a Court question, it is not necessary that in the case of every detonation there must necessarily be low frequencies in the spectrum. The CVR of Indian Airlines Boeing

737 has not been analysed either by Mr. Caiger or Mr. Davis. The analysis was, however, conducted by Mr. Seshadri and as is evident from his report, there were marked similarities between the spectra of Indian Airlines 737 and Air India's Kanishka CVR.

3.4.6.56 From what has been stated in the various reports, as well as in the testimony of the 3 experts who appeared in the Court, the only safe conclusion which can be drawn is that possibly enough study has not been done, due to lack of adequate data, which can lead one to the conclusion as to the exact nature of the sound and the distance from which it originated.

3.4.6.57 The fact that a bang was heard is evident to the ear when the CVR as well as the ATC tapes are played. The bang could have been caused by a rapid decompression but it could also have been caused by an explosive device.

3.4.6.59 With regard to the nature of the sound also we have 3 different opinions. Mr. Caiger is unable to give the nature of the sound, Mr. Davis says it is rapid decompression while Mr. Seshadri says it is a sound of an explosive device followed by decompression.

3.4.6.60 In the absence of any other technical literature on the subject, it is not possible for this Court to come to the conclusion as to which of the Experts is right. The only conclusion which can, however, be arrived at is that the aircraft had broken in midair and that there has been a rapid decompression in the aircraft. Just as it is not possible to say that the spectrum discloses that the bang is due to an explosive device similarly, and as has also been admitted by Mr. Caiger and Mr. Davis, it is not possible to say that the bang is due to break up of a structure.

3.4.6.61 The bang could have been due to either of the aforesaid two causes i.e. a bomb explosion or the sound emanating due to rapid decompression.

In the present case the bang, as already noticed, could have been due to the sound originating from the detonation of a device or by reason of rapid decompression. Other evidence on the record, however, clearly indicates that the accident occurred due to a bomb having exploded in the forward cargo hold of Kanishka. The spectra analysis and the conclusions of Mr. S.N. Seshadri are corroborated by other evidence.

4.5 It is evident that an event had occurred at 31,000 feet which had brought down 'Kanishka'. What could have possibly happened to it? The aircraft was apparently incapacitated and this was due either to it having been hit from outside; or due to some structural failure; or due to the detonation of an explosive device within the aircraft.

4.9 Thus we are left with only two of the possibilities viz., structural failure or accident having been caused due to a bomb having been placed inside the aircraft.

4.10 After going through the entire record we find that there is circumstantial as well as direct evidence which directly points to the cause of the accident as being that of an explosion of a bomb in the forward cargo hold of the aircraft. At the same time there is complete lack of evidence to indicate that there was any structural failure.

Excerpts of official corroborative statements mitigating against the breakup in flight of Air India Flight 182 as caused by an explosion of a 'bomb' in the forward cargo compartment:

From the Canadian Aviation Occurrence Report:

2.11.1- The wooden boxes which contained the fan blades of the 5th pod engine were loaded in container 24L in the forward cargo compartment and were found

broken apart exhibiting no burn marks. An electronic device was found among some floating wreckage and was forwarded to the Bhabha Atomic Research Centre for analysis. There was some concern that it could have been used to detonate an explosive device. The device was forwarded to the RCMP who in conjunction with the CASB determined it to be an item manufactured for use in radiosondes (weather balloons) and was not modified as a detonating device.

2.11.6.10 Target 362/396 - Lower Skin Panel - Forward Cargo Area. The chemical nature of the explosive material was not identified. No part of an explosive device, its detonator or timing mechanism was recovered.

2.2 It should be noted that some passengers from India book flights to Montreal with their intended destination being Toronto. The reason is that the fare to Montreal is cheaper and therefore some passengers get off the flight in Toronto, claim their luggage and leave without reporting a cancellation of the trip to Montreal. All checked-in baggage for AI 181/182 was to be screened by an X-ray machine which was located in Terminal 2 at the end of international belt number 4. This location would permit all baggage from the check-in counters and interline carts to be fed through the X-ray machine before being loaded. It has been established that this machine worked intermittently for a period of time and stopped working during the loading process at about 1700 EDT (2100 GMT). Rather than opening the bags and physically inspecting them, the Burns security personnel performing the X-ray screening were told by the Air India security officer to start using the hand-held PD-4 sniffer.

3.1 Initial Event The millisecond noise on a CVR as observed in this case is usually, as described in the available literature, the result of the shock wave from detonation of an explosive device. However, in this case, certain characteristics of the noise indicate the possibility that the noise was the result of an explosive decompression.

3.2 Passenger/Flight Deck Area From the examination of the wreckage recovered and wreckage on the bottom, there is no indication that a fire or explosion emanated from the cabin or flight deck areas. The medical examination of the bodies also showed no fire or explosion type injuries.

Excerpts of official corroborative statements mitigating against the breakup in flight of Air India Flight 182 as caused by an explosion of a 'bomb' in the forward cargo compartment:

From the Indian Kirpal Report

2.1.1. Air India Boeing 747 aircraft VT-EFO 'Kanishka' was operating flight AI-181 (Bombay-Delhi-Frankfurt-Toronto-Montreal) on 22nd June, 1985. From Montreal it becomes AI-182 from Mirabel to Heathrow Airport, London enroute to Delhi and Bombay.

2.1.7 As stated earlier, 68 transit passengers had disembarked at Toronto for completing the customs and immigration checks. However, only 65 of these passengers re-boarded the aircraft as per transit cards collected at the boarding gate. It is in evidence that almost every flight of Air India to Canada, two or three transit passengers do not re-board the flight at Toronto.

2.4.3.6 The entire baggage of passengers ex-Montreal was loaded in containers at positions 12R, 21R, 22R, 23R and 24R in the front cargo compartment.

2.4.3.7 All the baggage and engine parts in the aft and bulk cargo compartments were loaded at Toronto.

3.1.8 Air Vice Marshal Kunzru, witness No. 10 in his report dated 14th November, 1985, Ex.A-48, No evidence of fire burns or explosive material, other

than Kerosene burns on some bodies, which I had myself seen at Cork, could be found. Kerosene burns in such accidents is a fairly common findings and is of no significance"

3.2.11.21 In the metallurgical report it is stated that on an examination of this target it was also found that on the underside of this floor near the forward end, a number of dents and impact marks were observed. This region appeared to have suffered shrapnel penetration. This area was radiographed but no metallic fragment was detected.

3.2.11.42 The floating wreckage recovered was initially examined at Cork.

c. There was no evidence of fire internal or external.

f. Examination of clothing from the bodies did not show any explosive fractures or any signs of burning. The seat cushions and head cushions also did not show any explosive characteristics.

h. A number of lavatory doors and structure also did not show any damage consistent with explosion. The flight deck door showed no explosion damage inside or outside.

i. The circumstantial evidence strongly suggests a sudden and unexpected disaster occurred in flight.

j. There was no significant fire or explosion in the flight deck, first and tourist passenger cabin including several lavatories and the rear bulk cargo hold.

3.4.6.57 The fact that a bang was heard is evident to the ear when the CVR as well as the ATC tapes are played. The bang could have been caused by a rapid decompression but it could also have been caused by an explosive device. One fact which has, however, to be noticed is that the sound from the explosion must necessarily emanate a few milliseconds or seconds earlier than the sound of rapid decompression because the explosion must necessarily occur before a hole is made, which results in decompression. In the event of there being an explosive detonation then the sound from there must reach the area mike first before the sound of decompression is received by it. The sound may travel either through the air or through the structure of the aircraft, but if there is no explosion of a device, but there is nevertheless an explosive decompression for some other reason, then it is that sound which will reach the area mike. To my mind it will be difficult to say, merely by looking at the spectra of the sound, that the bang recorded on the CVR tape was from an explosive device.

3.4.6.59 With regard to the nature of the sound also we have 3 different opinions. Mr. Caiger is unable to give the nature of the sound, Mr. Davis says it is rapid decompression while Mr. Seshadri says it is a sound of an explosive device followed by decompression.

3.4.6.60 In the absence of any other technical literature on the subject, it is not possible for this Court to come to the conclusion as to which of the Experts is right. The only conclusion which can, however, be arrived at is that the aircraft had broken in midair and that there has been a rapid decompression in the aircraft. Just as it is not possible to say that the spectrum discloses that the bang is due to an explosive device similarly, and as has also been admitted by Mr. Caiger and Mr. Davis, it is not possible to say that the bang is due to break up of a structure.

3.4.6.61 The bang could have been due to either of the aforesaid two causes i.e. a bomb explosion or the sound emanating due to rapid decompression.

4.5 It is evident that an event had occurred at 31,000 feet which had brought down 'Kanishka'. What could have possibly happened to it? The aircraft was apparently incapacitated and this was due either to it having been hit from outside; or due to some structural failure; or due to the detonation of an explosive device within the

aircraft.

4.9 Thus we are left with only two of the possibilities viz., structural failure or accident having been caused due to a bomb having been placed inside the aircraft.

2.5 Premise Explanation: Explosion in the forward cargo compartment caused by explosive decompression of undetermined cause, exclusive of a bomb detonation:

2.5.1 **Proponent:** UK Air Accidents Investigation Branch, (AAIB) representative.

2.5.2 **Analysis:** There is unanimous opinion that Air India Flight 182 suffered an inflight breakup due to an explosion in the forward cargo compartment. The cause of the explosion is in dispute. The Canadian investigators left the cause unstated. The Indian Kirpal Report states it was a 'bomb'.

In 1985/1986, the UK AAIB investigator, Mr. Roy A. Davis, stated the cause of the explosion to be explosive decompression, exclusive of a bomb detonation, and the cause of the decompression was yet to be identified. Mr. Davis ruled out a bomb explosion, among other reasons, because of the sound spectrum analysis of the sudden loud audible sound on the cockpit voice recorder of Air India Flight 182 at event start time lacked the low frequencies and fast rise time associated with a bomb explosion.

There is ample evidence of explosive decompression in the forward cargo compartment, exclusive of a bomb explosion, in the official reports which is summarized as follows:

- A. Forward cargo door broken, frayed, and damage caused by outward force.
- B. CVR recording of an explosive decompression sound which matches another decompression sound in a wide body airliner.
- C. CVR recording not a bomb explosion because of lacking low frequencies and slow rise time.
- D. ATC recordings of sounds which matched another decompression event in wide body airliner.
- E. Many fragments and outward curling of fuselage skin in the forward cargo door area.
- F. Ruptures in the forward and aft cargo compartments.
- G. Passenger victims suffered hypoxia, decompression, flail injuries, and loss of clothing.
- H. No passengers sitting above or near the forward cargo door were recovered.
- I. More damage on starboard side than port side.
- J. Inflight damage to engine number three, right wing and right horizontal stabilizer.
- K. Forward cargo door ruptured from above.
- L. General absence of explosive residue, timing device, or other bomb explosion evidence.

In addition to the tangible evidence listed above, there are three crucial assumptions about items of evidence which, in 1985 and 1986, were used by Judge Kirpal to rule out explosive decompression and rule in 'bomb explosion'; whereas, in 1989, the opposite of two of the earlier assumptions was conclusively shown to be true.

In 1985, when Air India Flight 182 suffered an inflight breakup from an explosion, it was believed that an explosive decompression in an early model Boeing 747 could not cause an abrupt power cut to the data flight recorders. That belief was cited by the Indian Kirpal Report as a reason to reject the explosive decompression explanation because, in fact, Air India Flight 182 had

suffered an abrupt power cut to the data recorders. The Indian Kirpal Reports states: "It was not possible that any rapid decompression caused by a structural failure could have disrupted the entire electrical power supply from the MEC compartment." That assumption may have been correct in 1985 but a subsequent similar event with similar evidence to a similar type aircraft in 1989 has shown that assumption to be completely wrong. United Airlines (UAL) Flight 811, an early model Boeing 747 similar to Air India Flight 182, did in fact suffer a rapid decompression caused by a structural failure of a forward cargo door which inadvertently ruptured open in flight which did abruptly disrupt the entire electrical supply in the adjacent Main Equipment Compartment (MEC).

Therefore, one of the main reasons why the Indian Kirpal Report rejected the explosive decompression explanation has been conclusively proven incorrect, thereby supporting the wiring/cargo door/explosive decompression explanation as a plausible, reasonable, mechanical explanation for the events of Air India Flight 182.

The second reason used by the Indian Kirpal Report for rejecting the explosive decompression explanation was that the floor panels appeared to have failed in an upward direction whereas a decompression would have put downward pressure on the floor panels. However, the subsequent event of UAL 811, four years later, showed that when the decompression occurs, the floor beams are pulled downward with such force the floor panels separate. In effect, there is no difference in the appearance of floor panels which fail upward attached to stationary floor beams compared to floor panels remaining stationary as the floor beams beneath them are pulled downward. Both events could lead investigators to assume that the floor panels failed upward from an explosive force below or to assume the panels remained stationary and the supporting floor beams were suddenly sucked downward by decompression forces. Other corroborative evidence is needed for either conclusion to be accurate.

The third reason for accepting the 'bomb explosion' explanation was the belief by Judge Kirpal that only a bomb explosion could create the metallurgical effect known as 'twinning'. Since twins were found on fragments of pieces of metal examined under less than ideal conditions and believing he had the 'proof positive' for a bomb explosion, Judge Kirpal states in 3.2.11.58 'The metallurgical report indicates that the microscopic examination (conducted by them) discloses such features [twinning] being present which had been described as positive signatures of the detonation of an explosive device in an aircraft by Mr. Newton.' It is now known that under certain conditions, an aviation fuel explosion or a powerful explosive decompression can also create 'twins' in the metal affected by the blast; therefore, the identification of 'twining' on fragments of pieces of metal from the wreckage is not a positive indicator of a bomb explosion in Air India Flight 182. Other corroborative evidence is needed for any conclusion to be accurate.

Judge Kirpal relied on three beliefs to sustain his lone finding of a bomb explosion in Air India Flight 182; all three have been shown to lack corroborative support and over the subsequent sixteen years to be flawed and unreliable with alternative, plausible explanations for the evidence. It was understandable that Judge Kirpal made the error in judgment for the cause of the explosion that caused the breakup of Air India Flight 182 as a bomb explosion based on what he believed in 1985/1986.

Based upon the actual evidence presented in 1985/1986, there is considerable support for the probable cause for the explosion that caused the inflight breakup of Air India Flight 182 to be explosive decompression in the forward cargo compartment but not caused by a bomb explosion. The UK AAIB investigator concluded as such but gave no cause for the decompression. He stated in The Indian Kirpal Report 3.4.6.16: "It is considered that from the CVR and ATC recordings supplied for analysis, there is no evidence of a high explosive device having detonated on AI 182.

There is strong evidence to suggest that a sudden explosive decompression occurred but the cause has not been identified."

The British aviation accident investigator from AAIB rejected the bomb explosion explanation, accepted the explosive decompression premise but said the cause of it is not yet identified. The Canadian aviation accident investigators also declined to state the cause of the explosion in the forward cargo compartment but did not reject the bomb explosion explanation. The Indian judge rejected the explosive decompression explanation and accepted the bomb explosion explanation possibly because of the three assumptions valid in 1985 but now shown by a subsequent event to be unreliable.

To summarize, the UK AAIB representative concluded that there was an explosion in the forward cargo compartment caused by explosive decompression by an unidentified cause; the Canadians concluded there was an explosion in the forward cargo compartment on the starboard side but declined to state the cause; and the Indians found there was an explosion in the forward cargo compartment on the starboard side and stated the cause to be a bomb explosion, basing their finding on three flawed assumptions.

It might be presumed that had the Indian, Canadian, and British authorities known about the similar type event, United Airlines Flight 811, detailed in Section 3, in a similar type aircraft which left similar evidence four years later which would have explained the mysteries of Air India Flight 182, they all would have refined their probable cause for the explosion to be explosive decompression in the forward cargo compartment due to a ruptured open forward cargo door in flight.

2.5.3 Conclusion: There was an explosion in the forward cargo compartment caused by explosive decompression of undetermined cause, exclusive of a bomb detonation, based upon knowledge available in 1985/1986.

Excerpts of official corroborative statements for support of the breakup in flight of Air India Flight 182 as caused by an explosion by explosive decompression at the forward cargo door, exclusive of a bomb explosion:
From the Canadian Aviation Occurrence Report:

2.11.4.6 Section 42 Portions of section 42, consisting of the forward cargo hold, main deck passenger area, and the upper deck passenger area, were located near section 41. This area was severely damaged and some of section 42 was attached to section 44. Some of the structure identified from section 42 was the crown skin, the upper passenger compartment deck, the belly skin, and some of the cargo floor including roller tracks. All cargo doors were found intact and attached to the fuselage structure except for the forward cargo door which had some fuselage and cargo floor attached. This door, located on the forward right side of the aircraft, was broken horizontally about one-quarter 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. Because the damage appeared to be different than that seen on other wreckage pieces, an attempt to recover the door was made by CCGS John Cabot. Shortly after the wreckage broke clear of the water, the area of the door to which the lift cable was attached broke free from the cargo door, and the wreckage settled back onto the sea bed. An attempt to relocate the door was unsuccessful.

2.11.4.9 Sections 46 and 48 Sections 46 and 48 contain that part of the aircraft

structure aft of BS 1480 and, for purposes of this Submission, will include the horizontal stabilizer and vertical fin. The aft cargo and bulk cargo doors were found in place and intact, and 5L, 5R and 4R entry doors were identified. A large portion of the outer skin panels showed signs of a force being applied from the inside out. On several pieces of wreckage, the skin was curled outwards away from the stringers and formers. This could have been the result of an overpressure of air or water.

2.11.5 Wreckage Recovery and Initial Examination During the wreckage mapping, some small items were recovered, and an unsuccessful attempt was made to recover a portion of the forward cargo door.

2.11.6.8 Target 399 - Fuselage Side and 2R Entry Door The fuselage segment was located between BS 780 and 940. This piece was badly damaged and buckled inwards along a line through the lower door hinge. There were 12 holes or damaged areas on the skin generally with petals bending outwards. The curl on a flap around a hole had one full turn. This curl was in the outward direction. Cracks were also noticed around some of the holes. Part of the metal was missing in some of the holes. The edges of some of the petals showed reverse slant fracture. In one of the holes, spikes were noticed at the edge of a petal. When this target was recovered from the sea, along with it came a few hundred tiny fragments and medium-sized pieces. One of the medium-sized pieces recovered with this target was a floor stantion about 35 inches long. It was confirmed that this stantion belonged to the right side of the forward cargo hold. The inner face of the stantion had a fracture with a curl at the lower end, the curl being in the outboard direction and up into the centre of the stantion. Scientists from the Bhabha Atomic Research Centre, the National Aeronautical Laboratory and the Explosives Research and Development Laboratory in India conducted a metallurgical examination of certain items of wreckage. Their report on target 399 concluded that:

the curling of the metal on the floor channel was indicative of a shock wave effect; the large number of tiny fragments from the disintegration of nonbrittle aluminum was a characteristic indication of explosive forces; and the indications of punctures, outward petalling around holes, curling of metal lips, reverse slant fracture, formation of spikes at fracture edges and certain microstructural changes all were indicative of an explosion.

2.11.6.10 Target 362/396 Lower Skin Panel Forward Cargo Area This section of skin panel was located between BS 720 and 860 and is just below target 399. The skin was badly crumpled and torn and had several punctures. It was pulled free from a large mass of debris which included some mangled cargo floor beams and roller trays. Some of the punctures had a feathered or spiked profile, with spikes angled at approximately 45 degrees to the edge. Other puncture holes gave clear indication of being formed by underlying stiffeners at impact. Two of these holes contained pieces of web stiffener. Most of the punctures were the result of penetrations from inside. In the preliminary report of Mr. V.J. Clancy, representing Boeing, the following observations regarding target 362/396 were made: There were about 20 holes in the lower skin panel clearly resulting from penetration from inside. In addition to the fact that perforation was from inside, there were certain features which suggested that they were made by high velocity fragments such as those produced by an explosion. The production of a large number of small fragments is generally regarded as an indication of an explosion. One piece, which was isolated, was about an inch square of sheet alloy with characteristic spikes on one edge similar to those described by Tardif and Sterling. The following is an excerpt from the report by Mr. V.J. Clancy wherein he gives his opinion and

conclusions regarding target 362. "Opinion The features discernible to a careful close visual examination point towards the possibility of an explosion but taken alone do not justify a firm conclusion. Mr. Clancy concluded that: "there is strong circumstantial evidence that an explosion occurred but neither individually nor collectively do the several pointers give the degree of confidence necessary for a firm and final conclusion, at this time."

The Indian report, in addition to the observations made by Mr. Clancy, noted the following with respect to the metallurgical examination: The microstructure in the various areas examined on target 362/396 confirmed explosive loading in this part of the aircraft. The holes and other features observed in targets 362/396 and 399 must have been due to shock waves and penetration by fragments resulting from an explosion inside the forward cargo hold. The chemical nature of the explosive material was not identified. No part of an explosive device, its detonator or timing mechanism was recovered.

3.1 Initial Event From the correlation of the recordings of the DFDR, CVR and Shannon ATC tape, the unusual sounds heard on the ATC tape started shortly after the flight recorders stopped recording. The conversations in the cockpit were normal, and there was no indication of an emergency situation prior to the loud noise heard on the CVR a fraction of a second before it stopped recording. The DFDR showed no abnormal variations in parameters recorded before it stopped functioning. The abrupt cessation of the data recorder could be caused by airframe structural failure or the detonation of an explosive device as the initial event. The millisecond noise on a CVR as observed in this case is usually, as described in the available literature, the result of the shock wave from detonation of an explosive device. However, in this case, certain characteristics of the noise indicate the possibility that the noise was the result of an explosive decompression. There is some disagreement regarding the cause and location of the source of the noise heard on the CVR, that is, whether the noise resulted from an explosive device or an explosive decompression and whether the noise originated from the rear or closer to the front of the aircraft.

3.3 Aircraft Break-up Sequence The medical evidence showed a proportion of the passengers with indications of hypoxia, decompression, flail injuries and loss of clothing. The incidence of hypoxia and decompression indicates that the aircraft experienced a decompression at a high altitude. The flail injuries and loss of clothing indicate a proportion of the passengers were ejected from the aircraft before water impact

3.4 Aircraft Structural Integrity As described earlier, the sudden nature of the occurrence indicates the possibility of a massive airframe structural failure or the detonation of an explosive device.

3.4.1 Aircraft Break-up The forward cargo door which had some fuselage and cargo floor attached was located on the sea bed. The door was broken horizontally about one-quarter 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 and the fracture surfaces of the door appeared to be badly frayed. This damage was different from that seen on other wreckage pieces. A failure of this door in flight would explain the impact damage to the right wing areas. The door failing as an initial event would cause an explosive decompression leading to a downward force on the cabin floor as a result of the difference in pressure between the upper and lower portions of the aircraft. However, examination showed that the cabin floor panels separated from the support structure in an upward direction.

3.4.4 Structural Failure The initial event has been established as sudden and

without warning. The abrupt cessation of the flight recorders indicates the possibility of a massive and sudden failure of primary structure; however, there is evidence to suggest that there were ruptures in the forward and aft cargo compartments prior to any failure of the primary structure in flight.

3.4.5 Explosive Device Of the floating wreckage, there is little to indicate the possibility of an explosion:

the lining in one suitcase was severely tattered; although the wooden spares box was burned, this could have happened after the occurrence; although pieces of an overhead locker were damaged by fire, it is not known if the burning happened at the time of the occurrence; although the pieces of U-section alloy clearly indicated evidence of an explosion, it is quite possible that these pieces were not associated with the aircraft; the bottoms of some seat cushions show indications of a possible explosion; the inside of the right wing root fillet appears to have been scorched; and the deformation of the floor of the upper deck storage cabinet might have been caused by an explosive shock wave generated below the cabin floor and inboard from the cabinet. It is not known if the suitcase came from the aft or forward cargo compartment, and the location of the seats from which the cushions came is also unknown. The scorching of the right wing root fillet and the damage to the upper deck cabinet suggest, if there was an explosion, it emanated from the forward cargo compartment. Target 399, consisting of a piece of the skin and stringers on the right side in the area of the forward cargo compartment contained holes and several hundred metal fragments. The damage to the floor stantion and the presence of the fragments are consistent with an explosion.

The Canadian Aviation Safety Board respectfully submits as follows:

5. There is considerable circumstantial and other evidence to indicate that the initial event was an explosion occurring in the forward cargo compartment. This evidence is not conclusive. However, the evidence does not support any other conclusion.

Excerpts of official corroborative statements for support of the breakup in flight of Air India Flight 182 as caused by an explosion by explosive decompression at the forward cargo door, exclusive of a bomb explosion:

From the Indian Kirpal Report:

3.4.6.16 In conclusion, Mr. Davis reported as follows: "It is considered that from the CVR and ATC recordings supplied for analysis, there is no evidence of a high explosive device having detonated on AI 182. There is strong evidence to suggest that a sudden explosive decompression occurred but the cause has not been identified.

3.4.6.57 The fact that a bang was heard is evident to the ear when the CVR as well as the ATC tapes are played. The bang could have been caused by a rapid decompression but it could also have been caused by an explosive device.

3.4.6.60 In the absence of any other technical literature on the subject, it is not possible for this Court to come to the conclusion as to which of the Experts is right. The only conclusion which can, however, be arrived at is that the aircraft had broken in midair and that there has been a rapid decompression in the aircraft.

3.4.6.61 The bang could have been due to either of the aforesaid two causes i.e. a bomb explosion or the sound emanating due to rapid decompression. In the present case the bang, as already noticed, could have been due to the sound originating from the detonation of a device or by reason of rapid decompression.

3.5.6 Subjects were taken to 8,000 feet in the explosive decompression chamber with oxygen. They were exposed to an altitude of 25,000 feet within one second.

During the course of this explosion a loud bang was heard and inside the chamber there was misting and drop in temperature.

3.4.6.15 It was also reported by Mr. Davis that knocking sounds which were heard during the transmission were initially thought to be due to hand-held microphone vibration. This was discounted because of the frequency of the sounds. He noticed that almost identical sounds were heard on the DC-10 CVR after the decompression had occurred and the source of that sound had not been identified.

2.10.2 The AIB analysis was restricted to the CVR and the Shannon ATC tape. An analysis of the CVR audio found no significant very low frequency content which would be expected from the sound created by the detonation of a high explosive device. A comparison with CVRs recording an explosive decompression on a DC-10, a bomb in the cargo hold of a B737, and a gun shot on the flight deck of a B737 was made. Considering the different acoustic characteristics between a DC-10 and a B747, the AIB analysis indicates that there were distinct similarities between the sound of the explosive decompression on the DC-10 and the sound recorded on the AI 182 CVR. Knocking sounds were also heard during the transmission. These were initially thought to be due to hand-held microphone vibration, but this was discounted because of the frequency of the sounds. Almost identical sounds were heard on the DC-10 CVR after the explosive decompression had occurred. Their source was not identified.

3.4.6.59 With regard to the nature of the sound also we have 3 different opinions. Mr. Caiger is unable to give the nature of the sound, Mr. Davis says it is rapid decompression while Mr. Seshadri says it is a sound of an explosive device followed by decompression.

2.4.3.6 A question arose whether removal of the door stop fittings could have caused some difficulty in flight. From the video films of the wreckage it was found that the complete aft cargo door was intact and in its position except that it had come adrift slightly. The door was found latched at the bottom.

2.4.4.1 (ii) Fuselage Lower Bilge Area: Boeing Company have recommended modifications to provide improved drainage systems by incorporation of various Service Bulletins. All the relevant modification have been completed by Air India on the affected aircraft. In addition to completion of these modifications, repeat inspection of lower bilge area is being carried out to meet the requirements of Boeing (iv) Cargo Compartments: Inspection of all the cargo compartment interior structures for corrosion and cracks is being accomplished periodically by Air India after removal of linings and insulation blankets.

3.1.6 In his testimony in Court, Wing Commander Dr. I.R. Hill further stated that the significance of flail injuries being suffered by some of the passengers was that it indicated that the aircraft had broken in mid-air at an altitude and that the victims had come out of the aeroplane at an altitude. Furthermore, the seating pattern also shows that none of the bodies from Zone A or B was recovered, in fact as per the seating plan Zone B was supposed to have been unoccupied. This Zone is directly above the forward cargo compartment.

3.2.8.1 The forward fuselage section of the aircraft was found inverted and badly broken into many pieces, the major pieces being :

(vi) The lower portion of the fuselage skin/frame between the nose and B S 1000 was damaged past recognition except for a small portion with the forwarded cargo door (Target No.204) and another portion containing the aft access door cutout at B S 810 (Target No. 362).

3.2.9.5 Section 41 Section 41, consisting of the cockpit, first-class section, and electronics bay and identified as target 192, was found in a near-inverted attitude.

This section was severely damaged. The electronics bay and cockpit areas could not be located within the wreckage.

3.2.9.6 Section 42 Portions of Section 42, consisting of the forward cargo hold, main deck passenger area, and the upper deck passenger area, were located near section 41. This area was severely damaged and some of section 42 was attached to section 44. All cargo doors were found intact and attached to the fuselage structure, except for the forward cargo door which had some fuselage and cargo floor attached. This door, located on the forward right side of the aircraft, was broken horizontally about one-quarter 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. Because the damage appeared to be different from that seen on other wreckage pieces, an attempt to recover the door was made by CCGS John Cabot. Shortly after the wreckage broke clear of the water, the area of the door to which the lift cable was attached broke free from the cargo door, and the wreckage settled back on to the sea bed. An attempt to relocate the door was unsuccessful.

3.2.11.28 Target 362/396 Forward Cargo Skin This piece included the station 815 electronic access door, portions of seven longitudinal stringers to the left of bottom centre and five longitudinal stringers to the right of bottom centre. The original shape of the piece (convex in the circumferential direction) had been deformed to a concave inward overall shape. Multiple separations were found in the skin as well as in the underlying stringers. Further inward concavity was found in the skin between most of the stringers.

3.2.11.38 A number of small fragments were found along with the forward cargo skin in target 362. Amongst them was a piece from the web of a roller tray. This has pronounced curling of the edges towards the drive wheel, Fig. 362-27.

C. The ATC Transponder Stopped Transmitting :

Signals from this also stopped being received by the secondary radar at Shannon. Keeping in view that the CVR and the DFDR had stopped simultaneously at about the same time, when the signals from ATC transponder had also ceased, it is reasonable to presume that there must have been a complete breakdown of electrical supply which had affected all the three units. The only event which could have caused such a damage to paralyze the entire MEC compartment could only have been an explosion in the forward cargo hold. It was not possible that any rapid decompression caused by a structural failure could have disrupted the entire electrical power supply from the MEC compartment. In known cases of aircraft being subjected to rapid decompression there has never been such an instantaneous and total stoppage of electrical power and in fact aircraft have been known to have continued to fly and communicate with the ground even after decompression.

E. Damage in air : The examination of the floating and the other wreckage shows that the right hand wing leading edge, the No. 3 engine fan cowl, right hand inboard mid flap leading edge and the leading edge of the right hand stabilizer were damaged in flight. This damage could have occurred only if objects had been ejected from the front portion of the aircraft when it was still in the air. The cargo door of the front cargo compartment was also found ruptured from above. This also indicates that the explosion perhaps occurred in the forward cargo compartment causing the objects to come out and thereby damaging the components on the right hand side.

F. Evidence of Over pressurization: The examination of the structural panels and the other parts of the forward cargo compartment and the aft cargo compartment, recovered from the sea bed, indicates that overpressure condition had occurred in

both the cargo compartments. The failure of the passenger cabin floor panels in upward direction also indicates that overpressure was created in both the compartments.

G. Holes in the front cargo hold panels While the skin panels of the aft cargo compartment are fairly straight and undamaged, the panels of the front cargo compartment are ruptured and have a large number of holes. This shows that there was occurrence of an event in the front cargo compartment and not in the aft cargo compartment.

Excerpts of official corroborative statements mitigating against the breakup in flight of Air India Flight 182 as caused by an explosion by explosive decompression at the forward cargo door, exclusive of a bomb explosion:

From the Canadian Aviation Occurrence Report:

3.4.1 Aircraft Break-up The door failing as an initial event would cause an explosive decompression leading to a downward force on the cabin floor as a result of the difference in pressure between the upper and lower portions of the aircraft. However, examination showed that the cabin floor panels separated from the support structure in an upward direction.

3.4.4 Structural Failure The examination of the floating and recovered wreckage and the analysis of the photos and videos of the wreckage on the bottom failed to indicate any evidence of a failure of the primary or secondary structure as a result of a pre-existing defect. The initial event has been established as sudden and without warning. The abrupt cessation of the flight recorders indicates the possibility of a massive and sudden failure of primary structure; however, there is evidence to suggest that there were ruptures in the forward and aft cargo compartments prior to any failure of the primary structure in flight. Therefore, available evidence tends to rule out a massive structural failure as the initial event.

Excerpts of official corroborative statements mitigating against the breakup in flight of Air India Flight 182 as caused by an explosion by explosive decompression at the forward cargo door, exclusive of a bomb explosion:

From the Indian Kirpal Report:

C. The ATC Transponder Stopped Transmitting: Signals from this also stopped being received by the secondary radar at Shannon. Keeping in view that the CVR and the DFDR had stopped simultaneously at about the same time, when the signals from ATC transponder had also ceased, it is reasonable to presume that there must have been a complete breakdown of electrical supply which had affected all the three units. The only event which could have caused such a damage to paralyze the entire MEC compartment could only have been an explosion in the forward cargo hold. It was not possible that any rapid decompression caused by a structural failure could have disrupted the entire electrical power supply from the MEC compartment. In known cases of aircraft being subjected to rapid decompression there has never been such an instantaneous and total stoppage of electrical power and in fact aircraft have been known to have continued to fly and communicate with the ground even after decompression.

F. Evidence of Over pressurization: The examination of the structural panels and the other parts of the forward cargo compartment and the aft cargo compartment, recovered from the sea bed, indicates that overpressure condition had occurred in both the cargo compartments. The failure of the passenger cabin floor panels in

upward direction also indicates that overpressure was created in both the compartments.

I. Metallurgical Examination Results : A metallurgical examination, especially of Targets 362 and 399, clearly confirms that there was an explosion in the forward cargo compartment. Microscopy around some of the holes discloses that they have such characteristics like twinning which can be present only if the holes had been punctured due to the detonation of an explosive device.

2.6 Premise Explanation: Explosion in the forward cargo compartment caused by 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:

2.6.1 Proponent: John Barry Smith

2.6.2 Analysis: There is close agreement with the opinions of the two aviation authorities (CASB and AAIB), the judicial finding of Judge Kirpal, and this independent aircraft accident investigator in the specific location in the aircraft and consequences of the explosion with the only difference being the cause of the explosion on the starboard side of the forward cargo compartment of Air India Flight 182:

A. CASB: There was an explosion, which could have been a bomb explosion, on the starboard side of the forward cargo compartment near the forward cargo door which caused the inflight breakup of Air India Flight 182.

B. AAIB: There was an explosion, cause not identified but not a bomb explosion, of the forward cargo compartment which caused the inflight breakup of Air India Flight 182.

C. Judge Kirpal: There was an explosion, a bomb explosion, on the starboard side of the forward cargo compartment near the forward cargo door which caused the inflight breakup of Air India Flight 182.

D. John Barry Smith: There was an explosion, an explosive decompression when faulty wiring shorted on the forward cargo door unlatch motor which allowed one or both of the midspan latches to rupture open in the forward cargo door on the starboard side of the forward cargo compartment, which caused the inflight breakup of Air India Flight 182.

To determine the pattern in early model Boeing 747 accidents that suffered breakups in flight, it was necessary to evaluate carefully all the official accident reports concerning them. A pattern was detected of similar significant evidence among only four of the many hull losses, Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800.

It was very probable that one common initial event by one cause was the reason for all four since the matching evidence was so rare. There are many significant individual matches of evidence among each flight to each other. Table 1 in 7.17 in Section 3 gives all the individual matches to each other of the many significant evidence matches that appear among the flights such as:

- A. Boeing 747
- B. Early model -100 or -200
- C. Polyimide wiring (Poly X type)

- D. Sudden airframe breakup in flight (partial or total)
- E. Breakup occurs amidships
- F. Takeoff after sunset on fatal flight
- G. High flight time (over 55,000 flight hours)
- H. Aged airframe (over 18 years of service)
- I. Previous maintenance problems with forward cargo door
- J. Initial event within an hour after takeoff
- K. Initial event at about 300 knots while proceeding normally in all parameters
- L. Initial event has unusual radar contacts
- M. Initial event involves hull rupture in or near forward cargo door area
- N. Initial event starts with sudden sound
- O. Initial event sound is loud
- P. Initial event sound is audible to humans
- Q. Initial event followed immediately by abrupt power cut to data recorders
- R. Initial event sound matched to explosion of bomb sound
- S. Initial event sound matched to explosive decompression sound in wide body
airliner
- T. Torn off skin on fuselage above forward cargo door area
- U. Unusual paint smears on and above forward cargo door
- V. Evidence of explosion in forward cargo compartment
- W. Foreign object damage to engine or cowling of engine number three
- X. Fire/soot in engine number three
- Y. Foreign object damage to engine or cowling of engine number four
- Z. Right wing leading edge damaged in flight
- AA. Vertical stabilizer damaged in flight
- AB. Right horizontal stabilizer damaged in flight
- AC. More severe inflight damage on starboard side than port side
- AD. Port side relatively undamaged by inflight debris
- AE. Vertical fuselage tear lines just aft or forward of the forward cargo door
- AF. Fracture/tear/rupture at one or both of the midspan latches of forward cargo
door
- AG. Midspan latching status of forward cargo door reported as latched
- AH. Airworthiness Directive 88-12-04 implemented (stronger lock sectors)
- AI. Outwardly peeled skin on upper forward fuselage
- AJ. Rectangular shape of shattered area around forward cargo door
- AK. Forward cargo door fractured in two longitudinally
- AL. Status of aft cargo door as intact and latched
- AM. Passengers suffered decompression type injuries
- AN. At least nine missing and never recovered passenger bodies
- AO. Wreckage debris field in two main areas, forward and aft sections of aircraft
- AP. Initial official determination of probable cause as bomb explosion.
- AQ. Initial official determination modified from bomb explosion
- AR. Structural failure considered for probable cause
- AS. Inadvertently opened forward cargo door considered for probable cause
- AT. Official probable cause as bomb explosion
- AU. Official probable cause as 'improvised explosive device'
- AV. Official probable cause as explosion by unstated cause
- AW. Official probable cause as explosion in center fuel tank with unknown
ignition source
- AX. Official probable cause as improper latching of forward cargo door
- AY. Official probable cause as switch /wiring inadvertently opening forward

cargo door

AZ. "Bomb" allegedly loaded two flights previous to detonation flight.

2.6.3 **Conclusion:** The discovered common cause for all four aircraft, including Air India Flight 182, is the wiring/cargo door/explosive decompression premise explanation which is a mechanical explanation by an explosion on the starboard side 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 and explained in detail in Section 3 of this report.

3. Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, Trans World Airlines Flight 800 Wiring/Cargo Door/Explosive Decompression Matching Evidence

Introduction

4. Formatting style

5. Background

6. Purpose

7. **Premise Explanation:** Explosion in the forward cargo compartment caused by 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

- 7.1 Matching Significant Circumstantial Evidence
- 7.2 All four aircraft had probable causes initially thought to be bomb explosions.
- 7.3 All four aircraft had the probable cause of bomb explosion modified.
- 7.4 All four aircraft had initial breakups in their airframes in a similar amidships location.
- 7.5 All four aircraft had at least nine missing never recovered bodies.
- 7.6 All four aircraft had passengers which showed explosive decompression type injuries and no evidence of bomb explosion injuries.
- 7.7 All four aircraft experienced a sudden, loud, audible sound on the cockpit voice recorder at event start time.
- 7.8 All four aircraft had the source of the sudden, loud, audible sound as a bomb explosion disputed and the source as an explosive decompression supported.
- 7.9 All four aircraft had an abrupt power cut to the data recorders immediately after the sudden, loud, audible sound.
- 7.10 All four aircraft had an explosion in or adjacent to the forward cargo compartment.
- 7.11 All four aircraft had similar shattered fuselage skin in and around the forward cargo door.
- 7.12 All four aircraft had relatively mild damage on the port side of the nose forward of the wing.
- 7.13 All four aircraft had similar damage to their airframe structures from inflight ejected debris
- 7.14 All four aircraft had foreign object damage to engine number three.
- 7.15 All four aircraft had incomplete reports of the status of the forward cargo door, in particular, the status of the two midspan latches.
- 7.16 All four aircraft had similar debris patterns on the surface of the ground or sea

bottom.

7.17 Summary of matching evidence for all aircraft: Table 1

7.18 Summary of matching evidence between Air India Flight 182 and United Airlines Flight 811

8. Cargo Door Operation Boeing 747

9. Choice of Explosion Cause

10. Inadvertent Cargo Door Opening Causes

11. Wiring

12. Sequence of destruction for Air India Flight 182

13. Comment

14. Hindsight

15. General Conclusions

16. Specific Conclusions for Air India Flight 182

17. Contributing Causes

18. Recommendations

19. Concluding Comment

3. Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, Trans World Airlines Flight 800 Wiring/Cargo Door/Explosive Decompression Matching Evidence

Introduction

Hindsight is a luxury that is available to determine what happened to Air India Flight 182. It has been sixteen years since the tragic event and many Boeing 747 accidents have occurred before and since. (Appendix A, Boeing 747 Accidents) There have been fourteen hull losses of Boeing 747s since 1985 with a startling three of them suffering similar explosions in flight to Air India Flight 182 leaving significant matching evidence that gives circumstantial proof that all four aircraft suffered the same probable cause. The main fact in dispute for Air India Flight 182 is the cause of the explosion that caused the aircraft to breakup in flight. The three similar accidents, including one which did not totally breakup in flight, United Airlines Flight 811, prove by their existence and tangible evidence that all four should be included in a matching group of inflight breakups initiated by the same probable cause.

Once the evidence has been evaluated sufficiently to include them all into one similar group as matching, various premises may be evaluated to explain the inflight breakups, such as bomb explosion, center fuel tank explosion, missile explosion, or explosive decompression. The three similar accidents which occurred in similar circumstances and left similar matching evidence to United Airlines Flight 811 are Air India Flight 182, Pan Am Flight 103, and Trans World Airlines

Flight 800. The three flights are all controversial but evidence grouped the aircraft together, not the flight numbers.

When the matching evidence is examined thoroughly enough to deduce all four as having the same initial event then the conclusion can be made that the general cause is the one for the confirmed, indisputable event of United Airlines Flight 811 in which the forward cargo door ruptured open in flight causing the explosive decompression explosion which other investigators have mistakenly assumed to be a bomb or center fuel tank explosion.

All of the many potential causes of why those inadvertently ruptured forward cargo doors opened in flight may then be considered such as a bomb explosion, center tank explosion, or explosive decompression explosion. The most probable general cause is the same as the one irrefutably confirmed for the 'tremendous explosion' in United Airlines Flight 811, the cause of which was attributed to a faulty switch or wiring in the door control system which permitted electrical actuation of the door latches toward the unlatched position after initial door closure and before takeoff. The probable cause has been further refined, by this investigator, to the initial rupture location in the forward cargo door at one or both of the midspan latches and the electrical fault to that of faulty wiring failing in flight.

When evaluating at one time the probable causes from the point of view of the five accident reports and other research, there is overwhelming circumstantial and tangible evidence that all four aircraft suffered a breakup in flight from an explosion in the forward cargo compartment at the forward cargo door on the starboard side.

The current official general explanations for the inflight breakups can be summarized:

- A. Air India Flight 182: An explosion in the forward cargo compartment on the starboard side.
- B. Pan Am Flight 103: An explosion in the forward cargo compartment on the port side.
- C. United Airlines Flight 811: An explosion in the forward cargo compartment on the starboard side.
- D. Trans World Airlines Flight 800: An explosion in the center of the aircraft adjacent to the forward cargo compartment.

All of the above official explanations were stated years ago without benefit of hindsight or current research techniques. The explanations all try to explain the inflight breakup as an explosion in or near the forward cargo compartment. The only difference is the location of the explosion by a few feet and the cause of the explosion. The explosive decompression by the sudden rupturing open of the forward cargo door in flight is generally consistent with all current official explanations. All of the inconsistencies in each individual accident are fully explained by the wiring/cargo door/explosive decompression explanation applied to all four accidents.

One aircraft had a partial breakup, United Airlines Flight 811, and was thus able to land with its evidence of the event for a positive incontrovertible explanation of an explosion of explosive decompression at the forward cargo door which explained the tangible evidence of CVR, FDR, inflight damage, engine damage, and injuries to passengers. That substantial and tangible evidence of United Airlines Flight 811 matches the evidence for all four aircraft, Air India Flight

182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800. This pattern of evidence will be described below with summaries, findings, and matching evidence.

The individual evidence of Air India Flight 182 will be matched to United Airlines Flight 811 to show that the explanation for the explosion in the forward cargo compartment as a bomb is extremely unlikely and even impossible based upon the evaluation in Section 2 of this report and the explanation as an explosive decompression caused by a ruptured open forward cargo door at one or both of the midspan latches in flight from faulty wiring is most probable.

4. Formatting Style:

Formatting style for the specific matching accidents in Section 3: There are six Aviation Accident Reports concerning four Boeing 747 accidents referred to in Section 3 which compare the four accidents to each other into a matching pattern. For instance:

Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, Trans World Airlines Flight 800, experienced(Description and evidence Match)

Air India Flight 182 was flying normally.....(Individual flight evidence match)

Pan Am Flight 103 was flying normally..... (Individual flight evidence match)

United Airlines Flight 811 was flying normally (Individual flight evidence match)

Trans World Airlines Flight 800 was flying normally (Individual flight evidence match)

Excerpts of official corroborative statements to support the...(Indented excerpts to support the described pattern indented)

Air India Flight 182:

"From the CVR and DFDR, AI 182 was Canadian Aviation Safety Board Air India 23 June 1985, page 21 (Individual excerpts and source)

Pan Am Flight 103:

"The CVR tape was listened to..... UK AAIB Report 2/90 Page 15 (Individual excerpts and source)

United Airlines Flight 811:

"The CVR revealed normal NTSB Accident Report 92-02 Page 25 (Individual excerpts and source)

Trans World Airlines Flight 800:

"The recording appearedExhibit 12B (Individual excerpts and source)

5. Background:

There is a history of aviation accidents not being fully explained in the first AAR.



Icarus was the first aviation related fatality and his mythic accident was said to have been caused when the wax by which he affixed the wings to his body melted when he flew too close to the sun; the wings came off, and down he went.

The AAR might have been worded thus:

When King Minos of Crete found out that his son, the Minotaur, had been killed and Theseus had escaped with his daughter, he was angry with Daedalus for not building a complex enough labyrinth. In revenge, he imprisoned the inventor in there with his young son Icarus. Determined to escape from this unfair punishment, Daedalus fashioned two pairs of wings, each on a wooden frame, lined with many feathers which were fixed with beeswax.

When the inventor had finished, he and his son climbed up to the highest part of the labyrinth, catching the wind and looking down into the sea which surrounded the walls. They fixed their wings on each other and planned their escape. Daedalus told Icarus that he was to keep his arms wide apart so as to catch even the slightest breath of wind and to keep close behind his father, keeping a straight course between the sun and the sea. "For if you fly too close to the sea, your feathers will dampen and you will drown under the weight of the frame. If you fly too close to the sun however, the beeswax will melt and the feathers will loosen. Remember these words and you will be safe."

The two of them then leapt from the walls, Daedalus going first and Icarus following closely behind. However, Icarus soon became bolder as he flew effortlessly in the skies and left his father's straight course of flight to twirl and loop in the air. As his loops became bolder, he flew higher and forgot his father's warning. All too late, he noticed the feathers falling off the frame for he had flown too close to the sun. He called out to his father as he fell from the sky and into the sea where he drowned.

Daedalus had heard his cries but it was too late for Icarus had already fallen. He recovered the body which had swept up onto a nearby island and buried it there, naming it 'Icaria'. He then flew on and found refuge in Etna's land.

This explanation was not meant to be examined closely, of course, as the explanation makes no sense. For instance, how does one affix large wings to a human body with beeswax; how does one fly high enough to get too close to the sun, how did Icarus find enough energy to get off the ground in the first place, and lastly, who was to blame? Was it the designer Daedalus who used the defective wax? Was it the King who gave them reason to fly away? Was it pilot error of flying his craft outside accepted operating limits? What could be done to prevent such a reoccurrence? Better flight training, better adhesives? Aviation accident investigations are very complex affairs with many parties interested in the outcome. (Note that laypersons who have heard about Icarus are usually unaware of the wise admonition to not fly too low and are only aware of the warning hazard of flying too high. Only the fatal accident causes are remembered.)

The probable cause for Icarus' accident made sense at the time of telling, but now, years later, we understand it did make a good story and fulfilled the wishful thinking of those listening to it but was clearly impossible based on the tangible, circumstantial, and direct evidence.

With the introduction of the jet age in commercial airliners in the late 1950's, such as the Comet from the United Kingdom, large hulls were pressurized and subjected to many cycles of pressurizing and depressurizing. Cracks appeared in the fuselage which led to structural failure and powerful explosive decompressions which appeared as an explosion which led to the inflight breakup of the early airliner.

There is a history of inadvertent explosive decompressions in commercial airliners being initially suspected as bomb explosions. Those events are usually controversial. (Appendix B, Avianca Accident) It is an understandable error of deduction because an explosion of explosive decompression closely mimics a bomb in producing explosive effects such as ejecting material at high velocity, making a loud noise, being unexpected, and not supposed to happen inside an airliner as well as cratering, pitting curling, folding, and tearing metal. An explosive decompression is referred to in accident investigations as an 'explosion' and described by a crewmember who suffered through one as a 'tremendous explosion.'

All explosions give some similar evidence; it is the corroborating evidence for a specific type of explosion that is required before a determination may be made as to type of explosion, such as bomb, fuel tank, or explosive decompression. Explosive decompression is the most difficult to determine because it leaves no residue or soot and therefore, its determination lies largely in the absence of corroborating evidence for an alternative explanation of residue, timer, fuze, ignition source, burns, or soot. An explosive decompression does need a highly pressurized vessel and a rupture location identified whereas the others do not. Bombs and fuel tanks can explode on the ground; fatal explosive decompressions from any source have all occurred inflight.



The solution to the early mystery of the Comet crashes was achieved by matching two similar events in the similar aircraft which left similar evidence.

Excerpts of corroborative statements to support the Comet explosive decompression explanation: (Appendix C, Comet Accidents)
<http://www.tech.plym.ac.uk/sme/FailureCases/FAILURE.htm>

Professor M Neil James Webpage:
<http://www.plym.tech.ac.uk/sme/uoa30/structur.htm>

Comet Airliner: Jet transportation age began in on May 5 1952 when the De Havilland Comet 1 began scheduled flights from London to Johannesburg. In April 1953, a Tokyo to London service was inaugurated – flying time for the 10 200 mile distance dropped from 85 hours to 36 hours. The Comet had a cruising speed of 490 mph at 35 000 feet and a range of 1 750 miles with a payload of 44 passengers.

The cabin was pressurized to maintain a pressure equivalent to 8 000 feet at an aircraft altitude of 40 000 feet, which was required for efficient operation of the engines. This gave a pressure differential of 8.25 psi (56 kPa) across the fuselage – twice the value previously used. De Havilland conducted ‘many tests’ to ensure structural integrity of the cabin. However, a series of 3 accidents occurred where Comet aircraft disintegrated in flight:

(a) Investigation by R.A.E. (Excerpts) The loss of Yoke Peter and Yoke Yoke presented a problem of unprecedented difficulty, the solution of which was clearly of the greatest importance to the future, not only of the Comet, but also of Civil Air Transport in this country and, indeed, throughout the world. They thought it necessary to satisfy themselves about the structural integrity of the aircraft, in particular of the cabin and the tail and to consider in more detail possible sources of explosion and loss of control. But at the time when their attention became directed to fatigue of the pressure cabin they were influenced chiefly by the apparent similarity of the circumstances of the two accidents, and by the fact that the modifications carried out after Elba seemed to rule out many of the other possible causes.

(2) There were serious lessons resulting from explosive decompression and deceleration.

G-ALYV after leaving Calcutta – May 1953. Violent storms were thought to be involved and some wreckage was recovered. No firm conclusions drawn as to cause.

G-ALYP over Elba – January 1954 after 1 286 cabin pressurisation cycles. Little wreckage was recovered and no major problems found in fleet inspection. Fire was assumed the most likely cause and modifications made to improve fire prevention and control. Aircraft returned to service.

G-ALYY flying as SA 201 after leaving Rome – April 1954. and all Comet 1 aircraft were subsequently withdrawn from service.

A more intensive effort was made to recover the wreckage of G-ALYP using underwater television cameras for the first time. About 70% of the aircraft was recovered and reconstructed at Farnborough. The Royal Navy was charged with getting the relevant fuselage piece of G-ALYP from the sea (using simulation trials, based on the way the aircraft was now thought to break up in flight, to establish the likely position of this part of the aircraft on the seabed. This was recovered within a few hours of searching and showed, in the language of the coroner, the 'unmistakable fingerprint of fatigue'. The fatigue crack was associated with the stress concentrations of the rather square rear ADF window cutout (stress of 315 MPa at edge of window), and with a bolt hole around the window (although the stress at the bolt position was only 70 MPa).

In the 1960s a new type of airliner came into production called a 'widebody', the DC-10 (Appendix D, DC-10 Accidents) and the Boeing 747 (Appendix E, Boeing 747 History). These aircraft had a much larger cabin to accommodate several hundred passengers. This larger size of the hull required greater pressurization loads on the internal fuselage which were underestimated by designers. Subsequently two flights of the DC-10 suffered explosive decompressions in flight from inadvertent cargo door openings which left evidence of a sudden loud sound on the cockpit voice recorder which was used to match to later explosive decompression events in another wide body airliner, the Boeing 747. The design of the outward opening nonplug cargo door was criticized as inadequate for both types of aircraft in subsequent accident reports.



June 12, 1972

McDonnell Douglas DC-10-10 N103AA, American Airlines

Over Windsor, Ontario

Mechanical Failure due to Design Flaw/Human Error

Occupants: 67

Fatalities: 0

Following takeoff from Detroit, the rear cargo door blew off due to a door latch system that had been damaged by ground crew members. The loss of pressurization caused the cabin floor to buckle and damaged the hydraulic control lines of the aircraft. The captain, having trained himself in simulator sessions to fly the aircraft using its throttles (a method called “differential thrust steering”), made an emergency landing in Detroit.

March 3, 1974

McDonnell Douglas DC-10-10 TC-JAV Turk Hava Yollari - THY

Outside Paris, France

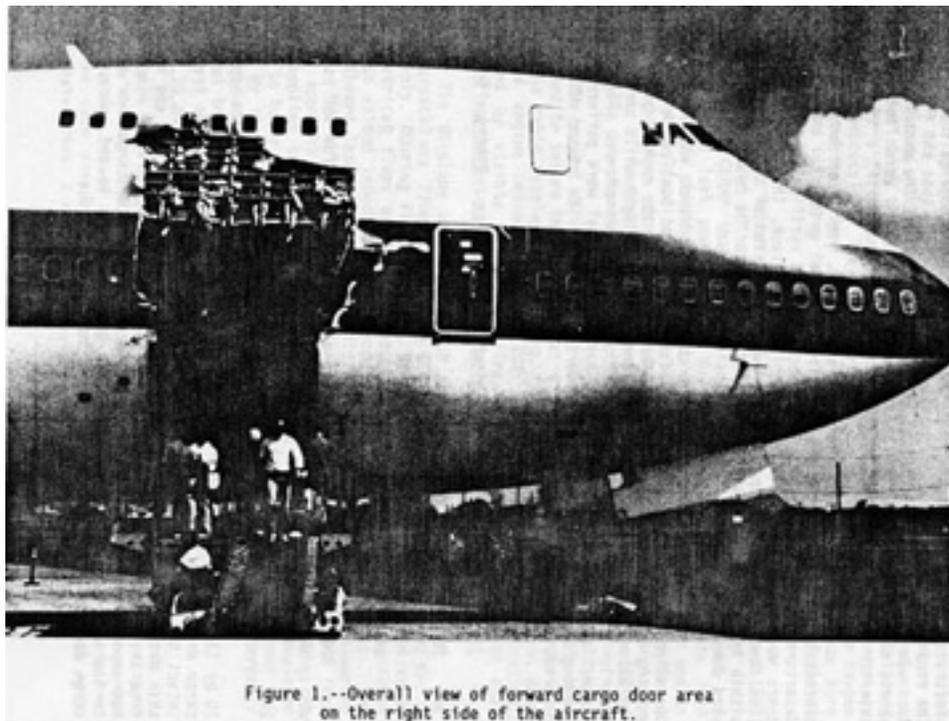
Mechanical Failure due to Design Flaw/Human Error

Occupants: 346

Fatalities: 346

The latch mechanism of the aft cargo door, the design of which was susceptible to damage, had been damaged before the accident. Before takeoff the door had not been secured properly. Shortly after takeoff from Paris, the door failed. The resulting depressurization led to the disruption of the floor structure, causing six passengers and parts of the aircraft to be ejected, rendering No.2 engine inoperative, and impairing the flight controls so that it was impossible for the crew to regain control of the aircraft.

On February 24, 1989, United Airlines Flight 811, a Boeing 747-122, experienced an explosive decompression as it was climbing between 22,000 and 23,000 feet after taking off from Honolulu, Hawaii, en route to Sydney, Australia with 3 flightcrew, 15 flight attendants, and 337 passengers aboard.



After an investigation, the NTSB issued AAR 90/01 which concluded:

'The National Transportation Safety Board determines that the probable cause of this accident was the sudden opening of the improperly latched forward lower lobe cargo door in flight and the subsequent explosive decompression.' NTSB also stated: 'The next opportunity for the FAA and Boeing to have reexamined the original assumptions and conclusions about the B-747 cargo door design and certification was after the findings of the Turkish Airline DC-10 accident in 1974 near Paris, France. The concerns for the DC-10 cargo door latch/lock mechanisms and the human and mechanical failures, singularly and in combination, that led to that accident, should have prompted a review of the B-747 cargo door's continuing airworthiness. In the Turkish Airlines case, a single failure by a ramp service agent, who closed the door, in combination with a poorly designed latch/lock system, led to a catastrophic accident. The revisions to the DC-10 cargo door mechanisms mandated after that accident apparently were not examined and carried over to the design of the B-747 cargo doors. Specifically, the mechanical retrofit of more positive locking mechanisms on the DC-10 cargo door to preclude an erroneous locked indication to the flightcrew, and the incorporation of redundant sensors to show the position of the latches/locks, were not required to be retrofitted at that time for the B-747.'

After extensive efforts from the family of one of the victims, the forward cargo door pieces of United Airlines Flight 811 were retrieved from the bottom of the ocean and it was discovered that, in fact, the cargo door had been properly latched, thus exonerating the accused ground baggage handler of the deaths of nine innocent passengers. The NTSB issued another aircraft accident report, AAR 92/02, with the corrected probable cause, the only known time that two aircraft accident reports have been written about the same accident.

NTSB AAR 92/02 states: "Thus, as a result of the recovery and examination of the cargo door, the Safety Board's original analysis and probable cause have been modified. This report incorporates these changes and supersedes NTSB/AAR-90/01. The National Transportation Safety Board determines that the probable cause of this accident was the sudden opening of the forward lower lobe cargo door in flight and the subsequent explosive decompression. The door opening was attributed to a faulty switch or wiring in the door control system which permitted electrical actuation of the door latches toward the unlatched position after initial door closure and before takeoff."

Over a period of eleven years, from 1985 to 1996, there have been four early model Boeing 747 aircraft which have suffered fatal explosive decompressions in flight which were all initially attributed to 'bombs', one of which was United Airlines Flight 811 as reported by the surviving crew. Two of the accidents have since had a bomb explosion ruled out as the probable cause while one cause is in dispute as a bomb or not and one cause is stated to be 'an improvised explosive device' which may or may not be a bomb. All four flights were and are controversial. It is these four flights that in similar circumstances with similar aircraft that left similar evidence that has led this investigator to conclude that one similar probable cause is the same for all, including Air India Flight 182, and that similar cause is the only confirmed and irrefutable probable cause: the sudden opening of the forward lower lobe cargo door in flight and the subsequent explosive decompression refined to the locations as the midspan latches and the cause as faulty wiring.

The implication of this conclusion is that there were never any bombs, or missiles, or center fuel tanks initially exploding inflight on the four flights but an event in each occurred which

mimics those other explosions, that is, an explosive decompression after an inadvertently ruptured open forward cargo door inflight.

6. Purpose:

This report shall evaluate the four fatal inflight breakups of Boeing 747s using the cumulative evidence of sixteen years to sustain the matching pattern for all four of an explosion in the forward cargo compartment by a sudden ruptured opening of the forward cargo door in flight at one or both of the midspan latches probably caused by faulty wiring.

Specific data about the four early model Boeing 747s:

Air India Flight 182: Sequence in construction:#330, Construction Number 21473
Date completed: 19 June 78, Type Aircraft: B747-237B Type of wiring: Poly-X
(Raychem Corp), accident date: June 23 1985

Pan Am Flight 103: Sequence in construction: #15, Construction Number 19646,
Date completed: 25 Jan 70, Type Aircraft: B747-121 Type of wiring: Poly-X
(Raychem Corp), accident date: 21 December 88

United Airlines Flight 811: Sequence in construction:#89, Construction Number
19875, Date completed: 20 Oct 70, Type Aircraft: B747-122 Type of wiring: Poly-
X (Raychem Corp), accident date: 23 February 89

Trans World Airlines Flight 800: Sequence in construction:#153, Construction
Number 20083, Date completed: 18 August 71, Type Aircraft: B747-131 Type of
wiring: Poly-X (Raychem Corp), accident date: 17 July 96

Excerpts of official corroborative statements for background: Air India
Flight 182

From: Report Of The Court Investigating Accident To Air India Boeing 747
Aircraft VT-EFO, "Kanishka" On 23rd June 1985

From Canadian Aviation Bureau Safety Board

Aviation Occurrence Air India Boeing 747-237b VT-EFO Cork, Ireland 110
Miles West 23 June 1985

Boeing 747-237B 'Kanishka' aircraft VT-EFO was manufactured by Messrs
Boeing Company under Sl.No. 21473. The aircraft was acquired by Air India on
19th June, 1978. Initially, it came with the expert Certificate of Airworthiness No.
E-161805. Subsequently, the Certificate of Airworthiness No. 1708 was issued by
the Director General of Civil Aviation, India on 5th July, 1978. The C of A was
renewed periodically and was valid up to 29th June, 1985. From the beginning of
June, 1985, C of A renewal work of the aircraft was in progress. The aircraft had
the Certificate of Registration No. 2179 issued by the DGCA on 5th May, 1978.
The commercial flight of 'Kanishka' aircraft started on 7th July, 1978.

2.4.1.2 The aircraft was maintained by Air India following the approved
maintenance schedules. It had logged 23634:49 hours and had completed 7525
cycles till the time of accident.

A. On the morning of 23rd June, 1985 Air India's Boeing 747 aircraft VT-EFO
(Kanishka) was on a scheduled passenger flight (AI-182) from Montreal and was
proceeding to London enroute to Delhi and Bombay. It was being monitored at
Shannon on the Radar Scope. At about 0714 GMT it suddenly disappeared from
the Radar Scope and the aircraft, which has been flying at an altitude of

approximately 31,000 feet, plunged into the Atlantic Ocean off the south-west coast of Ireland at position latitude 51 degrees 3.6 minutes N and Longitude 12 degrees 49 minutes W. This was one of the worst air disasters wherein all the 307 passengers plus 22 crew members perished.

The Canadian Aviation Safety Board respectfully submits as follows:

4.1 Cause-Related Findings

1. At 0714 GMT, 23 June 1985, and without warning, Air India Flight 182 was subjected to a sudden event at an altitude of 31,000 feet resulting in its crash into the sea and the death of all on board.
 2. The forward and aft cargo compartments ruptured before water impact.
 3. The section aft of the wings of the aircraft separated from the forward portion before water impact.
 4. There is no evidence to indicate that structural failure of the aircraft was the lead event in this occurrence.
 5. There is considerable circumstantial and other evidence to indicate that the initial event was an explosion occurring in the forward cargo compartment. This evidence is not conclusive. However, the evidence does not support any other conclusion.'
- The Indian Kirpal Report: "3.4.6.60 The only conclusion which can, however, be arrived at is that the aircraft had broken in midair and that there has been a rapid decompression in the aircraft.' and 4.10 'After going through the entire record we find that there is circumstantial as well as direct evidence which directly points to the cause of the accident as being that of an explosion of a bomb in the forward cargo hold of the aircraft.'

Excerpts of official corroborative statements for background: Pan Am Flight 103

From: Air Accidents Investigation Branch Aircraft Accident Report No 2/90

1.6.1 Leading particulars Aircraft type: Boeing 747-121 Constructor's serial number: 19646

N739PA first flew in 1970 and spent its whole service life in the hands of Pan American World Airways Incorporated. Its Certificate of Airworthiness was issued on 12 February 1970 and remained in force until the time of the accident, at which time the aircraft had completed a total of 72,464 hours flying and 16,497 flight cycles.

The accident was notified to the Air Accidents Investigation Branch at 19.40 hrs on the 21 December 1988 and the investigation commenced that day. 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 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.

Excerpts of official corroborative statements for background: United Airlines Flight 811:

From: National Transportation Safety Board

Washington, D.C. 20594

Aircraft Accident Report Explosive Decompression-- Loss Of Cargo Door In Flight
United Airlines Flight 811 Boeing 747-122, N4713U
Honolulu, Hawaii February 24, 1989

The accident airplane, serial No. 19875, registered in the United States as N4713U, was manufactured as a Boeing 747-122 transport category airplane by the Boeing Commercial Airplane Company (Boeing), Seattle, Washington, a Division of the Boeing Company. N4713U, the 89th B-747 built by Boeing, was manufactured in accordance with Federal Aviation Administration (FAA) type certificate No. A20WE, as approved on December 30, 1969. The airplane was certificated in accordance with the provisions of 14 CFR Part 25, effective February 1, 1965.

On February 24, 1989, United Airlines flight 811, a Boeing 747-122, experienced an explosive decompression as it was climbing between 22,000 and 23,000 feet after taking off from Honolulu, Hawaii, en route to Sydney, Australia with 3 flightcrew, 15 flight attendants, and 337 passengers aboard. The airplane made a successful emergency landing at Honolulu and the occupants evacuated the airplane. Examination of the airplane revealed that the forward lower lobe cargo door had separated in flight and had caused extensive damage to the fuselage and cabin structure adjacent to the door. Nine of the passengers had been ejected from the airplane and lost at sea.

The National Transportation Safety Board determines that the probable cause of this accident was the sudden opening of the forward lower lobe cargo door in flight and the subsequent explosive decompression. The door opening was attributed to a faulty switch or wiring in the door control system which permitted electrical actuation of the door latches toward the unlatched position after initial door closure and before takeoff.

Excerpts of official corroborative statements for background: Trans World Airlines Flight 800:

From: National Transportation Safety Board

Washington, D.C. 20594

Aircraft Accident Report

In-flight Breakup Over the Atlantic Ocean

Trans World Airlines Flight 800

Boeing 747-131, N93119

Near East Moriches, New York

July 17, 1996

The accident airplane, N93119, a 747-100 series airplane (model 747-131), serial number (S/N) 20083, was manufactured by Boeing in July 1971 and purchased new by TWA. The airplane was added to TWA's operating certificate on October 27, 1971, and, except for a 1-year period, was operated by TWA in commercial transport service until the accident occurred. According to TWA records, the accident airplane had 93,303 total hours of operation (16,869 flight cycles) at the time of the accident. The 747-100 is a low-wing, transport-category airplane that is about 225 feet long and 63 feet high (from the ground to the top of the vertical stabilizer), with a wingspan of about 195 feet.

On July 17, 1996, about 2031 eastern daylight time, Trans World Airlines, Inc.

(TWA) flight 800, a Boeing 747-131, N93119, crashed in the Atlantic Ocean near East Moriches, New York. TWA flight 800 was operating under the provisions of Code of Federal Regulations Part 121 as a scheduled international passenger flight from John F. Kennedy International Airport (JFK), New York, New York, to Charles DeGaulle International Airport, Paris, France. The flight departed JFK about 2019, with 2 pilots, 2 flight engineers, 14 flight attendants, and 212 passengers on board. All 230 people on board were killed, and the airplane was destroyed. Visual meteorological conditions prevailed for the flight, which operated on an instrument flight rules flight plan.

The National Transportation Safety Board determines that the probable cause of the TWA flight 800 accident was an explosion of the center wing fuel tank (CWT), resulting from ignition of the flammable fuel/air mixture in the tank. The source of ignition energy for the explosion could not be determined with certainty, but, of the sources evaluated by the investigation, the most likely was a short circuit outside of the CWT that allowed excessive voltage to enter it through electrical wiring associated with the fuel quantity indication system.

Excerpts of corroborative statements for background:

For Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800:

Findings of John Barry Smith, independent aviation accident investigator, in report 'Boeing 747 Rupture at Midspan Latches of Forward Cargo Door in Flight Probably Caused by Wiring/Electrical Fault Accidents TWA 800, UAL 811, PA 103, AI 182' at www.corazon.com, December, 1996. For AI 182: 'Explosion in forward cargo compartment explains observations. Explosive decompression which occurs when cargo door opens produces explosive effects.' 'A structural failure occurred in AI 182 when the forward cargo door inadvertently ruptured open in flight when faulty wiring probably shorted on the door unlatch motor which led to explosive decompression just forward of the wing on the starboard side creating a huge hole in which airframe integrity was compromised so that the aircraft broke up in flight'.

7. 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:

Proponent: John Barry Smith

Analysis: To determine the pattern in early model Boeing 747 accidents that suffered breakups in flight, it was necessary to evaluate carefully all the official accident reports concerning them. A pattern was detected of similar significant evidence among only four of the many hull losses. It was very probable that one initial event by one cause was the reason for all four. The evidence is detailed below. There are many significant individual matches of evidence among each flight to each other. For instance, three flights had strange radar returns at event time but Air India Flight 182 was out of radar range and therefore there is no match for all, therefore the match is not included below. Only the matches for all four flights are listed below. Table 1 in 7.17 of Section 3 gives all the individual matches to each other of the fifty four significant evidence matches that appear among the flights.

7.1. Matching Significant Circumstantial Evidence: The matching significant circumstantial evidence that follows is for all the four aircraft, Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800:

- A. All four aircraft had probable causes initially thought to be bomb explosions.
- B. All four aircraft had the probable cause of bomb explosion modified.
- C. All four aircraft had breakups in their airframes in a similar amidships location.
- D. All four aircraft had at least nine missing never recovered bodies.
- E. All four aircraft had passengers which showed explosive decompression type injuries and no injuries consistent with a detonation of a powerful bomb.
- F. All four aircraft experienced a sudden, loud, audible sound on the cockpit voice recorder at event start time.
- G. All four aircraft had the source of the sudden, loud, audible sound as a bomb explosion disputed and the source as an explosive decompression supported.
- H. All four aircraft had an abrupt power cut to the recorders immediately after the sudden, loud, audible sound.
- I. All four aircraft had an explosion in or adjacent to the forward cargo compartment.
- J. All four aircraft had similar shattered fuselage skin in and around the forward cargo door.
- K. All four aircraft 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.
- L. All four aircraft had similar damage to their airframe structures from inflight ejected debris.
- M. All four aircraft had foreign object damage to engine number three.
- N. All four aircraft had incomplete reports of the status of the forward cargo door, in particular, the status of the two midspan latches was omitted.
- O. All four aircraft had similar debris patterns on the surface of the ground or sea bottom. (United Airlines Flight 811 had much lesser debris that still fell in the same pattern as the rest which was first items to leave the aircraft landed the closest to the initial event location.)

7.2. 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:

Air India Flight 182. Initial action was to speculate on explosive sabotage for the cause and immediately requisition the services of a specialist in the detection of explosives sabotage in aircraft

wreckage.

Pan Am Flight 103: Within a few days items of wreckage were retrieved upon which forensic scientists found conclusive evidence of a detonating high explosive.

United Airlines Flight 811: The flight crew heard the explosion, checked the damage and reported to the tower a bomb had gone off in their aircraft.

Trans World Airlines Flight 800: Initial information led to consideration of the detonation of a high energy explosive device.

Excerpts of official corroborative statements to support the match that all four flights were thought initially to be 'bombs'.

Air India Flight 182

From the Indian Kirpal Report: Initial Action Taken by the Government of India
1.2.8 It was also being speculated that the accident may have occurred due to an explosion on board the aircraft. In order to see whether there was any evidence of an explosion which could be gathered from the floating wreckage which was being salvaged, the Government of India requisitioned the services of Mr. Eric Newton, a Specialist in the detection of explosives sabotage in aircraft wreckage.

Pan Am Flight 103

From Air Accidents Investigation Branch Aircraft Accident Report No 2/90
Synopsis: Within a few days items of wreckage were retrieved upon which forensic scientists found conclusive evidence of a detonating high explosive.

United Airlines Flight 811

From NTSB AAR 92/02 1.15 Survival Aspects: At 0210, the FAA notified the U.S. Coast Guard that a United Airlines, Inc., B-747, with a possible bomb on board, had experienced an explosion and was returning to HNL.

Trans World Airlines Flight 800

From NTSB AAR 00/03 2.2.1 The In-Flight Breakup: On the basis of this initial information, investigators considered several possible causes for TWA flight 800s in-flight structural breakup: a structural failure and decompression; detonation of a high-energy explosive device, such as a bomb exploding inside the airplane or a missile warhead exploding upon impact with the airplane; and a fuel/air explosion in the center wing fuel tank (CWT). 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.

7.3 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.

Two flights, United Airlines Flight 811 and Trans World Airlines Flight 800, had the accident cause changed from 'bomb explosion' to other; one flight, Air India Flight 182, remained a bomb for the Indians and maybe a bomb by the Canadians, and one flight, Pan Am 103, became

an 'improvised explosive device' which may or may not be a bomb.

Air India Flight 182 is now stated to be an explosion from an unstated source by the Canadian aviation accident investigators and an explosion by bomb by the judicial inquiry of Judge Kirpal.

Pan Am Flight 103 is now stated to be an explosion by an 'an improvised explosive device', which may or may not be a 'bomb'. The British accident investigators could certainly have called the cause a 'bomb' if they had chosen to but declined as the evidence supported a conclusion of an improvised explosive device but did not support the conclusion of a 'bomb.' A cargo door has become an improvised explosive device in the United Airlines Flight 811 and the Paris Turkish Airlines DC-10 events in which tremendous explosions occurred by the inadvertently improvised complex door device. Firecrackers and fireworks illegally carried aboard in a cabin or cargo compartment can become inadvertent improvised explosive devices.

United Airlines Flight 811 is now stated to be an explosion by explosive decompression caused by an inadvertently opened forward cargo door in flight from defective electrical wiring or switch. After landing safely the crew and ground personnel discovered that the forward cargo door had opened in flight and there was no evidence of a bomb on board as they previously reported.

Trans World Airlines Flight 800 is now stated to be an explosion of the center fuel tank by an unknown ignition source but probably faulty wiring. NTSB concluded that the in-flight breakup of TWA flight 800 was not initiated by a bomb or a missile strike because of the lack of any corroboration evidence associated with a high energy explosion. A bomb explosion or missile strike was the official working explanation for seventeen months. Evidence of a detonating high explosive was discovered but determined to be benign such as a 'dog sniffing' test.

Excerpts of official corroborative statements that two of the aircraft changed their initial cause from 'bomb', one aircraft had explosion as a bomb or an explosion of unstated cause, and one aircraft had an explosion by an improvised explosive device.

Air India Flight 182

From the Canadian Aviation Occurrence Report: Canadian Aviation Safety Board respectfully submits as follows:

4.1 Cause-Related Findings 5. There is considerable circumstantial and other evidence to indicate that the initial event was an explosion occurring in the forward cargo compartment. This evidence is not conclusive. However, the evidence does not support any other conclusion.'

From the Kirpal Report: 4.10 After going through the entire record we find that there is circumstantial as well as direct evidence which directly points to the cause of the accident as being that of an explosion of a bomb in the forward cargo hold of the aircraft. At the same time there is complete lack of evidence to indicate that there was any structural failure.

Pan Am Flight 103

From AAIB Aircraft Accident Report No 2/90: Synopsis. The 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

United Airlines Flight 811:

From NTSB AAR 92/02: Executive Summary: The airplane made a successful emergency landing at Honolulu and the occupants evacuated the airplane. Examination of the airplane revealed that the forward lower lobe cargo door had separated in flight and had caused extensive damage to the fuselage and cabin structure adjacent to the door.

Trans World Air Airlines Flight 800

From NTSB AAR 00/03: 2.2.1.2 Consideration of a High-Energy Explosive Device Detonation (Bomb or Missile Warhead) 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. The National Transportation Safety Board determines that the probable cause of the TWA flight 800 accident was an explosion of the center wing fuel tank (CWT), resulting from ignition of the flammable fuel/air mixture in the tank. The source of ignition energy for the explosion could not be determined with certainty,

7.4 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.

For three of the aircraft the sudden huge hole appearing on the starboard side just forward of the wing was too large and the forward part of the aircraft pulled away from the aft part for a total breakup. United Airlines Flight 811 had a partial breakup with 'only' a ten foot by fifteen foot hole appearing and was able, with difficulty, to safely land soon after the explosive decompression when the forward cargo door opened in flight.

Air India Flight 182 had an inflight breakup when the aft part separated from the forward part.

Pan Am Flight 103 had an inflight breakup when the forward part pulled away from the rear part.

United Airlines Flight 811 had an inflight partial breakup of the forward part when a huge hole appeared in the nose of the aircraft.

Trans World Airlines Flight 800 had an inflight breakup when the nose portion pulled away from the rest of the aircraft.

Excerpts of official corroborative statements to support the match that all four flights had breakups in their airframes at a similar amidships location:

Air India Flight 182:

From the Canadian Aviation Occurrence Report: 3.3 Aircraft Break-up Sequence Hence, it is likely that the aft portion of the aircraft separated from the forward portion before striking the water. Canadian Aviation Safety Board Air India 23 June 1985, page 48

Pan Am Flight 103:

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

United Airlines Flight 811:

From NTSB AAR 92/02: 1.3 Damage to the Airplane The primary damage to the airplane consisted of a hole on the right side in the area of the forward lower lobe cargo door, approximately 10 by 15 feet large. An area of fuselage skin measuring about 13 feet lengthwise by 15 feet vertically, and extending from the upper sill of the forward cargo door, to the upper deck window belt, had separated from the airplane at a location above the cargo door extending to the upper deck windows. The floor beams adjacent to and inboard of the cargo door area had been fractured and buckled downward. NTSB/AAR 92/02 Page 4

Trans World Airlines Flight 800:

From NTSB AAR 00/03: 2.2.1.3 Consideration of a Fuel/Air Explosion in the Center Wing Fuel Tank It was clear from the wreckage recovery locations that the first pieces to depart the airplane were from the area in and around the airplane's wing center section (WCS), which includes the CWT, and, therefore, that the breakup must have initiated in this area.

7.5 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.

Extensive and long searches were made at the four accident sites soon after the events. The never recovered passengers were mostly those seated in the cabin near and above the forward cargo door. One published report gives the macabre explanation for the missing bodies for United Airline Flight 811 as they were ingested into the adjacent number three engine.

Air India Flight 182 had 131 bodies recovered of the 329 which left 198 bodies never recovered with passengers assigned seats near and above the forward cargo compartment included in the missing.

Pan Am Flight 103 had ten passengers never recovered although evidence was presented of recovering very small items such as fragments of pieces of metal which indicates the extensive and thorough search that was conducted on land.

United Airlines Flight 811 had nine never recovered passengers, all expelled from the huge hole created when the forward cargo door opened in flight which took fuselage skin with it leaving the passengers above exposed. US Navy ships were on the scene very quickly but recovered no bodies.

Trans World Airlines Flight 800 has at least nineteen bodies never recovered although DNA testing of the fragments of bones identified all the passengers.

Excerpts of official corroborative statements to support the match that all four flights had at least nine missing, never recovered bodies.

Air India Flight 182

From the Canadian Aviation Occurrence Report: 3.1.6 In his testimony in Court, Wing Commander Dr. I.R. Hill further stated that the significance of flail injuries being suffered by some of the passengers was that it indicated that the aircraft had broken in mid-air at an altitude and that the victims had come out of the aeroplane at an altitude. He further explained that if an explosion had occurred in the cargo hold, it was possible that the bodies may not show any sign of explosion. It may here be mentioned that the forensic examination of the bodies do not disclose any evidence of an explosion. Furthermore, the seating pattern also shows that none of the bodies from Zone A or B was recovered, in fact as per the seating plan Zone B was supposed to have been unoccupied. This Zone is directly above the forward cargo compartment. Medical examination was conducted on the 131 bodies recovered after the accident. This comprises about 40 percent of the 329 persons on board. Canadian Aviation Safety Board Air India 23 June 1985, page 19

Pan Am Flight 103:

From AAIB Aircraft Accident Report No 2/90 1.13 Medical and pathological information 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. UK AAIB Report 2/90 Page 31

United Airlines Flight 811

From NTSB AAR 92/02: Executive Summary: Nine of the passengers had been ejected from the airplane and lost at sea. 1.2 Injuries to Persons Injuries Flightcrew Cabincrew Passengers Others Serious Lost in flight. An extensive air and sea search for the passengers was unsuccessful. 1.15 Survival Aspects The fatal injuries were the result of the explosive nature of the decompression, which swept nine of the passengers from the airplane. The explosive decompression of the cabin when the cargo door separated caused the nine fatalities. The floor structure and seats where the nine fatally injured passengers had been seated were subjected to the destructive forces of the decompression and the passengers were lost through the hole in the fuselage. Their remains were not recovered. Passengers-Nine Passengers who were seated in seats 8H, 9FGH, 10GH, 11GH and 12H, were ejected from the fuselage and were not found; and thus, are assumed to have been fatally injured in the accident.

Trans World Airlines Flight 800:

From NTSB AAR 00/03: 1.13 Medical and Pathological Information: Most identifications of occupants were accomplished through the use of fingerprints or dental records. However, in 29 cases, neither of these methods was successful; these cases required the use of deoxyribonucleic acid (DNA) protocols or forensic radiography as the primary means of identification. (Nineteen occupants were identified solely by DNA, and 10 were identified by forensic radiography, either by the medical examiner or the Armed Forces Institute of Pathology.)

7.6 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.

Air India Flight 182 has at least twenty five passengers who showed signs of decompression

injuries and no evidence of bomb explosion injuries.

Pan Am Flight 103 had a majority of passengers who had been injured by the inflight disintegration of the aircraft and showed no evidence of bomb explosion injuries.

United Airlines Flight 811 had surviving passengers who suffered decompression type injuries such as baro trauma to the ear and no evidence of bomb explosion injuries.

Trans World Airlines Flight 800 had passengers who suffered from the effects of an inflight breakup of the aircraft and no evidence of bomb explosion injuries.

Excerpts of official corroborative statements to support the match that all four flights had passengers who suffered from decompression type injuries and no evidence of bomb explosion injuries.

Air India Flight 182

From the Canadian Aviation Occurrence Report: 2.9 Medical Evidence Flail pattern injuries were exhibited by eight bodies. Five of these were in Zone E, one in Zone D, two in Zone C and one crew member. The significance of flail injuries is that it indicates that the victims came out of the aircraft at altitude before it hit the water. There were 26 bodies that showed signs of hypoxia (lack of oxygen), including 12 children, 9 in Zones C, 6 in Zone D and 11 in Zone E. There were 25 bodies showing signs of decompression, including 7 children. Pathological examination failed to reveal any injuries indicative of a fire or explosion.

Pan Am Flight 103

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.

United Airlines Flight 811

From NTSB AAR 92/02: Injury Information Passengers.--Nine Passengers who were seated in seats 8H, 9FGH, 10GH, 11GH, and 12H, were ejected from the fuselage and were not found; and thus, are assumed to have been fatally injured in the accident. Passengers seated in the indicated seats sustained the following injuries: Seat 7C Barotrauma to both ears 9E Superficial abrasions and contusions to the left hand, mild barotrauma to both ears 13D Barotrauma to both ears 13E Bleeding in both ears 14A Laceration in the parietal occipital area, barotrauma to both ears 16J Barotrauma to both ears 26A Barotrauma to both ears 26B

Barotrauma to both ears 26H Barotitis to both ears, low back pain, irritation to the right eye due to foreign bodies 27A Barotrauma to the right ear 28J Superficial abrasions and a contusion to the left hand, mild barotrauma to both ears

Trans World Airlines Flight 800

From NTSB AAR 00/03: 1.13 Medical and Pathological Information A Medical Forensic Investigation Analysis Report, dated January 28, 1999, and prepared for the Department of Justice/FBI by a medical/forensic expert, 166 concluded the following: Exhaustive analysis of all available medical data on the victims of TWA Flight 800 by an experienced team of forensic pathologists, biomechanicists and criminal investigators failed to find any evidence that any victim was directly exposed to a bomb blast or missile warhead detonation. This finding makes it highly unlikely that a localized explosion occurred within the passenger cabin of TWA Flight 800. All injuries found in the victims were consistent with severe in-flight break up and subsequent water impact.

7.7 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:

It is very unusual to have a sudden, loud, audible sound appear to the flightcrew in flight. It never happens under usual circumstances and only four times in accidents. The rarity and difficulty in creating such an event leads to the assumption that one identical initial event caused the sound which appeared on all four cockpit voice recorders, such as a bomb explosion, a center tank explosion, or an explosive decompression from a sudden hull rupture.

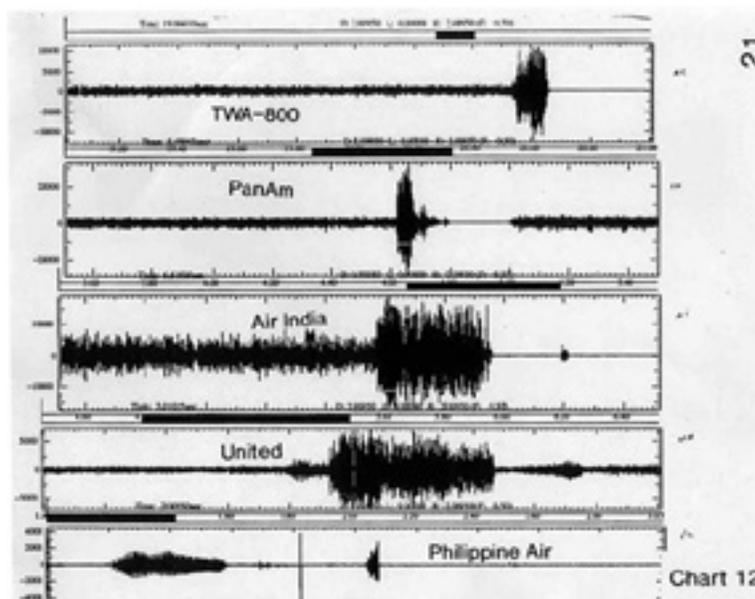
Air India Flight 182 was flying normally when a sudden, loud, audible sound occurred.

Pan Am Flight 103 was flying normally when a sudden, loud, audible sound occurred.

United Airlines Flight 811 was flying normally when a sudden, loud, audible sound occurred and described by a survivor as a 'tremendous explosion'.

Trans World Airlines Flight 800 was flying normally when a sudden, loud, audible sound occurred.

Excerpts of official corroborative statements to support the match that all four flights experienced a sudden, loud audible sound on the cockpit voice recorder at event start time.



Above Chart 12 from TWA 800 Public Docket for TWA 800 and shows CVR data for TWA 800, Pan Am Flight 103, Air India Flight 182, United Airlines Flight 811, and a Philippines Airlines 737.

Air India Flight 182:

From the Canadian Aviation Occurrence Report: 2.10.1 Analysis by National Research Council, Canada From the CVR and DFDR, AI 182 was proceeding normally en route from Montreal to London at an altitude of 31,000 feet and an indicated airspeed of 296 knots when the cockpit area microphone detected a sudden loud sound. The sound continued for about 0.6 seconds, and then almost immediately, the line from the cockpit area microphone to the cockpit voice recorder at the rear of the pressure cabin was most probably broken. This was followed by a loss of electrical power to the recorder. Canadian Aviation Safety Board Air India 23 June 1985, page 21

Pan Am Flight 103:

From AAIB Aircraft Accident Report No 2/90 1.11.2 Cockpit voice recorder The CVR tape was listened to for its full duration and there was no indication of anything abnormal with the aircraft, or unusual crew behaviour. The tape record ended, at 19:02:50 hrs +/- second, with a sudden loud sound on the CAM channel followed almost immediately by the cessation of recording whilst the crew were copying their transatlantic clearance from Shanwick ATC." UK AAIB Report 2/90 Page 15 It is not clear if the sound at the end of the recording is the result of the explosion or is from the break-up of the aircraft structure. The short period between the beginning of the event and the loss of electrical power suggests that the latter is more likely to be the case. UK AAIB Report 2/90 Page 38

United Airlines Flight 811:

From NTSB AAR 92/02: 1.11 Flight Recorders The CVR revealed normal communication before the decompression. At 0209:09:2 HST, a loud bang could be heard on the CVR. The loud bang was about 1.5 seconds after a "thump" was heard on the CVR for which one of the flightcrew made a comment. They heard a

sound, described as a "thump," which shook the airplane. They said that this sound was followed immediately by a "tremendous explosion." The airplane had experienced an explosive decompression. The electrical power to the CVR was lost for approximately 21.4 seconds following the loud bang. The CVR returned to normal operation at 0209:29 HST, and cockpit conversation continued to be recorded in a normal manner. NTSB Accident Report 92-02 Page 25.

Trans World Airlines Flight 800:

From NTSB AAR 00/03: 1. Factual Information 1.1 History of Flight The CVR then recorded a very loud sound for a fraction of a second (0.117 second) on all channels immediately before the recording ended. 1.11.1.2 Cockpit Voice Recorder-Related Airplane Tests As previously discussed in section 1.1, the CVR recorded an event (a very loud sound) that was about 40 percent louder than the previous signals during the last few tenths of a second of the CVR recording, which continued until the CVR recording abruptly stopped. The CVRs recovered from these airplanes all recorded very loud sound events just before they stopped recording. The sound signatures from these events were compared with the sound signatures recorded at the end of the TWA flight 800 CVR recording. Generally, the sound signatures could be characterized based on how quickly the loud noise event rose from the background noise (rise time), the duration of the loud noise event, and how quickly the loud noise event decreased (fall time). 121 The TWA flight 800 CVR recorded noise characteristics that were most similar to those recorded by the CVRs on board the United flight 811 and Philippine Airlines airplanes. At 2031:12, the CVR recording ended. A sound spectrum study of the information recorded by the CVR revealed that twice within the last second of the CVR recording (about 0.73 and 0.68 seconds before the recording stopped), the captain's channel recorded harmonic tones at the 400 Hertz 10 (Hz) frequency, but it did not record other electrical system background noise that it had recorded previously throughout the recording. These other electrical system background noises were recorded on the other CVR channels without interruption. 11 The CVR then recorded a every loud sound for a fraction of a second (0.117 second) on all channels immediately before the recording ended. The accident airplane's last recorded radar 12 transponder return occurred at 2031:12, and a review of the FDR data indicated that the FDR lost power at 2031:12.

7.8 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.

Air India Flight 182:

The sudden loud, audible sound lacked certain low frequencies and had a slower rise time for it to be the sound of a bomb explosion. The sudden loud sound matched that of an explosive decompression of a wide body DC-10 decompression accident sound.

Pan Am Flight 103:

The sudden loud, audible sound did not match any bomb explosion sounds. The sound did match the sound of its structure breaking up.

United Airlines Flight 811

The sudden loud, audible sound did not match any bomb explosion sounds because a bomb explosion was conclusively ruled out. The sudden loud sound did match the sound of the explosive decompression when its forward cargo door opened in flight which allowed the inside compressed air to rush out suddenly into the low pressure outside air.

Trans World Airlines Flight 800

The sudden loud, audible sound did not match any bomb explosion sounds because a bomb explosion was conclusively ruled out. The sudden loud sound was matched to the sound of a Boeing 747 explosive decompression accident sound, specifically, United Airlines Flight 811.

Excerpts of official corroborative statements to support the match that all had the source of the sudden, loud, audible sound as a bomb explosion disputed and the source as an explosive decompression supported.

Air India Flight 182

From the Canadian Aviation Occurrence Report: 2.10.2 Analysis by Accidents Investigation Branch (AIB), United Kingdom An analysis of the CVR audio found no significant very low frequency content which would be expected from the sound created by the detonation of a high explosive device. Considering the different acoustic characteristics between a DC-10 and a B747, the AIB analysis indicates that there were distinct similarities between the sound of the explosive decompression on the DC-10 and the sound recorded on the AI 182 CVR. 3.4.6.52 It would be pertinent to note that even according to the report of Mr. Davis the rise time in the case of Kanishka, which has been given for the peak is about 40 milliseconds. 3.4.6.55 A reference may also be made, at this stage, the frequency spectrum of the sound of the hand gun which was fired on a Boeing 737 flight deck. He has stated that the rise time for reaching the peak is almost instantaneous. Same is the case with regard to the frequency spectrum prepared by him of a bomb in a B-737 aircraft where the bomb had been placed in the freight hold which is shown in Fig. 6. A perusal of that spectrum also shows that the peak was reached in approximately 5 ms. 3.4.6.57 The fact that a bang was heard is evident to the ear when the CVR as well as the ATC tapes are played. The bang could have been caused by a rapid decompression but it could also have been caused by an explosive device. One fact which has, however, to be noticed is that the sound from the explosion must necessarily emanate a few milliseconds or seconds earlier than the sound of rapid decompression because the explosion must necessarily occur before a hole is made, which results in decompression. In the event of there being an explosive detonation then the sound from there must reach the area mike first before the sound of decompression is received by it. The sound may travel either through the air or through the structure of the aircraft, but if there is no explosion of a device, but there is nevertheless an explosive decompression for some other reason, then it is that sound which will reach the area mike. To my mind it will be difficult to say, merely by looking at the spectra of the sound, that the bang recorded on the CVR tape was from an explosive device.

Pan Am Flight 103

From AAIB Aircraft Accident Report No 2/90 2.3.2 Cockpit voice recorders The analysis of the cockpit voice recording, which is detailed in Appendix C, concluded

that there were valid signals available to the CVR when it stopped at 19:02:50 hrs ± 1 second because the power supply to the recorder was interrupted. It is not clear if the sound at the end of the recording is the result of the explosion or is from the break-up of the aircraft structure. The short period between the beginning of the event and the loss of electrical power suggests that the latter is more likely to be the case.

United Airlines Flight 811

From NTSB AAR 92/02: 1.11 Flight Recorders Examination of the data plotted from the DFDR indicated that the flight was normal from liftoff to the accident. The recorder operated normally during the period. However, the decompression event caused a data loss of approximately 2 1/2 seconds. When the data resumed being recorded, all values appeared valid with the exception of the pitch and roll parameters. Lateral acceleration showed a sharp increase immediately following the decompression. Vertical acceleration showed a sharp, rapid change just after the decompression and a slight increase as the airplane began its descent. The CVR revealed normal communication before the decompression. At 0209:09:2 HST, a loud bang could be heard on the CVR. The loud bang was about 1.5 seconds after a "thump" was heard on the CVR for which one of the flightcrew made a comment. The electrical power to the CVR was lost for approximately 21.4 seconds following the loud bang. The CVR returned to normal operation at 0209:29 HST, and cockpit conversation continued to be recorded in a normal manner

Trans World Airlines Flight 800

From NTSB AAR 00/03: 1.11.1.2 Cockpit Voice Recorder-Related Airplane Tests Sound spectrum analysis plots from these airplane tests were compared with those from the TWA flight 800 CVR recording. For further comparisons, the Safety Board plotted the CVR recordings from other known in-flight explosions/breakups (such as Pan Am flight 103, a 747-100 airplane that crashed at Lockerbie, Scotland, after a bomb on board exploded; 117 an Air India 747-100 that crashed in the Atlantic Ocean southwest of Ireland after a bomb on board exploded; and United flight 811, a 747-100 that lost its forward cargo door in flight. The CVRs recovered from these airplanes all recorded very loud sound events just before they stopped recording. The sound signatures from these events were compared with the sound signatures recorded at the end of the TWA flight 800 CVR recording. Generally, the sound signatures could be characterized based on how quickly the loud noise event rose from the background noise (rise time), the duration of the loud noise event, and how quickly the loud noise event decreased (fall time). The TWA flight 800 CVR recorded noise characteristics that were most similar to those recorded by the CVRs on board the United flight 811 and Philippine Airlines airplanes.

7. 9 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.

It is very unusual to have an abrupt power cut to the data recorders in flight. It never happens under usual circumstances and only four times in accidents which were preceded by another rare occurrence, a sudden, loud, audible sound on the flightdeck. The rarity and difficulty in creating such an event leads to the assumption that one identical initial event caused the abrupt power cut which disrupted all four data recorders, such as a bomb explosion, a center tank explosion, or an explosive decompression from a sudden hull rupture

The actual duration or the fall time of the sudden loud sound can not be determined because the power to the recording device was severed before the sound ended. The sound may have lasted for quite a long time but it is not recorded. The duration of the sound and the fall time of it on the recorders is independent of the actual duration and fall time of the sudden loud sound.

Air India Flight 182 was proceeding normally until a sudden, loud, audible sound was immediately followed by an abrupt power cut to the data recorders.

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.

United Airlines Flight 811 was proceeding normally until a sudden, loud, audible sound was immediately followed by an abrupt power cut to the data recorders.

Trans World Airlines Flight 800 was proceeding normally until a sudden, loud, audible sound was immediately followed by an abrupt power cut to the data recorders.

Excerpts of official corroborative statements to support the match that all four flights were proceeding normally until a sudden, loud, audible sound was immediately followed by an abrupt power cut to the data recorders.

Air India Flight 182

From the Canadian Aviation Occurrence Report: ' 2.10.1 Analysis by National Research Council, Canada From the CVR and DFDR, AI 182 was proceeding normally en route from Montreal to London at an altitude of 31,000 feet and an indicated airspeed of 296 knots when the cockpit area microphone detected a sudden loud sound. The sound continued for about 0.6 seconds, and then almost immediately, the line from the cockpit area microphone to the cockpit voice recorder at the rear of the pressure cabin was most probably broken. This was followed by a loss of electrical power to the recorder. Canadian Aviation Safety Board Air India 23 June 1985, page 21 When synchronized with other recordings it was determined, within the accuracy that the procedure permitted, that the DFDR stopped recording simultaneously with the CVR. Canadian Aviation Safety Board Air India 23 June 1985, page 22

Pan Am Flight 103

From AAIB Aircraft Accident Report No 2/90 2.3.1 Digital flight data recordings The analysis of the recording from the DFDR fitted to N739PA, which is detailed in Appendix C, showed that the recorded data simply stopped. Following careful examination and correlation of the various sources of recorded information, it was concluded that this occurred because the electrical power supply to the recorder had been interrupted at 19:02:50 +/- second. UK AAIB Report 2/90 Page 37 The analysis of the cockpit voice recording, which is detailed in Appendix C, concluded that there were valid signals available to the DVR when it stopped at 19:02.50 +/- second because the power supply to the recorder was interrupted. It is not clear if the sound at the end of the recording is the result of the explosion or is from the break-up of the aircraft structure. The short period between the beginning of the event and the loss of electrical power suggests that the latter is more likely to be the case. UK AAIB Report 2/90 Page 38

United Airlines Flight 811

From NTSB AAR 92/02: 1.11 Flight Recorders However, the decompression event caused a data loss of approximately 2 1/2 seconds. The CVR revealed normal communication before the decompression. At 0209:09:2 HST, a loud bang could be heard on the CVR. The loud bang was about 1.5 seconds after a "thump" was heard on the CVR for which one of the flightcrew made a comment. The electrical power to the CVR was lost for approximately 21.4 seconds following the loud bang. NTSB AAR 92/02. page 25

Trans World Airlines Flight 800:

From NTSB AAR 00/03: 1.11.2 Flight Data Recorder During the first 12 1/2 minutes of the accident flight (from the start of the takeoff roll until 2031:12, when the recording stopped abruptly), the FDR operated continuously and recorded data consistent with a normal departure and climb. The data indicated that the airplane was in a wings-level climb, and the vertical and longitudinal acceleration forces were consistent with normal airplane loads when the recording stopped. Examination of the FDR data revealed that the interruption of the recording at 2031:12 was consistent with the loss of electrical power to the recorder. 1.1 History of Flight At 2031:12, the CVR recording ended. The CVR then recorded a every loud sound for a fraction of a second (0.117 second) on all channels immediately before the recording ended. The accident airplane's last recorded radar 12 transponder return occurred at 2031:12, and a review of the FDR data indicated that the FDR lost power at 2031:12.

7.10 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.

Air India Flight 182 had an explosion in the forward cargo compartment.

Pan Am Flight 103 had an explosion in the forward cargo compartment.

United Airlines Flight 811 had an explosion in the forward cargo compartment.

Trans World Airlines Flight 800 had an explosion in the center fuel tank immediately adjacent to the forward cargo compartment with much tangible evidence of an explosion in the forward cargo compartment as the initial event and the center tank explosion later as a consequence.

Excerpts of official corroborative statements to support the match that all four flights had an explosion in or adjacent to the forward cargo compartment.

Air India Flight 182:

From the Canadian Aviation Occurrence Report: 4.1 Cause-Related Findings "There is considerable circumstantial and other evidence to indicate that the initial event was an explosion occurring in the forward cargo compartment." Canadian Aviation Safety Board Air India 23 June 1985, page 58

Pan Am Flight 103:

From AAIB Aircraft Accident Report No 2/90 1.12.2.4 Baggage containers It was evident, from the main wreckage layout, that the explosion had occurred in the forward cargo hold and, although all baggage container wreckage was examined,

only items from this area which showed the relevant characteristics were considered for the reconstruction. The initial explosion triggered a sequence of events which effectively destroyed the structural integrity of the forward fuselage. UK AAIB Report 2/90 Page 43 The direct explosive forces produced a large hole in the fuselage structure and disrupted the main cabin floor. UK AAIB Report 2/90 Page 56

United Airlines Flight 811:

From NTSB AAR 92/02: 1.6.2 Cargo Door Description and Operation Both the forward and aft lower cargo doors are similar in appearance and operation. They are located on the lower right side of the fuselage and are outward-opening. The door opening is approximately 110 inches wide by 99 inches high, as measured along the fuselage. 1.3 Damage to the Airplane The primary damage to the airplane consisted of a hole on the right side in the area of the forward lower lobe cargo door, approximately 10 by 15 feet large. The cargo door fuselage cutout lower sill and side frames were intact but the door was missing (see figures 1 and 2). An area of fuselage skin measuring about 13 feet lengthwise by 15 feet vertically, and extending from the upper sill of the forward cargo door to the upper deck window belt, had separated from the airplane at a location above the cargo door extending to the upper deck windows. The floor beams adjacent to and inboard of the cargo door area had been fractured and buckled downward. Executive Summary The National Transportation Safety Board determines that the probable cause of this accident was the sudden opening of the forward lower lobe cargo door in flight and the subsequent explosive decompression.

Trans World Airlines Flight 800:

NTSB AAR 00/03 Executive Summary: The National Transportation Safety Board determines that the probable cause of the TWA flight 800 accident was an explosion of the center wing fuel tank (CWT), resulting from ignition of the flammable fuel/air mixture in the tank. The source of ignition energy for the explosion could not be determined with certainty, but, of the sources evaluated by the investigation, the most likely was a short circuit outside of the CWT that allowed excessive voltage to enter it through electrical wiring associated with the fuel quantity indication system. From NTSB TWA 800 Photographs and text from Public Docket No. SA-516, Exhibit No. 18A, Sequencing Study, page 20, "Downward separation directions were noted at STA 900, 880, 840, 820, 800, and 780...The initial opening of the fuselage lower lobe (e.g. LF6A) would have the expected result of rapid depressurization accompanied by collapse of the main deck floor for some distance forward of STA 1000. The red area recovery of interior components as far forward as STA 600 would not be inconsistent with this floor collapse and associated structural breakup."

7.11 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.

The forward cargo doors of Pan Am Flight 103 and Air India Flight 182, are shown in drawings as equally split longitudinally which matches the retrieved United Airlines Flight 811 forward cargo door longitudinal split of its retrieved forward cargo door. The Trans World Airlines Flight 800 forward cargo door is shown in photographs as very shattered with two ruptures of outward peeled skin at each midspan latch.

The text description of the damage of the Air India Flight 182 forward cargo door and the surrounding area fits very closely with the photographs of the forward cargo door and the surrounding area of Trans World Airlines Flight 800, a Boeing 747 that also suffered an inflight breakup in flight thought to be caused by a bomb explosion in the forward cargo compartment. Photographs of the forward cargo door area of Trans World Airlines Flight 800 with the closeup of the forward cargo door area demonstrate the shattered destruction of the door area. The text from the Indian Kirpal report concerning pieces of wreckage debris around the forward cargo door of Air India Flight 182 describes very accurately the details in the photographs of the same area of Trans World Airlines Flight 800. The matches of both cargo door areas to each other with similar holes, flaps, fractures, inward concavity, tears, deformities, outward bent petals, curls, missing pieces, cracks, separations, curved fragments, spikes, and folds are apparent by matching the photographs of Trans World Airlines Flight 800 to the text of Air India Flight 182. There are no photographs yet available of the forward cargo door area of Air India Flight 182 in the accident reports to compare to the other three aircraft.



Above is a NTSB photograph of the wreckage reconstruction of Trans World Airlines Flight 800 starboard side over and forward of the wing. Fuselage station 600 is to the right extending to fuselage station 960 to the left in the photograph. A little over half of the forward cargo door is the shattered area in the lower right hand section. An outward opening petal shaped rupture can be seen at the aft midspan latch of the forward cargo door. The mildly damaged right hand, number two passenger door is in the middle left of the photograph.



Above is a closeup photograph of about a half of the Trans World Airlines Flight 800 forward cargo door extending from fuselage station 520 on the right to fuselage station 620 to the left in the photograph. The cargo door hinge is in red near the top of the photograph. The outward opening petal shaped oval rupture is located at the forward midspan latch of the forward cargo door.

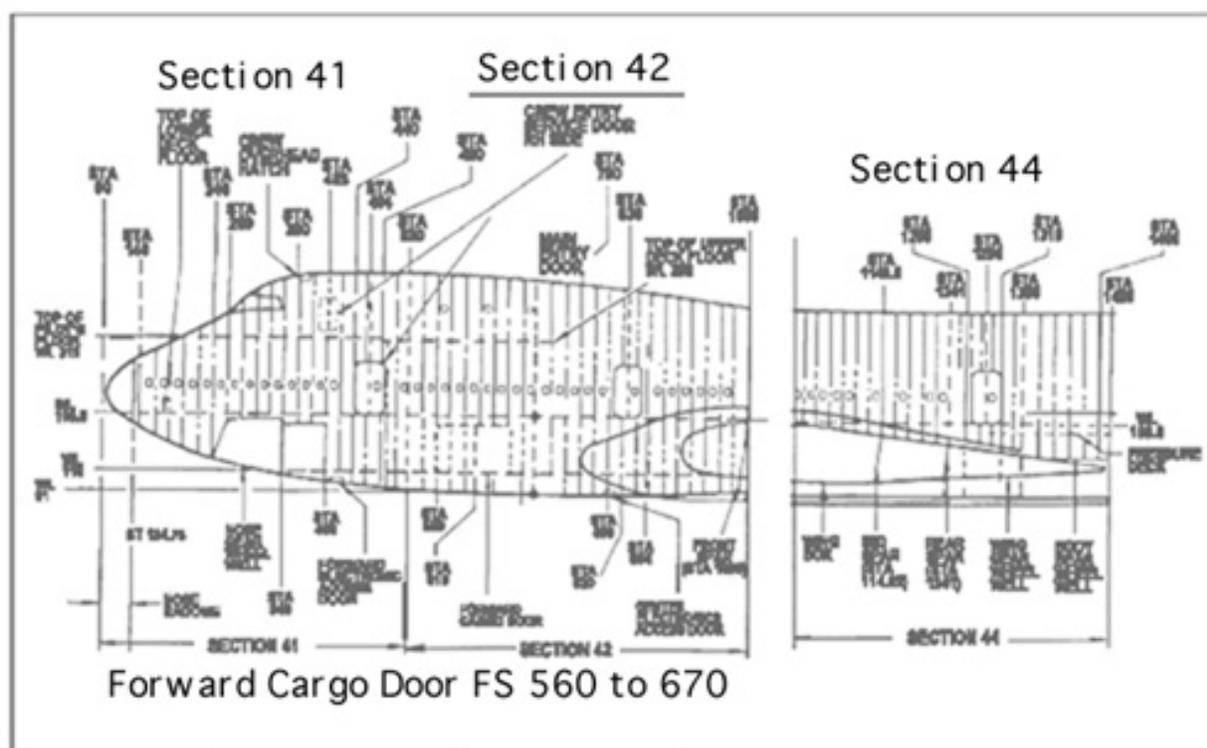


Figure 3a. Locator of fuselage sections 41, 42, and 44.

Above is a drawing from NTSB AAR 00/03 showing fuselage station numbers and sections.

Below is text from the Canadian Aviation Occurrence Report and the Indian Kirpal Report referring to Air India Flight 182 area forward of the wing on the starboard side:

E. Damage in air : The cargo door of the front cargo compartment was also found ruptured from above.

2.11.4.6 Section 42 Portions of section 42, consisting of the forward cargo hold, main deck passenger area, and the upper deck passenger area, were located near section 41. This area was severely damaged and some of section 42 was attached to section 44. Some of the structure identified from section 42 was the crown skin, the upper passenger compartment deck, the belly skin, and some of the cargo floor including roller tracks. The right-hand, number two passenger door including some of the upper and aft frame and outer skin was located beside section 44. Scattered on the sea bed near this area were a large number of suitcases and baggage as well as several badly damaged containers. All cargo doors were found intact and attached to the fuselage structure except for the forward cargo door which had some fuselage and cargo floor attached. This door, located on the forward right side of the aircraft, was broken horizontally about one-quarter 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.

3.2.11.23 Target 399 - Fuselage around 2R Door This target is shown in Fig. 399-1. A detailed description is given below : TARGET 399 Fuselage Station 780 to 940 in the longitudinal direction and stringer 7R down to stringer 35R circumferentially. This piece contained five window frames, one in the 2R

passenger entry door. Three of the window frames, including the door window frame, still contained window panes. Little overall deformation was found in the stringers and skin above the door. The structure did contain a significant amount of damage and fractures in the skin and stringers beneath the window level. In the area beneath the level of the windows, the original convex outward shape of the surface had been deformed into an inward concave shape. Further inward concavity was found in the skin between many of the stringers below stringer 28R. The skin at the forward edge of the piece was folded outward and back between stringers 25R and 30R. Over most of the remaining edges of the piece a relatively small amount of overall deformation was noted in the skin adjacent to the edge separations. Twelve holes or damage areas were numbered and are further described.

No.1 : Hole, 5 inches by 9 inches with two large flaps and one smaller curl, all folded outward. Reversing slant fractures, small area missing.

No.2 : Hole, 2 inches by 3/4 inch, one flap folded outward, reversing slant fractures, one curled sliver, no missing metal.

No.3 : Triangular shaped hole about 2 inches on each side. One flap, folding inward, with one area with a serrated edge. No missing metal, extensive cracking away from corners of the hole, reversing slant fracture.

No.4 : Tear area, 8 inches overall, with deformation inward in the centre of the area. Reversing slant fracture.

No.5 : Fracture area with two legs measuring 14 inches and about 24 inches. Small triangular shaped piece missing from a position slightly above stringer 27R. Inward fold noted near the joint of the legs. An area of 45° scuff marks extend onto this fold.

No.6 : Hole about 2.5 inches by 3 inches with a flap folded outward, reversing slant fracture. Approximately half the metal from the hole is missing.

No.7 : Hole about 3 inches by 1 inch, all metal from the hole is missing. Fracture edges are deformed outward.

No.8 : Forward edge of the skin is deformed into an "S" shaped flap. Three inward curls noted on an edge.

No.9 : Inwardly deformed flap of metal between stringers 11R and 12R at a frame splice separation. No evidence of an impact on the outside surface.

No.10 : Door lower sill fractured and deformed downward at the aft edge of the door.

No.11 : Frame 860 missing above stringer 14R. Upper auxiliary frame of the door has its inner chord and web missing at station 860. A 10 inch piece of stringer 12R is missing aft of station 860.

No.12 : Attached piece of floor panel (beneath door) has one half of a seat track attached. The floor panel is perforated and the lower surface skin is torn.

3.2.11.24 Much of the damage on this target was on the skin and stringers beneath the window level, i.e., on the right side of the front cargo hold. The inside and outside surface of the skin in this region are shown in Fig. 399-2 and 399-3 respectively. There were 12 holes or damaged areas on the skin as described above, generally with petals bending outwards. The curl on a flap around hole no.1 shown in Fig 399-4 has one full turn. This curl is in the outward direction. Cracks were also noticed around some of the holes. Part of the metal was missing in some of the holes. The edges of some of the petals showed reverse slant fracture. In one of the holes, spikes were noticed at the edge of a petal.

3.2.11.25 When this target was recovered from the sea, along with it came a large number, a few hundreds, of tiny fragments and medium size pieces, All of the fragments were recovered from the area below the passenger entry door 2R. One of

the medium size pieces recovered with this target was a floor stantion, about 35 inches long, shown in Fig. 399-5. It is a square tube. It had the mark station 880 painted on its inner face, i.e. facing the centre line of the cargo hold. The part number printed on this station is 69B06115 12 and the assembly number is ASSY 65B06115-942 E3664 1/31/78*. It was confirmed that this stantion belongs to the right side of the forward cargo hold. The inner face of the stantion had a fracture with a curl at the lower end, the curl being in the outboard direction and up into the centre of the station. Fig. 399-6 is a print from the radiograph of this station. The inward curling can be seen clearly in this figure. Curling of the metal in this manner is a shock wave effect.

3.2.11.26 A piece near the fracture edge of this stantion was cut, and examined metallographically. Fig. 399-7 and 399-8 show the micro-structure of this piece. Twins are seen in the grains close to the fracture edge. The normal microstructure of the stantion material is free from twins as shown in Fig. 399-9.

3.2.11.27 Fig. 399-10 shows a collection of small fragments recovered along with target 399. There were some curved fragments with small radius of curvature (A). Reverse slant fracture (B) was noticed in some of the skin pieces. A piece 3/4" x 1/2" and 3/16" thick was found to have three blunt spikes at the edge (C). This piece was metallographically polished on the longitudinal edge. The microstructure of the piece is shown in Fig. 399-11. It may be seen that the grains in this fragment also contain a large number of twins.

3.2.11.28 Target 362/396 Forward Cargo Skin This piece included the station 815 electronic access door, portions of seven longitudinal stringers to the left of bottom centre and five longitudinal stringers to the right of bottom centre. The original shape of the piece (convex in the circumferential direction) had been deformed to a concave inward overall shape. Multiple separations were found in the skin as well as in the underlying stringers. Further inward concavity was found in the skin between most of the stringers.

3.2.11.29 The two sides of this piece are shown in Fig. 362-1 and 362-2. This piece has 25 holes or damaged areas in most of which there are multiple petals curling outwards. These holes are numbered 1 to 3, 4a, 4b, 4c and 5 to 23. These are described below. Unless otherwise noted, holes did not have any material missing :

No.1 : Hole with a large flap of skin, reversing slant fracture.

No.2 : Hole with multiple curls, reverse slant fracture.

No.3: Hole with multiple flaps and curls, reversing slant fracture, one area of spikes (ragged sawtooth)

No.4A: One large flap, reverse slant fracture, one area of spikes.

No.4B : Hole with two flaps.

No.4C : Hole with two flaps, one area of spikes

No.5 : Hole with two flaps

No.6 : Branching tear from the left side of the piece, reversing slant fracture.

No.7 : Hole, with one flap, one curl and one area of spikes.

No.8: Very large tear from the left side of the piece with multiple flaps and curls, reversing slant fracture and at least two areas of spikes.

No.9 : Hole with multiple flaps, one curl.

No. 10: 2.5 inch tear

No.11: One flap

No. 12: Grip hole, plus a curl with spikes on both sides of the curl.

No.13: "U" shaped notch with gouge marks in the inboard/outboard direction. Three curls are nearby with one are of spikes. Gouges found on a nearby stringer

and on a nearby flap.

No. 14 : Nearly circular hole, 0.3 inch to 0.4 inch in diameter. Small metal lipping on outside surface of the skin. Most of the metal from the hole is missing.

No. 15 : Hole in the skin beneath the first stringer to the left of centre bottom. Small piece missing.

No. 16 : Hole in the stringer above hole No. 15. Most of the metal from this hole is missing.

No. 17 : Hole through the second stringer to the left of centre bottom, 0.4 inch in diameter. The hole encompassed a rivet which attached the stringer to the outer skin. Small pieces of metal missing.

No. 18 : Hole at the aft end of the piece between the third and fourth stringers to the left of centre bottom. The hole consisted of a circular portion (0.4 inch diameter), plus a folded lip extending away from the hole. The metal from the circular area was missing.

No. 19 : Hole with metal folded from the outside to the inside, about 0.6 inch by 1.5 inch. Flap adjacent to the hole contained a heavy gouge mark on the outside surface of the skin.

No. 20 : Hole containing a piece of extruded angle.

No. 21 : Hole containing a piece of extruded angle.

No. 22 : Hole with one flap.

No. 23 : Hole about 0.3 inch in diameter, with tears away from the hole. Small piece missing.

3.2.11.30 Fig. 362-3 to 362-7 show a few of these holes. There were also cracks or tears around some of the holes. The curls around some of the holes had nearly one full turn. In the large tear between body stations 700 and 740 and stringers between 41L and 45L, there were many pronounced curls as shown in Fig. 362-8. On the edges of the petals around several holes, reverse slant fracture was seen at a number of places. This slant fracture is at an angle of about 45° to the skin surface, the fracture continuing in the same general direction but with the slope of the slant fracture reversing frequently.

3.2.11.31 Sharp spikes were observed at the edges of the holes or at the edges of the petals around the holes No. 3, 4A, 4C, 7, 8 (at two locations), 12, 13 and 16. Some of the spikes are shown in Fig. 362-9 to 362-12. One of the holes, No. 14, on the skin was nearly elliptical with metal completely missing, as shown in Fig. 362-13. On the inside surface of the skin, paint surrounding this hole was missing. Hole No. 16 was through the hat section stringer, as shown in Fig. 362-14. In this, most of the metal was missing. On the inside of the hat section, the fracture edge of this hole had spikes, as shown in Fig. 362-15. Hole No. 17 was through the stringer and the skin, as shown in 362-16.

3.2.11.32 Through holes No. 20 and 21, extruded angles were found stuck inside, as shown in Fig. 362-17 and 362-18 respectively. In the petal around hole No. 20, there was an impact mark by hit from the angle as seen in Fig. 362-19 photographed after removing the angle. Such a mark was not present in the petals around other holes.

3.2.11.33 On the skin adjacent to hole No. 13 gouge marks were noticed, Fig. 362-20. These marks were on the inside surface of the skin. To check whether these could be due to rubbing by the bridal cable of Scarab during the recovery operations, a sample of bridal cable was obtained from "John Cabot" and gouge marks were produced by pressing this cable against an aluminum sheet. The gouge marks thus produced, as shown in Fig. 362-21, appear to be different from those observed near hole No. 13.

3.2.11.34 A piece surrounding hole No. 14 was cut out and examined in a Jeol 840 scanning electron microscope at the Naval Chemical and Metallurgical Laboratory, Bombay. Fig. 362-22 and 362-23 are the scanning electron micrographs showing the inside surface and outside surface of the skin around this hole. Flow of metal from inside to outside can be seen from these figures. Energy dispersive x-ray analysis was carried out on the edges of this hole. Only the elements present in this alloy and sea water residue were detected.

3.2.11.35 A portion of the skin containing part of hole No. 14 was cut, polished on the thickness side of the skin and examined in a metallurgical microscope. Fig. 362-24 shows the microstructure of this region. The flow of metal along the edge of the hole can be seen from the shape of the deformed grains near the hole. This can be compared with the bulk of the grains shown in Fig. 362-25, away from the hole. In addition, in Fig. 362-24, a series of twin bands can be seen in some of the grains near the hole. Fig. 362-26 shows these bands at a higher magnification. Normal deformation rates at various temperatures do not produce such twinning in aluminum or its alloys. It may be noted that this microstructural feature is absent in the microstructure of the skin, away from hole No. 14, Fig. 362-25.

3.2.11.36 Metallography was also carried out on a petal around hole No.7 and on a curl with spikes around hole No. 12. The microstructures indicate twins, however they could not be recorded due to their poor contrast.

3.2.11.37 Small pieces containing the spikes around holes No. 12 and 16 were cut and energy dispersive x-ray chemical analysis on the region of spikes in both was carried out in the Jeol 840 SEM. Only elements present in the alloys and sea water residue were detected.

3.2.11.38A number of small fragments were found along with the forward cargo skin in target 362. Amongst them was a piece from the web of a roller tray. This has pronounced curling of the edges towards the drive wheel, Fig. 362-27.

3.2.11.39 Another small fragment was found from the above target. This piece, identified as specimen No. 12 in box No. 1, target 362, has a number of spikes along the edge. A scanning electron micrograph of the spikes is shown in Fig. 362-28. The sides of the spikes on SEM examination revealed elongated dimples as shown in Fig. 362-29, characteristic of shear mode of fracture. Metallography was carried out on the thickness side of this specimen. Fig. 362-30 and 362-31 show the microstructure near the apex of the spike and at the root of the spike respectively. Extensive twinning can be seen in these regions of the spikes.

3.2.11.40 Another fragment recovered with target 362 and identified as specimen No. 8 in box No. 1, also showed extensive twinning. The microstructure is recorded in Fig. 362-32.

Air India Flight 182 forward cargo door was ruptured, split and shattered.

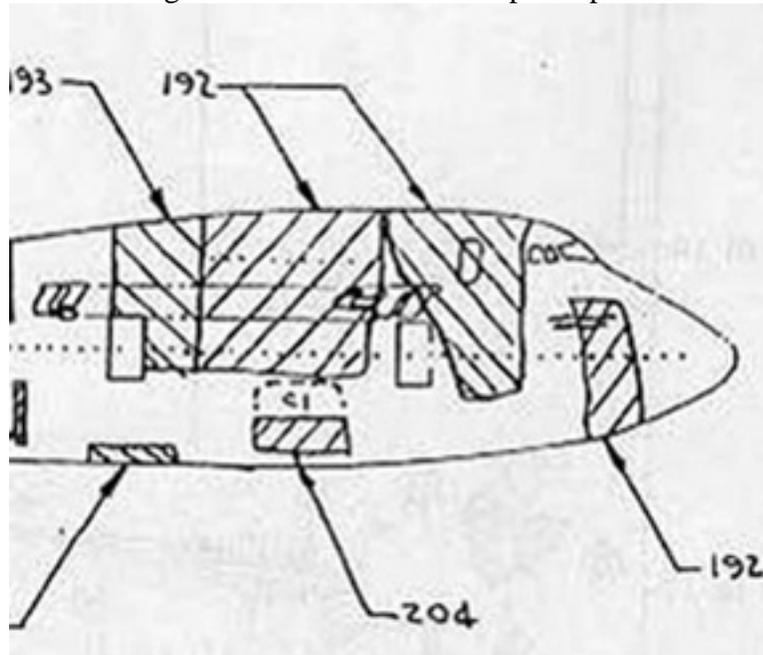
Pan Am Flight 103 has not text information about the forward cargo door although it was near the location of the explosion in the forward cargo compartment. The reconstruction drawing shows the forward cargo door split longitudinally at the midspan latches at the initial event start time.

United Airlines Flight 811 gives a detailed report on the ruptured and split forward cargo door.

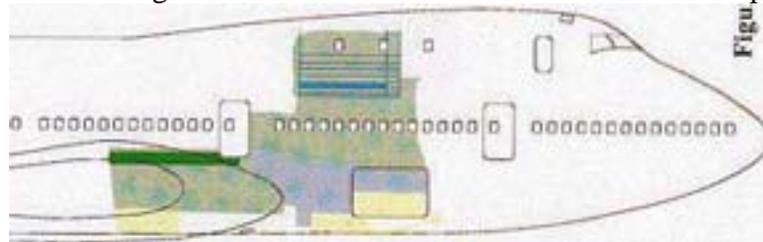
Trans World Airlines Flight 800 photographs show the ruptured, split and shattered forward cargo door.

Excerpts of official corroborative drawings and photographs to support all aircraft

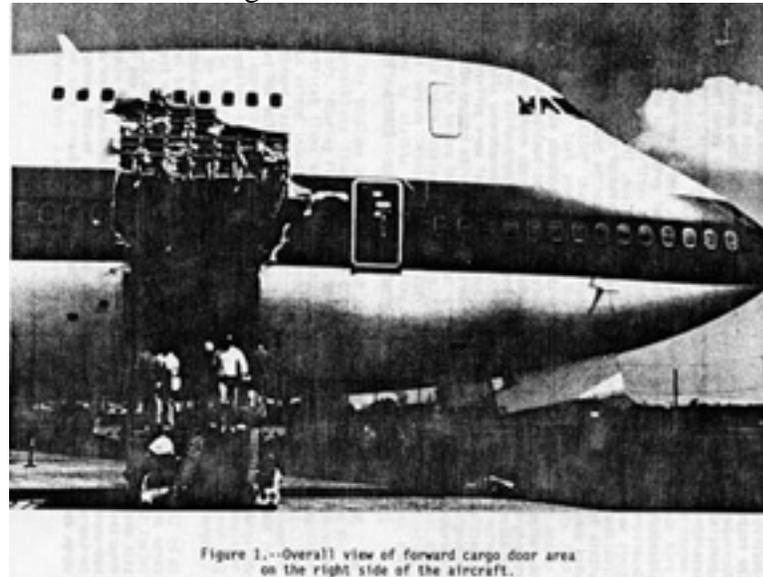
had similar shattered skin in and around the forward cargo door. Air India Flight 182 from the Indian Kirpal Report:



Pan Am Flight 103 below from AAIB Aircraft Accident Report No 2/90



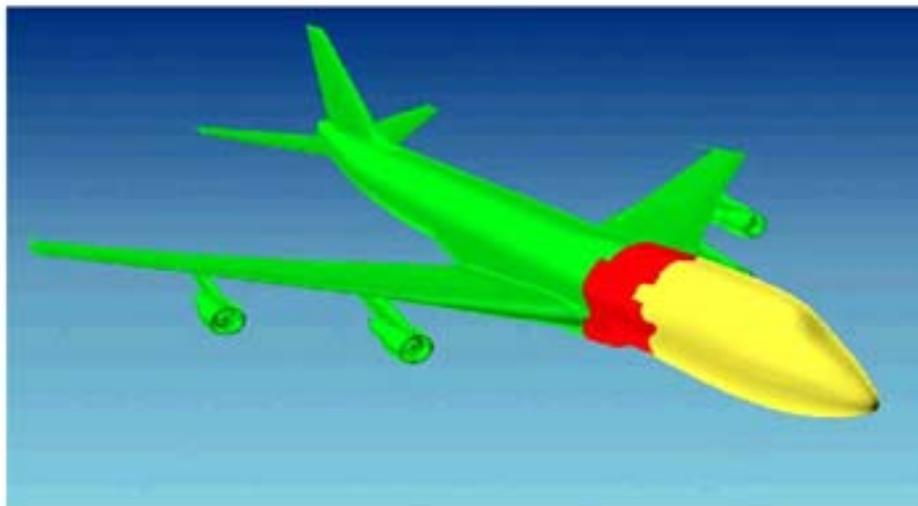
United Airlines Flight 811 below from NTSB AAR 92/02



Trans World Airlines Flight 800 below from NTSB public docket and AAR 00/03:



Below illustration shows the red zone of Trans World Airlines Flight 800 which is were all the first debris left the aircraft. The red zone includes the forward cargo door area but the zone is forward of the center fuel tank.



7.12 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.

Air India Flight 182 concentrated on the starboard side since it had unusual damage on the fuselage wreckage. No photographs are yet available of the port side. There is no report of any damage on the port side of the aircraft. Only a few parts of the port side were retrieved and nothing unusual was reported about those pieces.

Pan Am Flight 103 had large areas of skin torn away on the starboard side during the first instants of the initial event while immediately opposite at the same time only a few pieces were torn off.

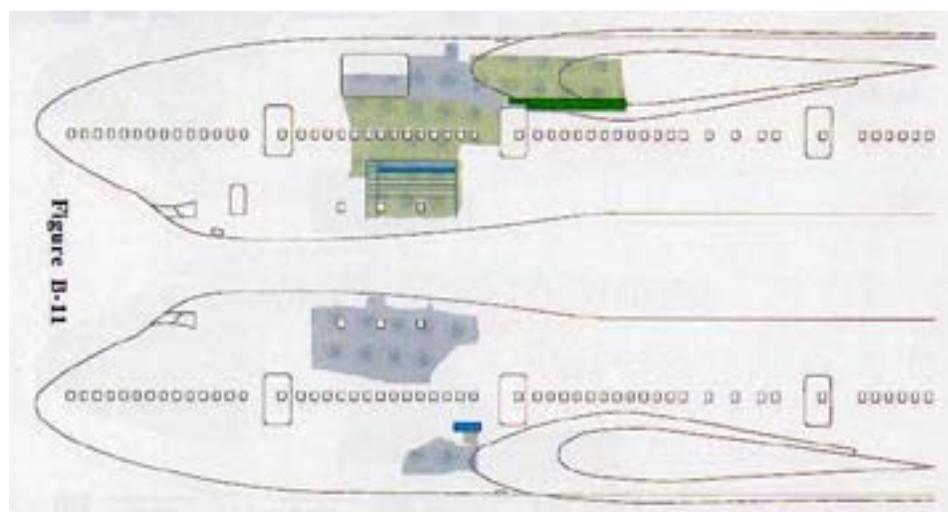
United Airlines Flight 811 had no damage to the port side of the airframe. All of the damage was on the starboard side from the explosive decompression and the ejected objects. The vertical stabilizer in the middle of the aircraft was damaged.

Trans World Airlines Flight 800 had no inflight damage on the port side while the starboard side directly opposite is shattered and torn.

Excerpts of official corroborative statements to support the match that all four flights 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.

Air India Flight 182: From the Indian Kirpal Report and the Canadian Aviation Occurrence Report: Five frames and door-port side aft# 5 left door (iii) Section of fuselage between B S 510 to B S 700, including the passenger window belt right side, up and over crown to include upper deck windows left side (Target No. 218). (iv) Section of fuselage between B S 720 to B S 840 including left side passenger window belt, up and over crown to right side passenger window belt. Forward and upper edges of L H No.2 door cutout can be seen (Target No. 193). (v) Large section of fuselage between B S 1000 to B S 1460 including left side passenger window belt, up and over crown to right side passenger window belt. This section was found lying on its right side (Target No. 137). There was no reported in flight damage to engines Nos. 1 and 2.

Pan Am Flight 103: From UK AAIB Report 2/90



Above drawing from Figure B-11 of the AAIB report shows the large amounts of fuselage skin around the forward cargo door (top drawing) torn away at initial event time while on the port side (bottom drawing) at the same time, only a few pieces are torn off. The dark blue rectangle is the very small 'bomb explosion' shatter zone which is purported to have caused the aircraft to break in two.

United Airlines Flight 811: From NTSB AAR 92/02: 1.3 Damage to the Airplane
 The primary damage to the airplane consisted of a hole on the right side in the area of the forward lower lobe cargo door, approximately 10 by 15 feet large. The cargo door fuselage cutout lower sill and side frames were intact but the door was missing (see figures 1 and 2). An area of fuselage skin measuring about 13 feet lengthwise by 15 feet vertically, and extending from the upper sill of the forward cargo door to the upper deck window belt, had separated from the airplane at a location above the cargo door extending to the upper deck windows. The floor beams adjacent to and inboard of the cargo door area had been fractured and buckled downward. Examination of all structure around the area of primary damage disclosed no evidence of preexisting cracks or corrosion. All fractures were typical of fresh overstress breaks. Debris had damaged portions of the right wing, the right horizontal stabilizer, the vertical stabilizer and engines Nos. 3 and 4. No damage was noted on the left side of the airplane, including engines Nos. 1 and 2.

Trans World Airlines Flight 800: From NTSB Public Docket photograph



Above photograph shows the smooth port side forward of the wing (nose to left in photograph), while directly opposite the starboard side is shattered and torn. There was no inflight damage to engines Nos. 1 or 2, both on the port side of the aircraft.

7.13 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.

Air India Flight 182 had inflight damage to the right wing root, number three engine and cowling, engine number four cowling, vertical stabilizer, and the right horizontal stabilizer.

Pan Am Flight 103 had inflight damage to number three engine and cowling, the vertical stabilizer, and the right horizontal stabilizer. The wing was destroyed and examination for inflight damage was not possible.

United Airlines Flight 811 had inflight damage to the leading edge of the right wing, engine number three and cowling, engine number four and cowling, the vertical stabilizer, the right horizontal stabilizer.

Trans World Airlines Flight 800 had inflight damage to the right wing, engine number three and cowling, and the right horizontal stabilizer.

Excerpts of official corroborative statements to support the match that all four flights had similar inflight damage to their airframe structures.

Air India Flight 182:

From the Canadian Aviation Occurrence Report 3.4.1 Aircraft Break-up The examination of the floating wreckage indicates that the right wing root leading edge, the number 3 engine inboard fan cowling, the right inboard midflap leading edge, and the right horizontal stabilizer root leading edge all exhibit damage consistent with objects striking the right wing and stabilizer before water impact. page 49. The fan cowls of the number 4 engine show evidence of being struck by a portion of the turbine from number 3 engine. page 49 The right wing root fillet which faired the leading edge of the wing to the fuselage ahead of the right spar had a vertical dent similar to that which would have resulted had the fillet run into a soft cylindrical object with significant relative velocity. page 30. The fan cowls of the number 4

engine had a series of five marks in a vertical line across the centre of the Air India logo on the inboard facing side of the fan cowl. These marks had the characteristic airfoil shape of a turbine blade tip. It is possible that a portion of the turbine parted from the number 3 engine and struck the cowl of the number 4 engine.

Pan Am Flight 103:

UK AAIB Report 2/90 1.14 Fire Of the several large pieces of aircraft wreckage which fell in the town of Lockerbie, one was seen to have the appearance of a ball of fire with a trail of flame. Its final path indicated this was the No 3 engine, which embedded itself in a road in the north-east part of the town. page 31 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. page 44. Containers and items of cargo ejected from the fuselage aperture in the forward hold, together with pieces of detached structure, collided with the empennage severing most of the left tailplane, disrupting the outer half of the right tailplane, and damaging the fin leading edge structure. page 57 Examination of the structure of the fin revealed evidence of in-flight damage to the leading edge caused by the impact of structure or cabin contents. 1.12.3.3 General damage features not directly associated with explosive forces. (v) A large, clear, imprint of semi-elliptical form was apparent on the lower right side at station 360 which had evidently been caused by the separating forward fuselage section striking the No 3 engine as it swung rearwards and to the right (confirmed by No 3 engine fan cowl damage)

United Airlines Flight 811:

From NTSB AAR 92/02: 1.3 Damage to the Airplane The primary damage to the airplane consisted of a hole on the right side in the area of the forward lower lobe cargo door, approximately 10 by 15 feet large. The cargo door fuselage cutout lower sill and side frames were intact but the door was missing. An area of fuselage skin measuring about 13 feet lengthwise by 15 feet vertically, and extending from the upper sill of the forward cargo door to the upper deck window belt, had separated from the airplane at a location above the cargo door extending to the upper deck windows. The floor beams adjacent to and inboard of the cargo door area had been fractured and buckled downwards. Debris had damaged portions of the right wing, the right horizontal stabilizer, the vertical stabilizer and engines Nos.3 and 4. The right wing had sustained impact damage along the leading edge between the No. 3 engine pylon and the No. 17 variable camber leading edge flap. Slight impact damage to the No. 18 leading edge flap was noted. The external surfaces of the No. 3 engine inlet cowl assembly exhibited foreign object damage including small tears, scuffs and a large outwardly directed hole. The entire circumference of all the acoustic (sound attenuator) panels installed on the inlet section of the cowl had been punctured, torn, or dented. The leading edges of all fan blade airfoils on the No. 3 engine exhibited extensive foreign object damage. External damage to the No 4 engine inlet and core cowls was confined to the inboard side of the inlet cowl assembly. The No. 4 engine fan blade airfoils had sustained both soft and hard object damage from foreign objects. NTSB/AAR 92/02 Page 7 NTSB/AAR 92/02 Page 8

Trans World Airlines Flight 800:

From NTSB TWA 800 Public Docket Exhibit 7A 3.1 Right Wing The right wing had separated into two major sections. The wing structure between the inboard and

outboard sections (WS 1224 to WS 1482) had broken into several pieces. Fire and soot damage was observed mainly on the inboard wing section, with some limited fire and soot damage on the other pieces. Docket No. SA-516, Exhibit No. 7A, Structures Group Report, page 33: 5.1 Horizontal Stabilizer, Some of the items found in the horizontal stabilizer are sections of seat track, a stator blade from turbine section, and glitter. On 5.1.1 Right Horizontal Stabilizer, page 34, An engine stator blade from turbine section penetrated the upper honeycomb surface near the outboard trailing edge.

7.14 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.

Engine number three is the engine closest to the fuselage on the starboard side and the engine closest to the forward cargo door. Any debris ejected from a sudden opening in the forward cargo compartment or cabin nearby will be ingested into the large fan of the engine. Foreign object damage to an engine inflight generally results in fire and bent or broken fan turbine blades. Sufficient ingestion of objects may result in an uncontainment where parts of the engine depart the nacelle and sometimes strike other parts of the aircraft such as the adjacent number four engine and cowling or the right horizontal stabilizer. Engine number three is directly in front of the right wing leading edge, the right wing fillet, and the right horizontal stabilizer.

Air India Flight 182 examination showed that an internal turbine part of engine number three departed and impacted the adjacent engine.

Pan Am Flight 103 examination showed engine number three ingested debris from within the aircraft.

United Airlines Flight 811 examination showed engine number three exhibited extensive foreign object damage.

Trans World Airlines Flight 800 examination showed that engine number three had many fan blades missing, soft body impacts on a partial airfoil, impact damage to the leading and trailing edges of the fan blades, and fan blade airfoils were bent rearward and the tips were bent forward. Foreign object damage is a cause for those damages.

Excerpts of official corroborative statements to support the match that all four flights had foreign object damage to engine number three.

Air India Flight 182:

From the Canadian Aviation Occurrence Report: The fan cowls of the number 4 engine show evidence of being struck by a portion of the turbine from number 3 engine. page 49 These marks had the characteristic airfoil shape of a turbine blade tip. It is possible that a portion of the turbine parted from the number 3 engine and struck the cowl of the number 4 engine.

Pan Am Flight 103:

UK AAIB Report 2/90 1.12.4 Examination of engines (ii) No 3 engine, identified on site as containing ingested debris from within the aircraft, nonetheless had no evidence of the type of shingling seen on the blades of No 2 engine.

United Airlines Flight 811: From NTSB AAR 92/02: 1.3 Damage to the Airplane

The leading edges of all fan blade airfoils on the No. 3 engine exhibited extensive foreign object damage.

Trans World Airlines Flight 800:

From NTSB TWA 800 Public Docket Exhibit 8A, Page 11, paragraph 3, discussing results of engine 3 disassembly: Of the 46 fan blades in the fan rotor, 21 blades with complete or partial airfoils and 6 root sections were recovered. All of the fan blades had sooting on the convex airfoil surfaces. Most of the full length airfoils were bent rearward and the tips outboard of the outer midspan shroud were bent forward slightly. About half of the fan blades had impact damage to the leading and trailing edges. Almost all of the impact damage to the airfoils could be matched to contact with the midspan shroud on an adjacent blade. One full length blade had four soft body impacts along the leading edge and a partial airfoil had a soft body impact, which had some streaking extending rearward.

7.15 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.

In particular, the status of the two midspan latches of the forward cargo door is omitted even though the door is close to the site of the initial explosion and the latched status of the other doors is usually given. There is evidence of ruptures at the midspan latches of all the forward cargo doors. There are two identically sized cargo doors on Boeing 747s with twenty latches and sixteen locking sectors. There are two midspan latches for each door. The aft cargo door, the bulk cargo door, and the CRAF door is often reported as intact and latched. The eight midspan latches for the forward cargo doors on the four accident aircraft have not been discovered, nor retrieved, nor examined, nor evaluated, nor status reported. The whereabouts of those eight midspan latches in the four forward cargo doors is a mystery.

Air India Flight 182 forward cargo door was shattered with no status reported for any of the ten latches yet the aft cargo door was intact and latched at the bottom. There is a description and drawing of a longitudinal split of the forward cargo door near the midspan latches.

Pan Am Flight 103 omitted the latch status of the forward cargo door which was split in two while the aft cargo door (frames 1800-1920) is reported as latched. A reconstruction drawing shows a longitudinal split at the midspan latches of the forward cargo door.

United Airlines Flight 811 reports on the split forward cargo door discuss the latching pins but omits the status of the midspan latch cams while the aft cargo door is intact and latched. The midspan latch area had a rupture at the aft midspan latch of the forward cargo door, giving the characteristic outward petal shaped explosion of metal.

Trans World Airlines Flight 800 reports on only the bottom eight latches of the forward cargo door and omits any discussion of the midspan latches which are missing from the wreckage database while the aft cargo door status is unreported. Trans World Airlines Flight 800 photographs show clearly the large petal shaped ruptures at both the midspan latches of the forward cargo door.

Excerpts of official corroborative statements to support the match that all four flights had incomplete reports of the status of the forward cargo door while status of aft cargo door is usually reported.

Air India Flight 182

From the Canadian Aviation Occurrence Report 2.11.4.6 Section 42 All cargo doors were found intact and attached to the fuselage structure except for the forward cargo door which had some fuselage and cargo floor attached. This door, located on the forward right side of the aircraft, was broken horizontally about one-quarter 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. 2.4.3.6 From the video films of the wreckage it was found that the complete aft cargo door was intact and in its position except that it had come adrift slightly. The door was found latched at the bottom.

Pan Am Flight 103

From AAIB Aircraft Accident Report No 2/90 1.12.1.2 The Rosebank Crescent site Other items found in the wreckage included both body landing gears, the right wing landing gear, the left and right landing gear support beams and the cargo door (frames 1800-1920) which was latched. The CRAF door itself (latched) apart from the top area containing the hinge.

United Airlines Flight 811:

From NTSB AAR 92/02: 1.16.1.1 Before Recovery of the Door The forward mid-span latch pin was relatively undamaged. The aft mid-span latch pin had definite areas of damage. Both pins had wear areas where the cams would contact the pins during latching.

Trans World Airlines Flight 800:

From NTSB AAR 00/03: 1.16.4.4 Metallurgical Examination of the Forward Cargo Door The Safety Board also considered the possibility that the forward cargo door (the forward edge of which is located several feet aft of STA 520 on the lower right side of the fuselage) separated from the accident airplane in flight and that this separation initiated the breakup sequence. The Board examined the pieces of the forward cargo door, which were recovered from the yellow zone. All eight of the latching cams at the bottom of the door were recovered attached to pieces of the lower end of the door and were in the latched position. Additionally, the latching cams and pieces of the cargo door remained attached to the pins along the lower door sill. The hinge at the top of the door was broken into several pieces, but the hinge pin still held the various pieces of the hinge together. There was no evidence to suggest that this hinge separated. The forward cargo door exhibited severe crushing deformation and fragmentation, very similar to damage observed on the adjacent fuselage structure.

Public Docket Exhibit No. 15C, Report Number 97-82, Section 41/42 Joint, Forward Cargo Door, Examination of the lower lobe forward cargo door showed that all eight of the door latching cams remain attached (along with pieces of the door itself) to the pins along the lower door sill.

7.16 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.

There was a denser, tight debris zone for the forward part of the aircraft and then scattered in a trail for the rest of aircraft. The forward part of the aircraft debris was closest to the initial event site. United Airlines Flight 811 had limited wreckage and it was found by tracking radar

information of the debris to the surface of the ocean. The similar debris patterns are to be expected because of the similar breakup amidships in flight.

Air India Flight 182 had the nose section and wing land in a localized zone with the rest of the aircraft spread out in a trail.

Pan Am Flight 103 had the forward fuselage fall in short trail and the aft fuselage in a loose trail with nose in one tightly packed zone.

United Airlines Flight 811 had pieces from the partial breakup of the forward fuselage fall to the sea.

Trans World Airlines Flight 800 had a tightly packed forward part of the fuselage fall in a zone and a looser trail for the aft fuselage.

Excerpts of official corroborative statements to support the match that all four flights had similar debris patterns.

Air India Flight 182

From the Canadian Aviation Occurrence Report 3.3 Aircraft Break-up Sequence The forward portion of the aircraft was highly localized, which indicates that it struck the water in one large mass. page 49. Although badly damaged, sections 41, 42, and 44, and the wing structure were located in a relatively localized area ... page 32. Section 46 and 48, including the vertical fin and horizontal stabilizer, extended in a west to east pattern... page 32. A third area which had some distinctive pattern was that of the engines, engine struts, and components and was localized ... page 32.

Pan Am Flight 103:

From AAIB Aircraft Accident Report No 2/90 1.12.1 General distribution of wreckage in the field The wreckage was distributed in two trails which became known as the northern and southern trails...page 15. The northern trail contained mainly wreckage from the rear fuselage, fin and the inner regions of both tailplanes together with structure and skin from the upper half of the fuselage forward to approximately the wing mid-chord position. page 17. The southern trail was easily defined...The trail contained numerous large items from the forward fuselage. page 18. 1.12.2.4 Baggage containers Discrimination between forward and rear cargo hold containers was relatively straightforward as the rear cargo hold wreckage was almost entirely confined to Lockerbie, whilst that from the forward hold was scattered along the southern wreckage trail.

United Airlines Flight 811:

From NTSB AAR 92/02: 1.12 Wreckage and Impact Information Navy radar near Honolulu tracked debris that fell from the airplane when the cargo door was lost. Refinement of the radar data led to a probable "splashdown" point in the ocean.

Trans World Airlines Flight 800:

From NTSB AAR 00/03: 1.12 Wreckage Recovery and Documentation Information Pieces of the wreckage were distributed along a northeasterly 123 path about 4 miles long by 3 1/2 miles wide in the Atlantic Ocean off the coast of Long Island.

1.12.1 Wreckage Recovered from the Red Zone The red zone was the largest of the three zones and was located farthest west (closest to JFK) in the wreckage distribution. Pieces recovered from the red zone generally included pieces from between about fuselage STA 840 and about fuselage STA 1000 (the aft portion of section 42 see figure 3a for station references); the structure from the aft end of the forward cargo compartment; and pieces from the WCS, including most of the front spar, a large portion of SWB3, and the manufacturing access door from SWB2.

1.12.2 Wreckage Recovered from the Yellow Zone The yellow zone was the smallest of the three zones and was contained within the red zone on its northeastern side (see figure 22a). This zone contained pieces of the airplane's forward fuselage, from about STA 840 to the nose of the airplane (STA 90). The wreckage recovered from the yellow zone included nearly all of fuselage section 41 (the nose section) and the forward portions of fuselage section 42.

1.12.3 Wreckage Recovered from the Green Zone The green zone was located farthest east (farthest from JFK) in the wreckage distribution. Most of the airplane wreckage was recovered from this zone, including most of the pieces of both wings, all four engines, and the fuselage aft of about STA 1000 (fuselage sections 44, 46, and 48 see figures 3a and 3b for reference).

7.17 Summary of matching evidence for all aircraft:

There is overwhelming circumstantial and tangible evidence from the five aircraft accident reports that all four aircraft suffered a breakup in flight amidships caused by an explosion in the forward cargo compartment. One aircraft had a partial breakup, United Airlines Flight 811, and was fortunately able to land with its invaluable evidence for a positive incontrovertible explanation for the tremendous explosion of explosive decompression which created the tangible evidence of CVR, FDR, inflight damage, engine damage, and injuries to passengers which matches the other other three accidents in many significant ways as detailed below in Table 1:

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 determination of probable cause as bomb explosion.	Yes	Yes	Yes	Yes
Initial official determination 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				

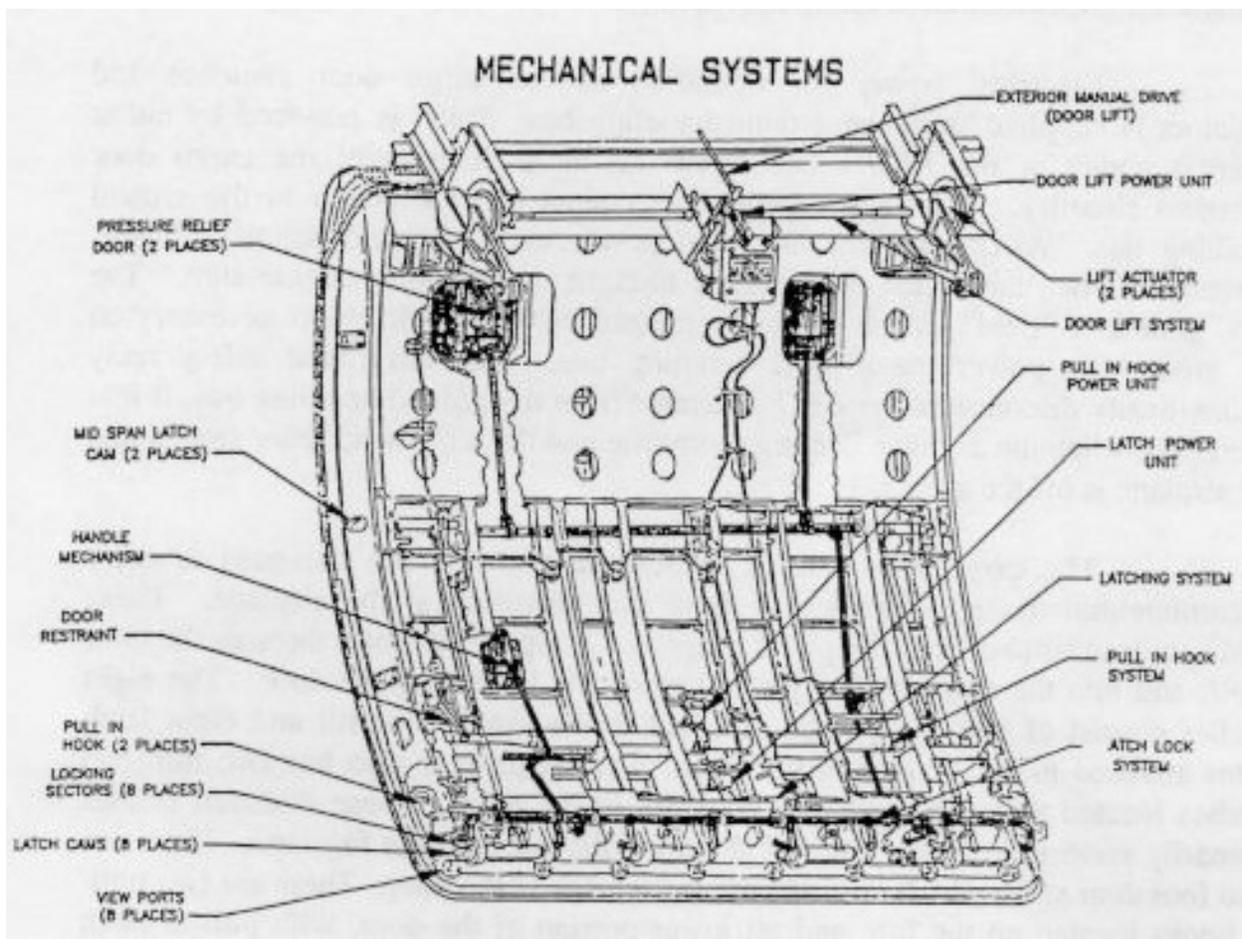
AI 182 PA103 UAL 811 TWA 800

7.18 Summary of matching evidence between Air India Flight 182 and United Airlines Flight 811 specifically:

- A. Boeing 747
- B. Early model -100 or -200
- C. Polyimide wiring (Poly X type)
- D. Sudden airframe breakup in flight (partial or total)
- E. Breakup occurs amidships
- F. Section 41 retrofit not done
- G. At least medium flight time
- H. At least medium aged airframe
- I. Previous maintenance problems with forward cargo door

- J. Initial event at about 300 knots while proceeding normally in all parameters
- K. Initial event involves hull rupture in or near forward cargo door area
- L. Initial event starts with sudden sound
- M. Initial event sound is loud
- N. Initial event sound is audible to humans
- O. Initial event followed immediately by abrupt power cut to data recorders
- P. Initial event sound not matched to explosion of bomb sound
- Q. Initial event sound is matched to explosive decompression sound in wide body airliner
- R. Torn off skin on fuselage above forward cargo door area
- S. Evidence of explosion in forward cargo compartment
- T. Foreign object damage to engine or cowling of engine number three
- U. Foreign object damage to engine or cowling of engine number four
- V. Right wing leading edge damaged in flight
- W. Vertical stabilizer damaged in flight
- X. Right horizontal stabilizer damaged in flight
- Y. More severe inflight damage on starboard side than port side
- Z. Port side relatively undamaged by inflight debris
- AA. Vertical fuselage tear lines just aft or forward of the forward cargo door
- AB. Fracture/tear/rupture at a midspan latch of forward cargo door
- AC. Midspan latching status of forward cargo door not reported as latched
- AD. Airworthiness Directive 88-12-04 not implemented (stronger lock sectors)
- AE. Outwardly peeled skin on upper forward fuselage
- AF. Rectangular shape of shattered area around forward cargo door
- AG. Forward cargo door fractured in two longitudinally
- AH. Status of aft cargo door as latched
- AI. Passengers suffered decompression type injuries
- AJ. At least nine missing and never recovered passenger bodies
- AK. Initial official determination of probable cause as bomb explosion.
- AL. Initial official determination modified from bomb explosion
- AM. Structural failure considered for probable cause
- AN. Inadvertently opened forward cargo door considered for probable cause
- AO. Takeoff after sunset on fatal flight
- AP. Takeoff after scheduled takeoff time on fatal flight

8. Cargo Door Operation for Boeing 747: Drawing of Boeing 747 cargo door from NTSB AAR 92/02



From AAR 92/02 United Airlines Flight 811: 1.6.2 Cargo Door Description and Operation: Normally, the cargo doors are operated electrically by means of a switch located on the exterior of the fuselage, just forward of the door opening. The switch controls the opening and closing and the latching of the door. If at any time the switch is released, the switch will return to a neutral position, power is removed from all actuators, and movement of the actuators ceases.

In order to close the cargo door, the door switch is held to the "closed" position, energizing the closing actuator, and the door moves toward the closed position. After the door has reached the near closed position, the hook position switch transfers the electrical control power to the pull-in hook actuator, and the cargo door is brought to the closed position by the pull-in hooks. When the pull-in hooks reach their fully closed position, the hook-closed switch transfers electrical power to the latch actuator. The latch actuator rotates the eight latch cams, mounted on the lower portion of the door, around the eight latch pins, attached to the lower door sill. At the same time, the two midspan latch cams, located on the sides of the door rotate around the two midspan latch pins located on the sides of the door frame. When the eight latch cams and the two mid-span cams reach their fully closed position, electrical power is removed from the latch actuator by the latch-closed switch. This completes the electrically powered portion of the door closing operation. The door can also be operated in the same manner electrically by a switch

located inside the cargo compartment adjacent to the door.

The final securing operation is the movement of lock sectors across the latch cams. These are manually moved in place across the open mouth of each of the eight lower cams through mechanical linkages to the master latch lock handle. The position of the lock sectors is indicated indirectly by noting visually the closed position of the two pressure relief doors located on the upper section of each cargo door. The pressure relief doors are designed to relieve any residual pressure differential before the cargo doors are opened after landing, and to prevent pressurization of the airplane should the airplane depart with the cargo doors not properly secured. The pressure relief doors are mechanically linked to the movement of the lock sectors. This final procedure also actuates the master latch lock switch, removing electrical control power from the opening and closing control circuits, and also extinguishes the cockpit cargo door warning light through a switch located on one of the pressure relief doors. Opening the cargo door is accomplished by reversing the above procedure.

The cargo door and its associated hardware are designed to carry circumferential (hoop) loads arising from pressurization of the airplane. These loads are transmitted from the piano hinge at the top of the door, through the door itself, and into the eight latches located along the bottom of the door. The eight latches consist of eight latch pins attached to the lower door sill and eight latch cams attached to the bottom of the door. The cargo door also has two midspan latches located along the fore and aft sides of the door. These midspan latches primarily serve to keep the sides of the door aligned with the fuselage. There are also four door stops which limit inward movement of the door. There are two pull-in hooks located on the fore and aft lower portion of the door, with pull-in hook pins on the sides of the door frame.' (Appendix F, Cargo Door Incidents)

9. Choice of Explosion Cause:

There is agreement among the authorities on where and when the explosion occurred in Air India Flight 182 and what happened afterward; the only difference of opinion is the source of the explosion:

A. CASB: There was an explosion, which could have been a bomb explosion, on the starboard side of the forward cargo compartment near the forward cargo door which caused the inflight breakup of Air India Flight 182.

B. AAIB: There was an explosion, not identified but not a bomb explosion, of the forward cargo compartment which caused the inflight breakup of Air India Flight 182.

C. Judge Kirpal: There was an explosion, a bomb explosion, on the starboard side of the forward cargo compartment near the forward cargo door which caused the inflight breakup of Air India Flight 182.

Throughout the Canadian and Indian reports on Air India Flight 182 the choice is considered for the explosion in the forward cargo compartment as being a bomb explosion or a structural failure causing an explosive decompression. The Canadians preferred to leave the cause of the explosion in the forward cargo hold which caused the explosive decompression unstated. The British statement was that the cause of the explosion was explosive decompression but was

not yet identified. The Indians stated the cause was a bomb possibly because there was no other reasonable alternative offered to them in 1985/1986. They also based the choice of bomb explosion cause on premises that were later proven to be unreliable: Explosive decompression by structural failure could not cause an abrupt power cut to the flight recorders and it can, twinning could not be produced by an explosive decompression and it can, and floor panels can appear to be broken upwards when in fact the floor beams were broken downward. They also could not have been aware of the several airworthiness directives issued to correct faults in the cargo doors that became apparent in the ensuing years.

It is now evident that the source of the explosions in all the aircraft was not a bomb, but a sudden, powerful decompression when the forward cargo door ruptured open at one or both of the midspan latches probably caused by faulty wiring turning on the door unlatch motor.

10. Inadvertent Cargo Door Opening Causes:

Once the direct and tangible evidence established that all four aircraft suffered a breakup in flight caused by an explosive decompression in the forward cargo compartment at the forward cargo door, the question became, "What made the forward cargo door suddenly rupture open in flight?"

There are many ways for a cargo door to inadvertently rupture open in flight: (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. (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.)

The four aircraft have had most of these probable causes considered at one time or the other by the authorities in varying degrees of attention. The initial answers were wrong twice for United

Airlines Flight 811 and Trans World Airlines Flight 800 and modified for Air India Flight 182 and Pan Am 103. United Airlines Flight 811 was at first explained as a bomb explosion, then it was changed to an improperly latched forward cargo door, then finally it was determined to be an electrical switch or wiring to cause the forward cargo door to open in flight. Trans World Airlines Flight 800 was at first explained as a bomb explosion, then a missile strike, and currently a center fuel tank explosion by an unknown ignition source.

The current official probable causes for all four are ambiguous or mysterious:

- A. Air India Flight 182 Explosion of unstated cause or explosion of a bomb.
- B. Pan Am Flight 103: Improvised explosive device or a bomb.
- C. United Airlines Flight 811: Electrical switch or wiring causing forward cargo door to open in flight.
- D. Trans World Airlines Flight 800: Center fuel tank explosion by unknown ignition source with wiring the main suspect.

In all the cases, based upon the evidence now available to this investigator, an explosion occurred in the forward cargo compartment on the starboard side at event start time; in all cases explosive decompression in the forward cargo compartment caused a tremendous explosion which mimics a bomb or fuel tank explosion; and in all cases there is much matching direct, tangible and circumstantial evidence to the one accident which has the irrefutable probable cause, United Airlines Flight 811, with the electrical switch or wiring causing the forward cargo door to rupture open inflight causing an explosion of explosive decompression in the forward cargo compartment.

Time has allowed this investigator to add further refinements to the confirmed probable cause of United Airlines Flight 811 in two ways; the location in the forward cargo door that ruptures first has been identified as one or both of the midspan latches and that the wiring has now been shown to be faulty in that it cracks and chafes to bare wire easily, especially in the presence of moisture.

The midspan latch area of the forward cargo door of United Airlines Flight 811, the reference accident, had a rupture at the aft midspan latch, showing the characteristic outward petal shaped explosion of metal. Air India Flight 182 describes the entire door in shattered terms of outward curled metal which would include the midspan latches and describes a longitudinal split near the latches. Pan Am Flight 103 shows a reconstruction drawing of a longitudinal split at the midspan latches. Trans World Airlines Flight 800 shows clearly the large petal shaped ruptures at both the midspan latches of the forward cargo door.

The midspan latches have no locking sectors to prevent the inadvertent backdriving of the latching cams while the bottom eight latching cams do have the eight safety locking sectors. Each midspan latch holds together an eight foot slice of fuselage skin at the aft and forward edges of the cargo door against the tens of thousands of pounds of internal pressure exerted outward in flight.

The matching evidence of missing midspan latches, the large slice of fuselage the latches hold together, the lack of locking sectors on those midspan latches, the lack of a status report on the latches, and drawings and photographs of ruptures at those latch locations on the actual doors on all four aircraft indicates the ruptures in the forward cargo door on all four aircraft occurred at one or both of the midspan latches as the initial event leading to the explosive decompression and airframe breakup.

The investigation authorities in 1985/1986/1989 also did not know of the faulty Poly X wiring because the faults of that type insulated wire only became apparent years later. That

defective type of wiring, which was on Air India Flight 182, was implicated in the explosive decompression of United Airlines Flight 811. Also, the investigators of 1985 did not have the sound of the explosive decompression in the forward cargo compartment of a early model Boeing 747 which occurred in 1989 to match with Air India Flight 182 in 1985. They would have discovered the sounds of the Boeing 747 that was United Airlines Flight 811 matched the sudden loud sound of Air India Flight 182, just as the DC-10 explosive decompression sound matched Air India Flight 182. Thus, Air India Flight 182 would have had two wide body airliners which had suffered explosive decompressions inflight, not caused by bomb explosions, which left a sudden loud audible sound on the cockpit voice recorders to match with the sudden loud audible sound on its own recorder.

If the 1985 CASB and AAIB and Indian investigators for Air India Flight 182 had had the UAL 811 NTSB AAR 92/02 and wiring records to review, they would have quickly discovered the many significant similarities and would probably have made the match between the two flights, and thus been able to make the right choice among an explosion of unstated cause, or a bomb explosion, or structural failure, or inadvertent rupture of the forward cargo door at one or both of the midspan latches due to faulty wiring causing the door to open in flight leading to explosive decompression.

11. Wiring:

The discovery of the faulty Poly X wiring, which was installed in all four aircraft, further narrows down the probable cause of the inadvertent door rupture to defective wiring. Cargo holds of Boeing 747s are known to have condensed water in them which accumulates in the bilges. The wire is of an aromatic polyimide type of insulation called Poly X. All four aircraft had this type of faulty wiring.

Excerpts of official corroborative statements to support the claim that Poly X wiring is defective: (Appendix G, Wiring)

Quote from Trans World Airlines Flight 800 Public Docket 516A, Exhibit 9A Systems Group Chairman's Factual report of Investigation, Page 47, "A Boeing telefax of June 25, 1997, stated that: The Poly-X wire was used as general purpose wire on the RA164 (TWA 800) aircraft. Wire insulation known as Poly-X had three in-service problems:

-Abrasion of the insulation in bundles installed in high vibration areas.

(This problem was corrected by Boeing Service Bulletin No. 747-71-7105, Dated July 19, 1974)

-Random flaking of the topcoat.

-Insulation radial cracks in tight bend radii.

Radial cracking phenomenon of the Poly-X wire was mainly associated with mechanical stress. Bend radius is the largest contributor to mechanical stress in installed wire or cable. Presence of moisture in conjunction with mechanical stress is also a contributor."

Trans World Airlines Flight 800 Public Docket 516A, Page 57, Letter from Commander Naval Air Systems Command to National Electrical Manufacturers Association, 1 Oct 82, "As you know, the problems with poly-x wire are well known to headquarters and its use had been curtailed."

From NTSB AAR 00/03 Trans World Airlines Flight 800: The results of these

reviews are discussed in this section. Wiring-Related Accidents/Incidents In an October 21, 1996, fax, the Civil Aviation Authority of Singapore described an event that occurred on October 12, 1996, in which an operator reported that arcing in a wire bundle on a 747-200 cargo airplane had resulted in a fire at the aft bulkhead of the forward cargo compartment about STA 1000. The airplane was undergoing maintenance at the time of the fire, and subsequent inspection revealed damage to wire bundles W834, W846, W1524, and W370; the insulation blanket; the aft bulkhead of the forward cargo compartment; and (possibly) the CWT sealant. The operator removed the affected components from the airplane and shipped them to Boeing for examination and evaluation. A December 16, 1996, letter from Boeing stated that X-ray microanalysis and chemical identification of the damaged wire suggest that the insulation of the wire was damaged and that arcing had occurred between the damaged wires or that arcing between the damaged wires and ground had occurred.

12. Sequence of Destruction for Air India Flight 182:

Hypothetical possible sequence of destruction for Air India Flight 182 based on circumstantial, tangible, deduced, historical, inferred, and direct evidence obtained through aircraft accident reports, 1952-2001.

On 18 July, 1984 a high lift vehicle damaged the fuselage skin near the forward cargo door of a Boeing 747-237B, construction number 330, operated by Air India airlines. The fuselage skin had wiring routed on the inside which became bent from the impact and subsequently cracked to bare wire, a characteristic of the polyimide type insulated Poly X wiring installed in the aircraft. The forward cargo door had non-steel locking sectors to keep the bottom eight latching cams from being back driven which would allow the door to open in flight causing explosive decompression which would be a catastrophic event well known to aircraft designers.

In June of 1986 several passengers changed their flight plans and their baggage routing for various flights through Canada to overseas destinations probably from Vancouver.

On 22 June, 1986, two aircraft had baggage loaded aboard them at the Vancouver B. C. airport; one flight was called CP 003 and the other CP 060. Flight 003 took off and flew uneventfully to the extremely busy Narita airport near Tokyo, Japan. After the baggage was unloaded from the flight, it was put on a baggage cart which was wheeled through a transit area of many other baggage carts containing many other bags from many other flights. An explosion of unspecified cause, unknown fuzing, unknown container, and unknown material occurred on the baggage cart which killed two people and injured others. The airport had high security because of previous terrorist attacks on it resulting in fatalities over the years.

The other flight, CP 060, flew uneventfully to Toronto Airport. The baggage was unloaded from CP 060 and those bags continuing on to London on Air India Flight 181/182 were loaded into the aft cargo compartment of the Boeing 747-237B, construction number 330. The flight, now called Air India Flight 181, flew uneventfully to Mirabel Airport in Montreal. After landing, some baggage of the departing passengers was unloaded from the aft compartment. Parts of a broken engine were placed in the aft cargo compartment for ferry back to India. New passengers and new baggage from Montreal for the next flight of the same aircraft, construction number 330 and now called Air India Flight 182, were loaded with all the new baggage going into the forward baggage compartment. The baggage from Vancouver on CP 060 and reloaded at Toronto remained in the aft cargo compartment of the Boeing 747-237B, construction number 330 and now called Air India

Flight 182.

The forward cargo compartment was filled with summer night air, warm and moist. When flying at altitude the air would be cooled by the air conditioning and the very cold outside air would cool the fuselage skin thus condensing out moisture along the inside of the compartment which would run through the wiring bundles and down into the cargo door bilge.

Air India Flight 182 took off from Montreal for London at 0218 Z on 23 June 1986 and flew uneventfully for about five hours and while at 31000 feet at 296 knots and about 115 miles west of Ireland a tragic sequence of events began at 0714 Z. The pressure differential between outside and inside air was at its maximum design limit, 8.9 pounds per square inch.

Water may have met the cracked insulated wire which may have been previously damaged by the high lift accident to 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 lower eight cams may have been able to overcome the weaker locking sectors to just turn past center and allow the door to unlatch in flight, a defect known years later in two other Boeing 747 flights, Pan Am Flight 125 and United Airlines Flight 811. The midspan cams may have turned just past center with not 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 nine foot by eight foot squarish forward cargo door would have instantly burst open at the midspan bottom latches sending the latches, door material, and large pieces of fuselage skin spinning away. The forward cargo compartment would have spewn its contents outward onto the starboard side of the fuselage. I was as if a huge mylar balloon had popped. 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. Many small bits of metal from the explosion were embedded into the cargo door area metal fuselage structure.

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 very lower part of the door sill with its eight bottom latches may have stuck to fuselage skin. 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 thirty feet wide and forty 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.

The forward cargo door had some fuselage and cargo floor attached. This door, located on the forward starboard side of the aircraft, was broken horizontally about one-quarter 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 fast and powerful explosion of the explosive decompression would have caused a metallurgical effect called 'twinning' on a few fragments of pieces of wreckage.

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, the cockpit voice recorder and transponder.

The number three engine and cowling, closest to the forward cargo compartment, were damaged by inflight debris from material ejected from the now exposed compartment and cabin above, debris which also damaged the number four engine cowling by a displaced turbine blade from number three engine. The resulting vibration from the internal damage to engine number three caused the nacelle and engine to fall away from the wing, as designed, and land apart from the other three engines.

The floor beams above the forward cargo hold were sucked downward, and were fractured and broken from the sudden decompression. The floor panels were stationary but gave the appearance of separating upward by the suddenly moving downward floor beams.

The flight attitude of the aircraft was askew to the left from reaction of explosive decompression from the right. Air rushed into the large hole and weakened other skin and frames peeling skin further outward and rupturing the aft part of the aircraft to include the aft cargo compartment and the aft pressure bulkhead. The 296 knots of wind force pressed upon the weakened airframe and broke it in half amidships. This wind force was larger than any wind force the surface of the earth had ever experienced. The nose portion and wings tore off and landed in a dense debris heap apart from the debris field of the aft part.

The rest of the plane without the forward section suddenly decelerated from 296 knots and caused whiplash injuries to passengers. After the breakup, the passengers who were not wearing their seatbelts were scattered to far distances. They suffered explosion type injuries such as pieces of metal embedded in them from flying debris in the cabin. They were not burned because there was no fire nor explosion from a bomb explosion. The passengers had no other bomb explosion evidence. The passengers and crew were ejected from the disintegrating aircraft to tumble to the water and suffer upward impact physical damage to their bodies. Some remained in their seats and were trapped in the fuselage underwater. Some had decompression type injuries of hypoxia from the high altitude aircraft breakup.

The passengers fell to the sea and some floated and some sank. The baggage from Vancouver passengers and loaded into the aft cargo compartment fell to the sea and some floated and some sank. The baggage from Montreal passengers and loaded into the forward cargo compartment fell to the sea and some floated and some sank. The aircraft fell in pieces and some pieces floated and some sank.

The pilots may have been conscious for a few seconds and adjusted the trim controls out of habit. The communications radio may have been activated by the disturbances in the cockpit and transmitted for a few seconds to air traffic control.

The port side forward of the wing was relatively smooth and undamaged from inflight debris while the starboard side forward of the wing was shattered, torn, and frayed at the ruptured cargo door area.

A few local fires appeared on the surface of the ocean from the jet kerosene fuel and singed some seat cushions and floating passengers.

Explanations were sought as to what happened. Immediately the suggestion was made by authorities that a bomb explosion had caused the accident because of the sudden and catastrophic nature of the immediate evidence.

The Canadian aviation accident investigation authorities became involved since the aircraft had taken off from Canada and had many Canadian citizens aboard. Indian authorities became involved since the airline, Air India, has government ties. The Indian authorities quickly dismissed their aviation experts and assigned a Judge of the Court the oversee the investigation.

After a period of investigation, much of which was conducted to confirm the bomb explosion explanation and identify the culprits, the Indian judge made a finding that a bomb in the forward cargo compartment had caused the inflight breakup of Air India Flight 182.

After a period of investigation, during which the opinion of the UK Air Accidents Investigation Branch representative of an explosive decompression not caused by a bomb but a cause as yet to be determined was given, the Canadian Aviation Safety Board made a conclusion that an explosion of unstated cause in the forward cargo compartment had caused the inflight breakup of Air India Flight 182.

The immediate suggestion by the Indians of a bomb explosion in the forward cargo compartment was accepted and remained the probable cause for Air India Flight 182 sixteen years later although subsequent accidents of a similar type aircraft in similar circumstances leaving similar evidence now resolutely contradict that finding although confirming the Indian finding of an explosion on the starboard side of the forward cargo compartment.

The Canadian probable cause of an explosion in the forward cargo compartment of an undermined cause has been proven to be correct by subsequent accidents of a similar type aircraft in similar circumstances leaving similar evidence which do reveal the cause of the explosion: faulty wiring causing the forward cargo door to rupture open inflight at the latches leading to a tremendous explosion of explosive decompression causing Air India Flight 182 to totally breakup in flight.

13. Comment:

Aging aircraft problems such as cracking wiring do not get better with age; they get worse. Design problems such as inadequately latched non plug doors which open outward in flight can not be fixed by putting more latches on them. Aircraft accidents will happen; most are caused by mechanical problems or pilot error. A very small percent are caused by sabotage in the air. (Appendix H, Accidents). Subsequent problems to 1985 discovered in and around the forward cargo door of Boeing 747s were expressed as Airworthiness Directives (AD) or service bulletins (SB).

- A. The locking sectors on the bottom eight latches of both cargo doors needed to be strengthened.
- B. The lower sill of the forward cargo door needed strengthening.
- C. Section 41 needed to be strengthened.
- D. Instructions needed to be made clearer to ground personnel to not backdrive the latches.
- E. Caution placards needed to be easily understandable.
- F. Wire bundles alongside the forward cargo door needed to be rerouted so they would not bind and chafe.

14. Hindsight:

In 1985, when Air India Flight 182 suffered an inflight breakup from an explosion, it was believed that an explosive decompression in an early model Boeing 747 could not cause an abrupt power cut to the data flight recorders. That belief was cited by the Indian Kirpal Report as a reason to reject the explosive decompression explanation because, in fact, Air India Flight 182 had suffered an abrupt power cut to the data recorders. The Indian Kirpal Reports states: "It was not possible that any rapid decompression caused by a structural failure could have disrupted the entire electrical power supply from the MEC compartment." The later event of United Airlines Flight 811 showed that it was possible, and indeed, did happen, that an explosive decompression caused by a structural failure could and did cause an abrupt electrical cutoff to the recorders.

The reason for the Indians in 1985 to rule out explosive decompression by structural failure was negated by the reality of United Airlines Flight 811 in 1989. If the Indians had the foreknowledge of United Airlines Flight 811 and the explosive decompression which cut off abruptly the power to the recorders, it is most probable they would have sustained the findings of the Canadians and the British who said that a explosion in the forward cargo compartment occurred and all would have then known the solution to the mystery posed by the AAIB investigator: "...but the cause has not been identified." The cause was identified in 1989 and demonstrated by United Airlines Flight 811 in NTSB AAR 92/02: The National Transportation Safety Board determines that the probable cause of this accident was the sudden opening of the forward lower lobe cargo door in flight and the subsequent explosive decompression.'

The evidence that was unavailable to the Air India Flight 182 CASB, AAIB, and Indian accident investigators in 1985 that became available in the ensuing 16 years that would have been invaluable in assisting them in determining the probable cause was:

- A. Evidence that an explosive decompression could cause an abrupt power cut to the data recorders.
- B. Evidence that floor panels can appear to separate upwards when in fact the floor beneath were pulled down.
- C. Testimony that twinning can occur in explosions other than bombs, such as an aviation fuel explosion, or explosive decompression.
- D. Evidence that the type of wiring installed, Poly-X, was defective in that it cracked

to bare wire easily, especially in the presence of moisture.

E. Visible ruptures in flight in forward cargo doors of other early model Boeing 747s that suffered the same events in flight.

F. Several Airworthiness Directives for defects in and around the forward cargo doors of Boeing 747s that if uncorrected could lead to inadvertent opening of the cargo door in flight leading to catastrophic explosive decompression.

The evidence that was available to the Air India Flight 182 CASB, AAIB, and Indian accident investigators in 1985 was such to lead them to conclude that an explosion had taken place on the starboard side in the forward cargo compartment which was picked up by the cockpit voice recorder and cut off the electrical power in the adjacent main electrical equipment compartment. The cause of the explosion was given as either unknown, structural failure of explosive decompression, or a bomb explosion. Since the event in 1989 with United Airlines Flight 811 had not happened yet, the understandable decision of the Indians, based on three assumptions later proven unreliable, was to state the cause of the explosion in the forward cargo compartment a bomb whilst the cautious Canadian CASB and the British AAIB left the cause unstated or unidentified.

15. General Conclusions for Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800:

When all the evidence is objectively considered using the hindsight of sixteen years, it is apparent that Air India Flight 182, Pan Am Flight 103, and Trans World Airlines Flight 800 suffered the same and only confirmed and irrefutable probable cause for the explosion of the explosive decompression in the forward cargo compartment that led to the breakup in flight, that of United Airlines Flight 811.

It is apparent that all four aircraft are related by direct, tangible, and circumstantial evidence to have suffered an amidships breakup in flight which occurred after an explosion on the starboard side in the forward cargo compartment which caused an explosive decompression, the cause of which was a suddenly ruptured open forward cargo door in flight probably at one or both of the midspan latches and probably caused by faulty wiring which turned on the door unlatch motor. The implications of these conclusions raises many questions which are addressed in Appendix I, Questions.

Based on the direct, tangible and circumstantial evidence of the four accidents, and using the benefit of hindsight, the conclusion of this investigator and author of this report is that the probable cause of the forward cargo door rupturing open in flight for the four aircraft, including Air India Flight 182, was faulty wiring shorting on the door unlatch motor causing the forward cargo door to inadvertently rupture open in flight at one or both of the midspan latch leading to explosive decompression in the forward cargo compartment.

A. Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800 experienced inflight breakups.

B. The breakup was caused by an explosion in the forward cargo compartment on the starboard side.

C. The explosion was a severe and sudden explosive decompression.

D. The explosive decompression was caused by the suddenly ruptured open forward cargo door probably at one or both of the midspan latches.

E. The ruptured open forward cargo door was probably caused by faulty wiring which turned on the door unlatch motor which unlatched the latching cams from around the latching pins

in flight.

F. The wiring fault was probably the Poly X wiring with inferior insulation which easily cracked to bare wire especially in the presence of moisture.

G. There were no bomb explosions in any cargo compartment, crew cabin, passenger cabin, or anywhere else in any of the aircraft.

16. Specific Conclusions for Air India Flight 182:

These conclusions are based on evidence available before and after 1985.

A. While proceeding normally, an inflight breakup of Air India Flight 182 occurred suddenly and catastrophically at 0714Z at 31000 feet at 300 knots TAS about 110 miles west of Cork, Ireland on 23 June, 1985. There were no survivors.

B. The breakup was caused by an explosion in the forward cargo compartment.

C. The explosion was a severe and sudden explosive decompression.

D. The explosive decompression was caused by the suddenly ruptured open forward cargo door probably at one or both of the midspan latches.

E. The ruptured open forward cargo door was probably caused by faulty wiring which turned on the door unlatch motor which unlatched the latching cams from around the latching pins in flight.

F. The wiring fault was probably the Poly X wiring with inferior insulation which easily cracked to bare wire especially in the presence of moisture.

G. There was no bomb explosion in any cargo compartment, crew cabin, passenger cabin, or anywhere else on the aircraft.

H. There was no explosion in the aft cargo compartment.

I. The sudden loud sound on the cockpit voice recorder was the sound of the air rushing out during the explosive decompression in the forward cargo compartment.

J. The abrupt power cut to the recorders was caused by the explosive effects of the decompression affecting the power cables in the adjacent main equipment compartment to the forward cargo compartment.

17. Contributing causes:

A. Water or moisture in the forward cargo compartment.

B. Weak locking sectors on the bottom eight latches of the cargo doors.

C. Poor design of one midspan latch per each eight foot side of the cargo doors.

D. Poor design of no locking sector for each midspan latch of the cargo doors.

E. Poor design of outward opening nonplug type large, squarish cargo doors in a highly pressurized hull.

18. Recommendations:

A. An emergency airworthiness directive for immediate compliance should be issued for all operators of early model Boeing 747s to visually and electrically wire check all the wiring for integrity in the forward cargo door area as well as all wiring involved with operation of the forward cargo door.

B. All unnecessary electrical equipment on early model Boeing 747s should be turned off and remain off during flight.

C. All early model Boeing 747s should have the Poly X insulated wiring removed or isolated and replaced as soon as practicable.

D. All early model Boeing 747s should have the aft and forward outward opening nonplug cargo doors sealed shut permanently or modified into plug type doors.

19. Concluding Comment:

From the Indian Kirpal Report: 1.1.4 The aircraft in question - Kanishka, was named after the most powerful and famous king of the Kushanas who perhaps ruled in India from AD 78 to AD 103. Besides being a great conqueror, he was an ardent supporter and follower of Buddhism - a religion which preaches non-violence. Emperor Kanishka, however, met a violent end. After 25 years of reign he was killed by some of his own subjects. His life was thus brought to an abrupt end. 1.1.5 It is indeed ironical that the Jumbo Jet which bore the name 'Kanishka' also met with a violent and a sudden end on that fateful morning of 23rd June, 1985.

It is indeed ironic that the Jumbo Jet which bore the name 'Kanishka' also met with a violent and a sudden end on that fateful morning of 23rd June, 1985, after seven years of reign, accidentally killed by some of his own subjects.

Respectfully submitted;

John Barry Smith
Independent Aircraft Accident Investigator
1 May 2001,
Carmel Valley, California

Air India Flight 182

Report on the accident to Boeing 747-237B VT-EFO, Air India Flight 182,
off Cork, Ireland on 23 June 1985
by John Barry Smith,
Independent aircraft accident investigator

Appendix A: Boeing 747 Accidents (Unofficial 1970 through 1997) Harro Ranter

Following is a listing of all Boeing 747 aircraft, damaged beyond repair in accidents.

1) 06.09.70 () Boeing 747-121 N752PA (19656/34) Pan American World Airways 0 fatalities / 0 occupants +
Location: Cairo IAP (Egypt) Nature: Scheduled Passenger Phase: Ground from: Amsterdam-Schiphol APT to: New York-John F. Kennedy IAP Flightnr.: PA93 The aircraft was hijacked by two men just after leaving Amsterdam. The flight diverted to Beirut, where 7 others boarded the plane. The aircraft was flown to Cairo. All occupants were released and the aircraft was blown up. Source: Aircraft hijackings and other criminal acts against civil aviation : statistics and narrative reports / FAA

2) 23.07.73 () Boeing 747-246B
JA-8109 (20503/180) Japan Air Lines - JAL 0 fatalities / 0 occupants +
Location: Benghazi-Benina (Libya) Nature: Scheduled Passenger Phase: Ground from: Amsterdam-Schiphol APT to: Anchorage IAP Flightnr.: JA404 Flight 404 was hijacked by 4 men and a woman, shortly after leaving Amsterdam. The woman hijacker got killed in an accidental explosion of the explosive device she was carrying. The aircraft landed at Dubai and later took off for Damascus and Benghazi. All passengers and crew were released and the aircraft blown up.

3) 20.11.74 (ca. 07:50) Boeing 747-130
D-ABYB (19747/29) Lufthansa
59 fatalities / 157 occupants +
Location: Nairobi-Wilson APT (Kenya) Nature: Scheduled Passenger Phase: Take-off from: Nairobi-Wilson APT to: Johannesburg-Jan Smuts APT Flightnr.: LH540 Boeing 747 D-ABYB was taking off for the last leg of the Frankfurt-Nairobi- Johannesburg flight when the crew felt vibration or buffeting following lift off. The captain, suspecting wheel imbalance, raised the gear. A lack of acceleration forced the crew to lower the nose in order to maintain airspeed. The Boeing continued to descend however and contacted the ground 1120m past the end of Runway 24 and struck an elevated road 114m further on. The aircraft broke up and caught fire before coming to rest 454m past the initial point of impact. PROBABLE CAUSE: "The accident was caused by the crew initiating a take-off with the leading edge flaps retracted because the pneumatic system which operates them had not been switched on. This resulted in the aircraft becoming airborne in a partially stalled condition which the pilots did not identify in the short time available to them for recovery. Major contributory factors were the lack of warning of a critical condition of leading edge flap position and the failure of the crew to complete satisfactorily their checklist items."

4) 12.06.75 () Boeing 747-128
N28888 (20542/201) Air France
0 fatalities / 394 occupants +
Location: Bombay (India) Nature: Scheduled Passenger Phase: Take-off from: Bombay to:

Flightnr.: During a 180o turn at the beginning of Runway 27 the No.11 tire (on the right hand maingear) failed. During take-off the no.12 tire also failed. Wheels and braking assembly then started rubbing the runway, causing a fire. The take-off was aborted. Initial delay in shutting down the engines and an improper deployment of fire services caused the fire to spread.

5) 09.05.76 () Boeing 747-131F

5-8104 (19677/73) Islamic Republic of Iran Air Force 17 fatalities / 17 occupants +

Location: Madrid; nr (Spain) Nature: Freight Phase: Descent from: to: Madrid-Torrejon AFB
Flightnr.: ULF48 The aircraft was struck by lightning while descending through FL100 on its way to Torrejon AFB. The explosion in the no.1 fuel tank which followed caused severe damage to the left wing. 54 Seconds later the left wing failed and freighter crashed. POSSIBLE CAUSE: Ignition of fuel vapour in the ullage of the tank in the vicinity of a motor drive fuel valve. Source: FI 15.5.76(1283)

6) 27.03.77 (17.06) Boeing 747-121

N736PA (19643/11) Pan American World Airways 335 fatalities / 396 occupants + 248

Location: Tenerife (Spain) Nature: Non Scheduled Passenger Phase: from: Tenerife-Norte Los Rodeos to: Las Palmas Flightnr.: PA1736 At 12.30h a bomb explodes in the Las Palmas passenger terminal. Because of warnings of a possible second bomb, the airport was closed. A large number of flights were diverted to Tenerife, a.o. KLM Flight 4805 from Amsterdam and PanAm Flight 1736 (coming from Los Angeles and New York). Las Palmas Airport opened to traffic again at 15.00h. Because the PanAm passengers remained on aboard it was possible to leave Tenerife at once. The taxiways were congested by other aircraft however. This meant the PanAm crew had to backtrack on Runway 12 for take-off on Runway 30. The entrance to Runway 12 however, was blocked by the KLM Boeing. The PanAm flight had to wait for almost 2 hours before all KLM passengers (except 1) had reboarded and refuelling had taken place. The KLM flight was then cleared to backtrack Runway 12 and make a 180deg. turn at the end. Three minutes later (at 17.02h) Pan Am 1736 was cleared to follow the KLM aircraft and backtrack Runway 12. The PanAm crew were told to leave the runway at the third taxiway and report leaving the runway. At 17.05:44h KLM 4805 reported ready for take-off and was given instructions for a Papa beacon departure. The KLM crew repeated the instructions and added "We are now at take-off". The brakes were released and KLM 4805 started the take-off roll. Tenerife tower, knowing that Pan Am 1736 was still taxiing down the runway replied "OK Stand by for take-off, I will call you." This message coincided with the PanAm crew's transmission "No ... uh we're stil taxiing down the runway, the Clipper 1736". These communications caused a shrill noise in the KLM cockpit, lasting approx. 3.74 seconds. Tenerife tower replied: "Papa Alpha 1736 report runway clear.", were upon the PanAm crew replied: "OK, will report when we're clear". This caused some concerns with the KLM flight engineer asking the captain: "Is he not clear then?" After repeating his question the captain answers emphatically: "Oh, yes". A number of second before impact the KLM crew saw the PanAm Boeing still taxiing down the runway. The crew tried to climb away and became airborne after a 65ft taildrag in an excessive rotation. The PanAm crew immediately turned the aircraft to the right and applied full power. The KLM aircraft was airborne, but the fuselage skidded over the PanAm's aft fuselage, destroying it and shearing off the tail. The KLM aircraft flew on and crashed out of control 150m further on, sliding another 300m bursting into flames. PROBABLE CAUSE: "The KLM aircraft had taken off without take-off clearance, in the absolute conviction that this clearance had been obtained, which was the result of a misunderstanding between the tower and the KLM aircraft. This misunderstanding had arisen from the mutual use of usual terminology which, however, gave rise to misinterpretation. In combination with a number of other coinciding circumstances, the premature take-off of the KLM aircraft resulted in a collision with the Pan Am aircraft, because the latter was still on the runway since it had missed the correct intersection."

Source: Flight Safety Digest July 1995(1-10)/Flight Safety Foundation; ICAO Circular 153-AN/56 (p.22-68) Human factors report on the Tenerife accident / Air Line Pilots Association (ALPA)

7) 27.03.77 (17.06) Boeing 747-206B

PH-BUF (20400/157) KLM Royal Dutch Airlines 248 fatalities / 248 occupants + 335

Location: Tenerife (Spain) Nature: Non Scheduled Passenger Phase: Take-off from: Tenerife-Norte Los Rodeos to: Las Palmas Flightnr.: KL4805 At 12.30h a bomb explodes in the Las Palmas passenger terminal. Because of warnings of a possible second bomb, the airport was closed. A large number of flights were diverted to Tenerife, a.o. KLM Flight 4805 from Amsterdam and PanAm Flight 1736 (coming from Los Angeles and New York). Las Palmas Airport opened to traffic again at 15.00h. Because the PanAm passengers remained on board it was possible to leave Tenerife at once. The taxiways were congested by other aircraft however. This meant the PanAm crew had to backtrack on Runway 12 for take-off on Runway 30. The entrance to Runway 12 however, was blocked by the KLM Boeing. The PanAm flight had to wait for almost 2 hours before all KLM passengers (except 1) had reboarded and refuelling had taken place. The KLM flight was then cleared to backtrack Runway 12 and make a 180deg. turn at the end. Three minutes later (at 17.02h) Pan Am 1736 was cleared to follow the KLM aircraft and backtrack Runway 12. The PanAm crew were told to leave the runway at the third taxiway and report leaving the runway. At 17.05:44h KLM 4805 reported ready for take-off and was given instructions for a Papa beacon departure. The KLM crew repeated the instructions and added "We are now at take-off". The brakes were released and KLM 4805 started the take-off roll. Tenerife tower, knowing that Pan Am 1736 was still taxiing down the runway replied "OK Stand by for take-off, I will call you." This message coincided with the PanAm crew's transmission "No ... uh we're stil taxiing down the runway, the Clipper 1736". These communications caused a shrill noise in the KLM cockpit, lasting approx. 3.74 seconds. Tenerife tower replied: "Papa Alpha 1736 report runway clear.", where upon the PanAm crew replied: "OK, will report when we're clear". This caused some concerns with the KLM flight engineer asking the captain: "Is he not clear then?" After repeating his question the captain answers emphatically: "Oh, yes". A number of second before impact the KLM crew saw the PanAm Boeing still taxiing down the runway. The crew tried to climb away and became airborne after a 65ft taildrag in an excessive rotation. The PanAm crew immediately turned the aircraft to the right and applied full power. The KLM aircraft was airborne, but the fuselage skidded over the PanAm's aft fuselage, destroying it and shearing off the tail. The KLM aircraft flew on and crashed out of control 150m further on, sliding another 300m bursting into flames. PROBABLE CAUSE: "The KLM aircraft had taken off without take-off clearance, in the absolute conviction that this clearance had been obtained, which was the result of a misunderstanding between the tower and the KLM aircraft. This misunderstanding had arisen from the mutual use of usual terminology which, however, gave rise to misinterpretation. In combination with a number of other coinciding circumstances, the premature take-off of the KLM aircraft resulted in a collision with the Pan Am aircraft, because the latter was still on the runway since it had missed the correct intersection."

Source: Flight Safety Digest July 1995(1-10)/Flight Safety Foundation; ICAO Circular 153-AN/56 (p.22-68) Human factors report on the Tenerife accident / Air Line Pilots Association (ALPA)

8) 01.01.78 (ca. 20:15) Boeing 747-237B VT-EBD (19959/124) Air India

213 fatalities / 213 occupants +

Location: Arabian Sea, off Bandra (India) Nature: Scheduled Passenger Phase: Climb from: to: Dubai IAP Flightnr.: AI855 The aircraft left Bombay-Santa Cruz Airport for a flight to Dubai (Flight AI855). Following a right turn, the aircraft rolled to the left beyond 90o, lost control and crashed into shallow (10m deep) water, 3km offshore at an angle of 35-40o. PROBABLE CAUSE: The Attitude Director Indicator (ADI) probably malfunctioned during the right turn, which led to a complete loss of situational awareness of the crew members.

9) 19.11.80 () Boeing 747-2B5B

HL-7445 (21773/366) Korean Air Lines - KAL 14 fatalities / 212 occupants +

Location: Seoul-Kimpo IAP (Korea) Nature: Scheduled Passenger Phase: Landing from: to: Seoul-Kimpo IAP Flightnr.: The aircraft struck a 45o embankment slope 2.4m from the top, crashed on Runway 14, broke up and caught fire. Weather at the time of the accident was a visibility 1000m, fog, temperature 2deg.

10) 04.08.83 () Boeing 747-121

N738PA (19645/14) Pan American World Airways 0 fatalities / 243 occupants +

Location: Karachi IAP (Pakistan) Nature: Scheduled Passenger Phase: Landing from: to: Karachi IAP Flightnr.: The aircraft touched down on a wet runway and reverse thrust was applied on all engines, except no.4 (of which the reverser had been de-activated). When coming out of reverse, the no.4 engine reached 1.4199 EPR, causing the Boeing th yaw to the left and depart the runway 2400m past the threshold. PROBABLE CAUSE: Inadvertent application of power on the no.4 engine while coming out of reverse.

11) 01.09.83 (18.26) Boeing 747-230B

HL-7442 (20559/186) Korean Air Lines - KAL 269 fatalities / 269 occupants +

Location: Okhotsk Sea () Nature: Scheduled Passenger Phase: Cruise from: Anchorage IAP, AK to: Seoul-Kimpo IAP Flightnr.: KE007 The Boeing arrived at Anchorage at 03.30 local time after a flight from New York. At 05.00h the aircraft took off again from Runway 32, bound for Seoul. The flight was cleared directly to the Bethel VOR beacon and then on to the Romeo 20 route. However, the aircraft started diverging from it's intended course and passed 12mls North of the Bethel beacon. While approaching the Kamchatka peninsula, 6 MiG-23 fighters were scrambled. Because a US Boeing RC-135 intelligence plane was flying in the area East off Kamchatka, the Soviet defence forces probably thought the B747 radar echo to be the RC-135. KAL 007 left Russian airspace over the Okhostk Sea and the fighters returned to their base. Passing abeam the Nippi beacon (4hrs after take-off), the aircraft was 185mls off course and headed for Sakhalin. Two Soviet Sukhoi Su-15 fighters were scrambled from the Dolinsk-Sokol airbase at 17.42h UTC and 17.54 respectively. At 18.16h UTC flight 007 re-entered Soviet airspace. At 18.22h the Soviet command ordered destruction of the target (for the 2nd time). Two air-to-air missiles were launched by one of the fighters and struck the Boeing at 18.26h. Cabin pressure was lost and the aircraft suffered control problems, causing the Boeing to spiral down and crash into the sea.

12) 27.11.83 (00.06) Boeing 747-283B

HK-2910 (21381/311) Avianca

181 fatalities / 192 occupants +

Location: Madrid-Barajas APT; 12km SE (Spain) Nature: Scheduled Passenger Phase: Final Approach from: Paris-Charles de Gaulle to: Madrid-Barajas Flightnr.: AV011 Avianca Flight 011 took off from Paris-Charles de Gaulle at 22.25h for a flight to Bogota via Madrid. The crew intercepted the ILS (for an approach to Runway 33) on the wrong track and continued to descend below MDA. This led to some problems with inserting the Madrid VOR coordiantes in the aircraft's INS (inertial navigation system), which caused the pilot to initiate a right turn short of the VOR beacon (the point were he should have made the turn). The right maingear and no.4 engine suddenly contacted a hill at an altitude of 2247ft and a speed of 142kts. Three seconds later the aircraft impacted a second hill at a sped of 135kts and a 4,9deg. nose-up attitude. Six seconds after contacting the 2nd hill, the aircraft (at 126kts) hit the ground with the right wing, which broke off. The Boeing cartwheeled and broke in five pieces and came to rest upside down. PROBABLE CAUSE: "The pilot-in-cormnand, without having any precise knowledge of his position, set out to intercept the ILS on an incorrect track without initiating the published instrument approach

manoeuvre; in so doing he descended below all; the area safety minima until he collided with the ground. Contributory factors were: a) Inaccurate navigation by the crew, which placed them in an incorrect position for initiating the approach manoeuvre.; b) Failure of the crew to take corrective action in accordance with the operating instructions of the ground proximity warning system.; c) Deficient teamwork on the flight deck.; d) Imprecise position information supplied to the aircraft by APP.; e) The APP controller, in failing to inform the aircraft that radar service had terminated, did not maintain a proper watch on the radar scope." (Accident Investigation Board, Spain) Source: ICAO Circular 196-AN/119 (105-107, incomplete)

13) 16.03.85 () Boeing 747-3B3

F-GDUA (22870/573) Union de Transportes Ariens - UTA 0 fatalities / 0 occupants +
Location: Paris-Charles de Gaulle (France) Nature: Phase: Ground from: - to: - Flightnr.:
Destroyed by fire.

14) 23.06.85 (07.15 GMT) Boeing 747-237B VT-EFO (21473/330) Air India

329 fatalities / 329 occupants +

Location: Atlantic Ocean () Nature: Scheduled Passenger Phase: Cruise from: Montreal-Mirabel IAP to: London-Heathrow APT Flight nr.: AI182 The aircraft left Toronto almost 2 hours late due to the installation of a 5th spare engine, fitted below the left wing. The engine had to be ferried for repairs in India. After a stopover at Montreal, Flight 182 continued to London. At 07.15h GMT the aircraft suddenly disappeared from radar screens. An explosion had occurred at FL310, causing a rapid decompression, followed by an inflight break-up. The aircraft crashed into the 2000m deep ocean off Shannon. PROBABLE CAUSE: A bomb, placed on board by a Sikh terrorist, caused an explosion, powerful enough to cause an inflight break-up. Source: Aircraft hijackings and other criminal acts against civil aviation : statistical and narrative reports / FAA; Aviation disasters / D. Gero (p. 182-183); Air Disasters / S. Stewart; Flight International 1.11.86 + 18.10.86

15) 12.08.85 (18.56) Boeing 747-SR46

JA-8119 (20783/230) Japan Air Lines - JAL 520 fatalities / 524 occupants +

Location: Tokyo; nr (Japan) Nature: Scheduled Passenger Phase: Climb from: Tokyo-Haneda IAP to: Osaka IAP Flightnr.: JL123 JAL Flight 123 took off from Tokyo-Haneda at 18.12h for a flight to Osaka. At 18.24h, while climbing through 23900ft at a speed of 300kts, an unusual vibration occurred. An impact force raised the nose of the aircraft and control problems were experienced. Two minutes later hydraulic pressure had dropped and ailerons, elevators and yaw damper became inoperative, followed by dutch roll and plughoid oscillations (unusual movement in which altitude and speed change significantly in a 20-100sec. cycle without change of angle of attack). The aircraft started to descend to 6600ft while the crew tried to control the aircraft by using engine thrust. Upon reaching 6600ft the airspeed had dropped to 108kts. The aircraft then climbed with a 39deg. angle of attack to a maximum of approx. 13400ft and started to descend again. JA123 finally brushed against a tree covered ridge, continued and struck another ridge, bursting into flames. PROBABLE CAUSE: "Deterioration of flight characteristics and loss of primary flight controls due to rupture of the aft pressure bulkhead with subsequent ruptures of the tail, vertical fin and hydraulic flight control systems. The reason for the aft pressure bulkhead rupture was that its strength was reduced by the fatigue cracks propagating in the spliced portion of the bulkhead's webs. The initiation and propagation of the fatigue cracks are attributable to the improper repairs of the bulkhead, conducted in 1978, and since the fatigue cracks were not found in the later maintenance inspections, this contributed to the accident." Source:

16) 02.12.85 () Boeing 747-228B

F-GCBC (22427/485) Air France

0 fatalities / 273 occupants +

Location: Rio de Janeiro (Brazil) Nature: Scheduled Passenger Phase: Landing

The aircraft veered off the runway on landing, crossed a ditch and collided with a concrete ramp. It appeared that the no.1 engine throttle cable had broken, making it impossible for the flightcrew to control engine power. The engine had accelerated to an unusually high level of (forward) thrust (above take-off power).

17) 28.11.87 (00:07 UTC) Boeing 747-244B ZS-SAS (22171/488) South African Airways - SAA 159 fatalities / 159 occupants +

Location: Indian Ocean () Nature: Scheduled Passenger Phase: Descent from: Taipei-Chang Kai Shek IAP to: Flightnr.: SA295 South African flight 295 took off from Taipei at 14.23, carrying 159 occupants and 6 pallets of cargo in the main deck cargo hold. At 23.49h the crew reported Mauritius Approach control they had a fire on board. An emergency descent to FL140 was carried out. Mauritius ATC cleared the aircraft to FL50, followed by a approach clearance. The captain's response was the last radio contact with SA295. It appeared that a fire had started in the cargo pallet at position PR. The aircraft had somehow lost control, broke up and crashed into the Ocean. PROBABLE CAUSE: Fire of an unknown origin had possibly: 1) incapacitated the crew; 2) caused disorientation of the crew due to thick smoke; 3) caused crew distraction; 4) weakened the aircraft structure, causing an inflight break-up.; 5) burned through several control cables; 6) caused loss of control due to deformation of the aircraft fuselage. Source:

18) 21.12.88 (19.03) Boeing 747-121A

N739PA (19646/15) Pan American World Airways 259 fatalities / 259 occupants + 11

Location: Lockerbie (UK) Nature: Scheduled Passenger Phase: Cruise from: London-Heathrow APT to: New York-John F. Kennedy IAP Flightnr.: PA103 Flight PA103 departed London-Heathrow Runway 27R for New York at 18.25. The aircraft levelled off at FL310 31 minutes later. At 19.03 Shanwick Oceanic Control transmitted an oceanic clearance. At that time an explosion occurred in the aircraft's forward cargo hold at position 4L. The explosive forces produced a large hole in the fuselage structure and disrupted the main cabin floor. Major cracks continued to propagate from the large hole while containers and items of cargo ejected through the hole, striking the empennage, left- and right tailplane. The forward fuselage and flight deck area separated when the aircraft was in a nose down and left roll attitude, peeling away to the right at Station 800. The nose section then knocked the No.3 engine off its pylon. The remaining aircraft disintegrated while it was descending nearly vertically from 19000ft to 9000ft. A section of cabin floor and baggage hold (from approx. Station 1241-1920) fell onto housing at Rosebank Terrace, Lockerbie. The main wing structure struck the ground with a high yaw angle at Sherwood Crescent, Lockerbie causing a massive fire. The Semtex bomb which caused the explosion had probably been hidden in a radio cassette player and was transferred to PA103 from a Pan Am Boeing 727 flight, arriving from Frankfurt. The Popular Front for the Liberation of Palestine General Command (PFLP-GC) was probably the organization responsible for the bombing. PROBABLE CAUSE: "The in-flight disintegration of the aircraft was caused by the detonation of an improvised explosive device located in a baggage container positioned on the left side of the forward cargo hold at aircraft station 700." (Accident Report 2/90) Source: ICAO Circular 260-AN/154 (133-188); ASW 12.4.93(3); AW&ST 2.1.89 (28-32)

19) 19.02.89 (06.36) Boeing 747-249F

N807FT (21828/408) Flying Tiger Line

4 fatalities / 4 occupants +

Location: Kuala Lumpur; 7,5 mls (Malaysia) Nature: Freight Phase: Final Approach from: to: Kuala Lumpur-Subang IAP Flightnr.: FT66 The Boeing crashed into a wooded hillside, while on an NDB approach to Runway 33. The aircraft had descended 1800ft below minimum altitude and

collided with a hill at 600ft MSL. PROBABLE CAUSE: Non-standard phraseology was used by Kuala Lumpur ATC, causing the the crew to misinterpret the instructions.
Source: ICAO Adrep Summary; AW&ST 27.02.89 (24); FI 17- 12.01.90 (44)

20) 07.05.90 () Boeing 747-237B

VT-EBO (20558/188) Air India

0 fatalities / 215 occupants +

Location: Delhi (India) Nature: Scheduled Passenger Phase: Landing from: London-Heathrow APT to: Delhi-Indira Gandhi IAP Flightnr.: AI132 The Boeing 747 touched down at Delhi after a flight from London. On application of reverse thrust, a failure of the no.1 engine pylon to wing attachment caused this engine to tilt nose down. Hot exhaust gasses caused a fire on the left wing. The aircraft was damaged beyond repair. PROBABLE CAUSE: "The accident was caused due to the migration of the improperly installed diagonal-brace aft fuse-pin of the No.1 engine from its fitting which substantially reduced the load carrying capability of the engine fittings resulting in failure of the upper-link forward fuse pin due to excessive loads on account of probably improper landing leading to a partial separation of engine and fire." Source: NTSB/SIR-94/02 (p. 16)

21) 18.02.91 () Boeing 747-136

G-AWND (19764/107) British Airways

0 fatalities / 0 occupants +

Location: Kuwait City IAP (Kuwait) Nature: - Phase: Ground from: - to: - Flight nr.: - The aircraft was at Kuwait Airport during the Iraqi invasion of August 2, 1990 and blown up by Iraqi forces when allied forces intervened.

22) 29.12.91 (ca 15.05) Boeing 747-2R7F B- 198 (22390/482) China Airlines

5 fatalities / 5 occupants +

Location: Wanli; nr (Taiwan) Nature: Freight Phase: Climb from: Taipei-Chang Kai Shek IAP to: Anchorage IAP Flightnr.: CI358 The aircraft was climbing through 5200ft when the no.3 engine separated from the wing. The engine struck the no.4 engine, which separated also. Control was lost and the aircraft crashed into a hillside at 700ft. The aircraft had accumulated 45868 hours and 9094 cycles. PROBABLE CAUSE: Initial findings suggest a failure of both no.3 engine inboard midspar fittings, partly in fatigue partly ductile. Source: S152; Aircraft Accident Report 92-11 El Al Flight 1862 ... / Netherlands Aviation Safety Board (p.32); AW&ST 6.1.92 (23); fi 8-14.1.92 (11)

23) 04.10.92 (17.35 UTC) Boeing 747-258F 4X-AXG (21737/362) El Al

4 fatalities / 4 occupants + 47

Location: Amsterdam (Netherlands) Nature: Freight Phase: Climb from: Amsterdam-Schiphol APT to: Tel Aviv-Ben Gurion Flightnr.: LY1862 PROBABLE CAUSE: "The design and certification of the B747 pylon was found to be inadequate to provide the required level of safety. Furthermore the system to ensure structural integrity by inspection failed. This ultimately caused - probably initiated by fatigue in the inboard midspar fuse-pin - the no.3 pylon and engine to separate from the wing in such a way that the no.4 pylon and engine were torn off, part of the leading edge of the wing was damaged and the use of several systems was lost or limited. This subsequently left the flight crew with very limited control of the airplane. Because of the marginal controllability a safe landing became highly improbable, if not virtually impossible." Source: Aircraft Accident Report 92-11 El Al Flight 1862 Boeing 747-258F 4X-AXG Bijlmermeer, Amsterdam October 4, 1992 / Netherlands Aviation Safety Board; NTSB Safety Recommendations A-92-117

24) 04.11.93 () Boeing 747-409

B- 165 (24313/966) China Airlines

0 fatalities / 396 occupants +

Location: Hon Kong-Kai Tak APT (Hong Kong) Nature: Scheduled Passenger Phase: Landing from: to: Hon Kong-Kai Tak APT Flightnr.: CI605 The aircraft skidded off the wet runway and ended up in shallow water. The flight landed with heavy crosswinds, caused by tropical storm Ira. Source: ASW 8.11.93(4) + ASW 13.12.93(6) + ASW 28.3.94(3); Air Letter No. 13,186 - 20.2.95 (1)

25) 20.12.95 (11.36 EST) Boeing 747-136 N605FF (20271/172) Tower Air

0 fatalities / 468 occupants +

Location: New York-John F. Kennedy IAP (USA) Nature: Scheduled Passenger Phase: Take-off from: New York-John F. Kennedy IAP, NY to: Miami IAP Flightnr.: FF41 Flight 41, bound for Miami was pushed back from the gate at 10.36h. At 11.00h deicing procedures were started at 11.00h, using both Type I and Type II fluids. The crew received clearance for Runway 4L at 11.16h and started to taxi slowly towards the assigned runway. The aircraft was stopped on the taxiway to clear the engines of any ice by increasing power to 45% N1 for 10 seconds. The aircraft continued and the flight was cleared to taxi in position and hold at 11.32h and got take-off clearance at 11.36h. The take-off was normal, until shortly before 80kts. The aircraft started to move to the left; corrections by the crew were ineffective. The captain then aborted the takeoff by retarding powerlevers to idle and by applying maximum braking. He didn't use reverse thrust, because of the slow speed, long runway and the possibility that it could worsen directional control. At 2100ft past the threshold, the 747 departed the left side of the runway. The aircraft finally struck a transformer, causing the no,4 engine to separate. The Boeing came to rest at 4800ft past the threshold and 600ft to the left of the runway centerline with the nosegear collapsed. PROBABLE CAUSE" The captain's failure to reject the takeoff in a timely manner when excessive nosewheel steering tiller inputs resulted in a loss of directional control on a slippery runway. Inadequate Boeing 747 slippery runway operating procedures developed by Tower Air, Inc., and the Boeing Commercial Airplane Group and the inadequate fidelity of Boeing 747 flight training simulators for slippery runway operations contributed to the cause of this accident. The captain's reapplication of forward thrust before the airplane departed the left side of the runway contributed to the severity of the runway excursion and damage to the airplane." (NTSB)

Source: AW&ST 1.1.96(31); Knipselkrant Luchtvaart 52-1995; S201(50); ASW 29.01.96(6) + 05.02.96(7) + 26.02.96(7) + 4.11.96 (8); NTSB Safety Recommendations A-96-45 through -47

26) 17.07.96 (20.31 EDT) Boeing 747-131 N93119 (20083/153) Trans World Airlines - TWA
230 fatalities / 230 occupants +

Location: Long Island, off (USA) Nature: Scheduled Passenger Phase: Climb from: New York-John F. Kennedy IAP, NY to: Paris-Charles de Gaulle Flightnr.: TW800

27) 12.11.96 (18.40) Boeing 747-168B

HZ-AIH (22748/555) Saudia

312 fatalities / 312 occupants + 37

Location: Charki Dadri; 3mls (India) Nature: Scheduled Passenger Phase: Climb from: Delhi-Indira Gandhi IAP to: Dhahran IAP Flightnr.: SV763 Air Kazakhstan Flight 1907 had taken off from Chimkent for a flight to New Delhi and was inbound to Delhi on Airway G452, descending to FL150. Saudia Flight 763 had taken off from New Delhi at 18.32h for a scheduled flight to Dhahran and Jeddah. The aircraft followed the Parvi SID and climbed to FL140. Apparently the Kazakh aircraft had descended below its assigned altitude and was flying at 14500ft when the crew were told there was a Saudi Boeing 747 8 miles away at FL140. Thirteen seconds later the Ilyushin had descended another 310ft. Shortly afterwards both aircraft collided, plummeted down in flames and crashed in an arid farming area. Source: AW&ST 18.11.96 (34-36); IHT 6.5.97 Pilot error focus of India Collision investigation - Nov. 14, 1996 India buries, cremates victims of air disaster

- Nov. 14, 1996

28) 05.08.97 (01.50) Boeing 747-3B5

HL7468 (22487/605) Korean Air

223 fatalities / 254 occupants +

Location: Guam-Agana IAP; nr (USA) Nature: Scheduled Passenger Phase: Final Approach from:
Seoul-Kimpo IAP to: Flightnr.: KE801

Air India Flight 182

Report on the accident to Boeing 747-237B VT-EFO, Air India Flight 182,
off Cork, Ireland on 23 June 1985

by John Barry Smith,
Independent Aircraft Accident Investigator

Appendix B: Avianca Accident (Unofficial narrative)

I. Introduction

On November 27, 1989, Avianca Airlines Flight 203, originating from Bogota, Colombia, exploded shortly after take-off, killing the 107 persons on board including two Americans. SSA Richard Hahn was assigned to this case as part of a team of representatives from the United States. Hahn collected evidence at the crime scene, examined evidence, and prepared a final report. Dandeny Munoz-Mascara (Munoz) was indicted for causing the explosion and in 1994 was tried twice in the Eastern District of New York. The first trial resulted in a mistrial; he was convicted in the second trial. Hahn testified as an explosives expert in both trials.

Whitehurst alleges that in the trials Hahn, among other things, fabricated evidence, committed perjury, and testified outside his area of expertise. Whitehurst's principal allegations concern Hahn's testimony about (1) the type of explosive that caused the crash, (2) Whitehurst's scientific results, and (3) the fire and secondary explosion that followed the initial blast.

To investigate Whitehurst's claims, we reviewed the pertinent Laboratory reports and, where available, the underlying work papers and test results. We reviewed transcripts of the testimony of Hahn and the closing arguments made by the prosecutor in both trials. We also questioned agents Hahn and Whitehurst and their former unit chiefs, J. Christopher Ronay and James Corby. Finally, we also interviewed others involved in the case, including Edward Bender, James Kearney, Donald Thompson, Dwight Dennett, former Assistant United States Attorneys (AUSAs) Cheryl Pollak and Beth Wilkinson (who jointly tried the Munoz case twice), and DEA agent Sam Trotman.

We conclude that Hahn did not commit perjury or fabricate evidence. We further conclude, however, that Hahn gave testimony that was, in part, either scientifically unsound or beyond his expertise. We also conclude that Kearney erred when he failed to resolve a dispute between Hahn and Whitehurst; the result was that Hahn gave incomplete testimony regarding Whitehurst's scientific results. Finally, we conclude that Whitehurst sent a scientifically flawed memorandum to the prosecutor during the first trial and committed other errors in the case.

The following section (Section II) summarizes the factual background to the allegations. Section III analyzes the issues relating to Hahn's testimony (Section A) and Whitehurst's conduct (Section B). We state our conclusions in Section IV.

II. Factual Background

A. The Crime Scene

On November 29, 1989, Hahn arrived in Colombia to investigate the crash. While there, he met

with and discussed the aircraft explosion with experts from the Federal Aviation Administration (FAA) and the National Transportation Safety Board (NTSB). He and other experts in various fields examined the crime scene, collected evidence, attempted to reconstruct the aircraft, and formed theories as to what happened.

After days of investigation, Hahn and the FAA representatives concluded as follows: A small explosive device functioned on the aircraft beneath a seat over the wing. This explosion breached certain portions of the aircraft and caused a fire and a second explosion described as a fuel-air explosion, which blew the aircraft apart and sent it to the ground in pieces.

On December 6, 1989, while Hahn was still in Colombia investigating the Avianca crash, a Colombian government building (the DAS Building) was bombed. Later that day Hahn went to the scene of the DAS explosion to offer his assistance. He examined the damage there and took soil samples in which no explosives residues were found.

B. The Laboratory Analysis

Hahn sent samples of evidence from the Avianca crime scene to the FBI Laboratory. Once the samples arrived, an EU technician catalogued the evidence and sent it to various units in the Laboratory for examination. Whitehurst, as an examiner in the MAU, was asked to examine various items for explosives residues. Edward Bender, the technician then assigned to Whitehurst, received and analyzed this evidence. As was customary in the Laboratory, Bender ran the instrumental analysis and reported the results to Whitehurst. Whitehurst's role as an examiner was to review and draw conclusions from the data provided by the technician.

In January 1990 Whitehurst identified RDX and PETN high explosives on a specimen from a portion of the aircraft. He wrote a report (dictation), which was approved by MAU Chief James Corby and was sent to Hahn who included it verbatim in one of his two reports. In his other report Hahn noted that a portion of the aircraft skin bore pitting and cratering unique to high explosives. Hahn concluded that an explosive device with a relatively small amount of high explosives functioned on board the aircraft, causing a breach of the fuselage and other parts of the aircraft, a fire, and a fuel-air explosion that caused the aircraft to break apart.

C. The Confessor

In the spring of 1994, on the eve of the first Munoz trial, the Attorney General of Colombia wrote a letter to the District Court Judge in the case and stated that the wrong person was charged in the Avianca case and that the responsible person was in custody in Colombia and had confessed to the crime. In interviews by an ATF agent in Colombia, the Confessor stated, among other things, that he was responsible for making the bomb that destroyed Avianca Flight 203 and that the explosive consisted of 5 kilograms of an ammonium based gelatin dynamite. The Confessor claimed that this dynamite was A the same explosive used at the DAS Building.

The Munoz prosecutor sought Hahn's advice regarding this development. According to a memorandum Hahn wrote in 1995, he advised the prosecutor [in 1994] that neither was the damage to the aircraft consistent with dynamite, based on the pitting and cratering that was present on the fuselage, nor was the damage consistent with the functioning of a single dynamite device of five kilos in size. Hahn added that his opinion was A supported by the finding of residues RDX and PETN and the lack of residues consistent with a dynamite.

On June 4, 1994, Hahn telephoned Whitehurst to tell him that he (Whitehurst) might be called as a witness to rebut the claims of the Confessor, which Hahn described. According to Whitehurst,

Hahn asked whether Whitehurst could discredit the Confessor's story based on the residue analysis. According to Hahn, he asked Whitehurst, A[C]an you say, from your material analysis, whether or not this might have been an ammonia gel dynamite or not.

During the June 4, 1994, conversation, Hahn told Whitehurst that Hahn believed the pitting and cratering on the evidence was indicative of an explosive with a VOD of 20,000 feet per second. Whitehurst responded that there are ammonia-gel dynamites capable of detonation velocities of approximately 20,000 feet per second and that therefore the damage may have been possible from such a dynamite. Hahn dismissed Whitehurst's views because Whitehurst was not at the crime scene or aircraft reconstruction and because explosives damage assessment is outside Whitehurst's expertise. Hahn did not ask Whitehurst to prepare any documents regarding his analysis of the Confessor's statement. On June 6th Hahn faxed Whitehurst a copy of one of the Confessor's statements.

D. The Whitehurst Memorandum

On June 7, 1994, Whitehurst prepared a memorandum to Corby (the Whitehurst Memorandum) relating to whether the FBI could scientifically disprove the Confessor's story. The following day Whitehurst delivered to Corby the memorandum with technical papers that Whitehurst claimed supported his views. Whitehurst stated in the memorandum that he could not disprove the use of an ammonium gel dynamite and that in fact the data is consistent with the use of an ammonium nitrate based high explosive. The memorandum asserted that the pitting and cratering did not rule out the use of a gelatin dynamite, citing the attached literature. Whitehurst also raised questions concerning possible contamination that would affect the significance of his previous findings of PETN and RDX.

Corby reviewed the memorandum overnight, and on June 9, 1994, according to Whitehurst, Corby told him to quickly provide Whitehurst's assessment to the prosecutor. Corby stated that he did not authorize Whitehurst to send the memorandum itself directly to the prosecutor, only to provide the information in the memorandum to the prosecutor. On June 9, 1994, Whitehurst gave the memorandum to an agent on the case (Dwight Dennett) to give to the prosecutor. Dennett delivered the document as promised. Whitehurst did not send a copy of the memorandum to Hahn or discuss this memorandum with him prior to sending it to the prosecutor.

On June 14, 1994, Whitehurst received a note from Corby stating that AUSA Pollak wanted to talk to him. Whitehurst called Pollak, who was angry. They discussed the memorandum. According to Whitehurst, Pollak explained the concept of Brady material and told Whitehurst that now she would have to turn the information over to the defense. At about the same time, Pollak also told Hahn that she would have to disclose the memorandum to the defense under Brady. Although Hahn later assumed the Whitehurst Memorandum was disclosed to the defense, it is unclear whether in fact disclosure was made. The prosecutors did not contact Whitehurst further regarding this case.

E. The Trials

Hahn testified in the first Munoz trial on June 7, 1994. This was two days before Whitehurst gave his memorandum to Dennett, and thus Hahn did not have the memorandum when he testified. Among other things, Hahn testified to his opinion as to how the initial and secondary explosions occurred on the aircraft and related the conclusions regarding RDX and PETN as set forth in Whitehurst's dictation. Hahn also gave testimony that tended to contradict the Confessor's story by asserting that the damage to the aircraft indicated the use of a fast-moving explosive like RDX or

PETN while the damage to the DAS Building indicated a slower-moving explosive like dynamite.

On June 14, 1994, Hahn received a copy of the Whitehurst Memorandum from Pollak. He then sent a copy to his former unit chief, J. Christopher Ronay, and discussed the matter with him. Between the two trials, SAS Chief James Kearney, MAU Chief Corby, and Ronay addressed the issues raised by Whitehurst's Memorandum but made no communication to Hahn regarding any resolution of the controversy. Hahn, therefore, proceeded to the second trial with no guidance from management about how to testify in light of the views expressed in the Whitehurst Memorandum.

On November 22, 1994, during the second trial, Hahn repeated essentially the same testimony he gave in the first trial. No mention was made of any of the opinions discussed in the Whitehurst Memorandum.

III. Analysis

A. Hahn's Testimony

1. Contradiction of Confessor, Pitting and Cratering

In both trials Hahn opined that the pitting and cratering on the fuselage of the aircraft was caused by an extremely or Avery high explosive but that the DAS Building was damaged by a slower-moving explosive such as dynamite. This testimony contradicted the Confessor's story that the same explosive--a dynamite--was used at the DAS Building and on the aircraft. We conclude that Hahn's opinions correlating the pitting and cratering to a high velocity explosive were unsound and not justified by his experience or by the scientific literature. Although a high velocity explosive may have been used on the aircraft, Hahn's opinions at the trials regarding pitting and cratering were flawed.

a. Trial Testimony

In the first trial, Hahn testified that an extremely high explosive caused the pitting and cratering on the aircraft, that RDX and PETN are explosives in that category, that no dynamite could have caused that damage, and that the damage at the DAS Building was indicative of a heaving explosive such as dynamite and not a brisant explosive like RDX or PETN. Hahn further testified that by extremely high explosive he meant the ones that do travel at 22, 24 thousand feet per second. Hahn was certain that this testimony contrasting dynamite with RDX and PETN was elicited to anticipate and contradict the Confessor's story should it be introduced by the defense. A defense based on the Confessor, however, was not interposed in either trial.

In the second trial Hahn testified that the pitting and cratering on the fuselage was caused by a very high explosive here functioning in the area of 20,000 feet per second. Regarding the damage at the DAS Building, he testified:

It indicated to me that again the explosive that was used here, unlike the explosive device or an explosive that would cause pitting and cratering, this was a much slower moving explosive. This was going to be like a dynamite or ammonia-base type nitrate explosive that would have a long period heaving effect, if you will.

b. Validity of Hahn's Correlation of the Pitting to a VOD Range

In the first trial, Hahn testified that no dynamite could have caused the pitting and cratering on the aircraft. This testimony was clearly erroneous even under Hahn's own theories, since Hahn firmly maintains that the pitting was caused by an explosive with a VOD of about 20,000 feet per second and he testified at the first trial and the OIG interviews that some dynamites have a VOD in that range.

Taken literally, Hahn's testimony in the second trial indicated that he believed the phenomenon of pitting and cratering can only occur with a Very high explosive --that is, an explosive with a VOD of about 20,000 feet per second or more. This is implied from his testimony that the damage at the DAS Building was indicative of an explosive such as a dynamite rather than an explosive that would cause pitting and cratering. Hahn told us in his first interview that at the time of the Munoz trials he had only experienced pitting and cratering with explosives having a VOD of at least 20,000 feet per second and believed that pitting and cratering would only occur with such explosives. Hahn's experience, however, was, at best, incomplete. In fact, pitting and cratering can be achieved with some high explosives with a VOD as low as 10,000 feet per second. Most dynamites have a VOD in excess of 10,000 feet per second.

In a letter after his first OIG interview and in a second interview, Hahn insisted that his testimony should not be taken literally. He maintained that when he said the explosive at the DAS Building was not the type of explosive that would cause pitting and cratering, he meant it was not the type of explosive that would cause the distinctive pitting and cratering on the Avianca aircraft. The pits on the aircraft had diameters of about one-eighth to one-quarter inch. By contrast, the pitting and cratering discussed in the articles attached to the Whitehurst Memorandum contained much smaller pits (.1 to .5 millimeters). To Hahn the size of the pits on the Avianca aircraft indicated a VOD of about 20,000 feet per second or more. Hahn insisted that it was this type of pitting and cratering (A the large pits) that he was referring to in his trial testimony.

Hahn believed that large pits, as in the Avianca case, are indicative of a VOD of about 20,000 feet per second or more because he had never seen pitting of that size or anything closely resembling that except with explosives in the range of 20,000 ft/second detonation velocity. Hahn has seen such pitting in his tests of shaped charges at the FBI range. In these tests Hahn used explosives with a VOD of at least 20,000 feet per second. Hahn theorized that the pitting on the Avianca aircraft was caused by jetting resulting from a deformation on the explosive's surface that was, in effect, a small shaped charge. See also Hahn OIG Interview: AI speculated far enough to say, there had to be some imperfection in this explosive charge to cause this shape, to form this jet.

Hahn admitted, however, that in his tests with shaped charges at the range he had never seen such pitting at all except when he was trying to deliberately achieve that effect with a shaped charge that was lined (e.g., with an old vehicle headlight) and that he had never experimented with shaped explosives with a VOD less than 20,000 feet per second. Based on this experience, therefore, Hahn was unqualified to say whether it was the shaping, the fragmentation from the lining, or the high velocity, or some combination of these elements, that was necessary to produce the large pits.

Moreover, the pitting here was found on aircraft aluminum, and Hahn had no experience using aircraft aluminum as a target material with any type of explosive. Hahn acknowledged that pitting would occur more readily on aircraft aluminum than on steel, which Hahn used in his tests.

Hahn assumed that the perpetrators of the Avianca blast did not take the time to create an intentionally shaped charge. Hahn's tests at the FBI range, in which he obtained pitting similar to Avianca's, involved lined, intentionally shaped charges and targets of steel, which had little connection to the scenario he posited in the Avianca case--an explosive not intentionally shaped with a target of aircraft aluminum.

Hahn theorized that the jetting that caused the large pits on the aircraft came from random imperfections at the surface of the explosive. Hahn acknowledged, however, that he has no experience, documentation, or anything that validates the proposition that such pits can be created from accidental imperfections on the explosive.

Additionally, Hahn admitted at one point in the OIG interviews that the pitting and cratering in this case is merely consistent with an explosive with a VOD of at least 20,000 feet per second. He stated that, because we don't have the experimental data, he cannot exclu[de] other explosives.

Accordingly, for all these reasons, we conclude that Hahn's experience was inadequate to support his opinion that the large pits found on the aircraft aluminum in this case were necessarily caused by an extremely or Avery high explosive with a VOD of at least 20,000 feet per second.

Hahn's correlation of the pitting to a VOD range was not based on his experience but was a speculative extrapolation from his experience. This speculation was based on Hahn's understanding of the science of pitting and cratering (his jetting theory). Hahn admitted, however, that the science of pitting and cratering is beyond his expertise: I'm not qualified to talk to you about exactly how this process functions. I'm not even sure that the scientific community knows exactly what goes on here, to be honest with you. Hahn was qualified to render opinions based only on his experience, which did not justify his attempt to correlate the pitting with the VOD of the explosive.

Hahn asserted that he relied on his jetting theory because AI don't know how else you would get that damage. That Hahn could conceive of no other theory, however, did not make his jetting theory valid.

Finally, Hahn's recent involvement in the Oklahoma City case has broadened his experience. The pitting in that case is similar in size to the pitting in the Avianca case, although the VOD of the explosive in Oklahoma City, according to Hahn, is significantly below 20,000 feet per second. Given the Oklahoma City case, Hahn acknowledged that big pits can be obtained from an explosive with a VOD substantially less than 20,000 feet per second. Based on the Oklahoma City case and our own experience, we conclude that there is no scientific basis for correlating large pits, as in the Avianca and Oklahoma City cases, with a VOD of about 20,000 feet per second or more.

c. Other Theories in Support of Hahn's VOD Opinion

Hahn also told us that his opinion that the explosive had a VOD of at least 20,000 feet per second rested on two factors in addition to the pitting and cratering: (1) the shattering of an I-beam on the aircraft showing that the explosive was very brisant and (2) the short amount of time the gas jet would have had to cause the pitting before the explosive shock wave and the depressurization of the cabin pushed the fuselage away. This explanation is problematic for three reasons. First, Hahn's VOD opinions at the trials only relied on the pitting and cratering. Second, the evidence that the I-beam in fact was shattered by the explosive is weak. All that one can say with certainty is that a portion of the I-beam, like many other portions of the aircraft, was missing. Hahn made no scientific comparison between (1) the ends of the I-beam that were adjacent to the missing piece and (2) the ends of other items adjacent to missing pieces, to determine whether the breakage of the I-beam was necessarily from a brisant explosive. Further, in the opinion of Walter Korsgaard, the FAA expert who investigated the Avianca crash, the wing box that contained the I-beam was violated after the second (fuel-air) explosion. Third, regardless of the VOD of the explosive, a gas jet will precede the shock wave and hit the target before the shock wave pushes it away. Hahn made no calculations of the difference in speed between a jet from an explosive with a VOD of

20,000 feet per second and a jet from an explosive with a VOD of, say, 16,000 feet per second. Needless to say, jets from either explosive would travel extraordinarily fast. Hahn has no scientific basis for concluding that the depressurization of the cabin would have pushed the fuselage away before it could have been hit by a jet from an explosive with a VOD below 20,000 feet per second.

On January 8, 1997, an attorney representing Hahn submitted a letter arguing, among other things, that, quite apart from the pitting and cratering, Hahn's VOD opinion was reasonable in light of (1) the shattering of the I-beam and (2) the detection of residue of RDX and PETN. The letter asserts that these two factors, taken together, alone establish the reasonableness of Agent Hahn's conclusion. (Emphasis in original). Again, this justification is not the one Hahn used in his trial testimony, in which he asserted that the pitting established the explosive's VOD. In any event, as discussed in the preceding paragraph, the evidence that the I-beam was shattered in such a way as to show high brisance is weak. As to the second factor, if the explosive device on the aircraft used RDX and PETN as the explosive main charge, then by definition the main charge would have had a VOD in excess of 20,000 feet per second since the VODs of RDX, PETN, and Semtex (which combines RDX and PETN) exceed 23,900 feet per second. The residue evidence does indicate that the main charge may have consisted of RDX and PETN and that therefore the VOD of the main charge may have exceeded 23,900 feet per second. Had Hahn so testified, his testimony would have been reasonable, but he testified to something else. The problem with Hahn's testimony was that he correlated the pitting to a particular VOD range. That testimony was scientifically unsound and not justified by Hahn's experience, regardless of what the residue evidence may have shown.

d. Hahn's Rejection of the Whitehurst Literature

On June 14, 1994--a few days after his testimony in the first trial and 5 months before his testimony in the second trial--Hahn received the Whitehurst Memorandum with its attached scientific literature. One of the attached articles indicated that pitting and cratering could be achieved on aircraft aluminum with a 40% Forcrite gelatin dynamite. Although Hahn assumed in 1994 that this dynamite had a VOD of 20,000 feet per second, in fact its VOD is about 13,800 feet per second.

Hahn told us that he ignored the literature when he testified in the second trial, because the pitting depicted in the literature (pits with a diameter of .1 to .5 millimeters) was vastly different in dimension from the pitting in the Avianca case (pits with a diameter of 1/8 to 1/4 inch). Hahn stated in his interview that A[u]ntil such time as I saw Mr. Whitehurst's paper, I never paid attention to, looked for, [or] was even aware of this sort of microscopic pitting and cratering that that paper refers to.

The literature also discussed how pitting and cratering is caused. One article (by H. P. Tardif and another author) stated:

This phenomenon can be produced by two separate mechanisms. The first is due to the shaped charge effect caused by tiny imperfections at the surface of the charge. These imperfections, such as holes and cavities, collapse to form extremely high velocity jets of gases which impinge on the surface to form small crater-like pits. The second appears to be caused by the high velocity impact of small amounts of unconsumed explosive with a nearby surface or by friable extraneous material placed between the charge and the nearby surface.

A second article (by D. G. Higgs and T. S. Hayes) stated: AIt is thought that the pits are caused by the impingement of high velocity particles of partially combusted explosive and/or fused

extraneous matter encountered between the explosive charge and the witness' material.

The Tardif and Higgs explanations differed from Hahn's jetting theory in two respects. First, Hahn believed that pitting was derived from gas jets. Both articles, however, provide another mechanism for pitting--namely, the impingement of particles of unconsumed explosive or extraneous matter placed between the explosive and the target. Second, the Tardif article does include as one mechanism Hahn's theory that pits can be caused by jets formed from imperfections at the surface of the explosive. But Tardif states that these pits will be small, presumably within the size range discussed in the article (.1 to .5 millimeters). The Tardif article thus at least raises the question whether Hahn's jetting theory can account for the large pits on the Avianca aircraft.

After Hahn received the Whitehurst memorandum and the attached scientific literature, he made no inquiries before the second trial concerning the soundness of his theories regarding pitting and cratering. Because Hahn was unfamiliar with microscopic pitting and had no experience with pitting on aircraft aluminum and because the articles raised questions concerning the validity of his jetting theory, we conclude that Hahn erred when he failed to look into these matters before he testified in the second trial.

2. Hahn's Testimony About the Results of Whitehurst's Examination

Whitehurst contends that in both trials Hahn gave inappropriate testimony regarding the findings of RDX and PETN, because Hahn failed to mention the conclusions set forth in the Whitehurst Memorandum. We conclude that Hahn's testimony in the first trial was unobjectionable but that his testimony in the second trial was incomplete. Further, we conclude that SAS Chief James Kearney contributed to Hahn's incomplete testimony by not properly resolving the issues raised by the Whitehurst Memorandum. As discussed in Section B, infra, however, the Whitehurst Memorandum was a deeply flawed document. Accordingly, the impact of Hahn's failure to mention the opinions in the document may have been insignificant.

a. Background

In 1990 Whitehurst submitted AE dictation in which he identified the presence of RDX and PETN high explosive[s] on a specimen consisting of a piece of the rubber fuel bladder Hahn had cut from the Avianca wreckage in Colombia. The dictation contained no other findings on any specimen. The instrumental analyses upon which Whitehurst based his conclusions were performed by a technician, Edward Bender.

On June 8, 1994, the Whitehurst Memorandum was submitted to Corby. In the memorandum, Whitehurst reviewed this matter and offered opinions that supplemented or questioned his 1990 dictation. Whitehurst stated: AIt is my opinion at this time that the data we acquired from analysis of the evidence provided to us in this matter does not disprove the use of an ammonium nitrate based high explosive and in fact is consistent with but not proof of the use of such an explosive. Regarding his 1990 chemical analysis that detected PETN and RDX, Whitehurst stated that A[a] number of questions [about possible contamination] need to be answered before we can determine the significance of that data. He then listed a series of questions concerning possible contamination at the crime scene, during transportation of the evidence, and during the processing of the evidence at the Laboratory. He further opined that A[t]he upshot of all of this is that the data we have at this time cannot be used to successfully disprove the statement that a gelatin dynamite was used in this bombing.

On June 14, 1994, a week after he testified in the first trial, Hahn received the Whitehurst

Memorandum. He discussed the memorandum with EU Chief Ronay and sent Ronay a copy of the memorandum on June 14, 1994. On June 16, 1994, Ronay sent a memorandum to SAS Chief Kearney regarding the Whitehurst Memorandum, which he attached. On June 22, 1994, Hahn also sent Kearney a memorandum. Shortly after receiving Ronay's memorandum, Kearney sent a list of questions to Corby about the events surrounding the Whitehurst Memorandum and its dissemination to Pollak. Corby responded to Kearney's questions in writing on July 6, 1994. Corby supported many of Whitehurst's opinions.

Kearney told us he thought both Hahn and Whitehurst should have testified at the trials. However, neither Kearney, Ronay, nor any other supervisor advised Hahn on how he should deal with the Whitehurst Memorandum in his testimony at the second trial.

Hahn regarded the Whitehurst Memorandum as a rejection of his [Whitehurst's] own scientific findings. Hahn stated, "In this case, Mr. Whitehurst has, in writing, offered an opinion contrary to his own scientific findings. Nevertheless, on November 22, 1994, Hahn testified in the second Munoz trial that in 1990 he submitted pieces of the aircraft and swabbings to the Materials Analysis Unit of the F.B.I. laboratory to try -- who specialize in looking for explosives residue to try to determine what explosive was used here.

Q. What were the results of those tests?

A. The results were although they found no residue that they could identify here on this piece, or any other piece, except a piece of the fuel bladder, and on that piece of fuel bladder taken from the area right immediately underneath the blast, they found residue of two explosives, Research Development Explosive, RDX, which is again a very fast brisant explosive; and PETN, or Penta-erithrit[o]l tetranitrate. . . .

In his testimony Hahn made no mention of anything in the Whitehurst Memorandum.

Hahn maintains that he properly ignored the Whitehurst Memorandum in his testimony for the following reasons:

What he says in the letter [referring to the Whitehurst Memorandum] is not based on any sort of analysis. What he says in the letter is based on speculation, it's not the results of his material analysis.

I mean, Fred does nothing in that letter [but] speculate as to what could have been or what might have been or what may have occurred. His scientific analysis, his instrumental analysis that he conducts, still remains that the results were PETN and RDX.

Furthermore, I spoke to Bender, who actually conducted it, who, again, was completely comfortable with those results, felt they could be relied upon. Why should I not rely on them.

Further, Hahn told us that he answered the questions raised by Whitehurst regarding contamination and assured himself that there was no contamination of the evidence. Finally, Hahn relied on his belief that the defense had a copy of the Whitehurst Memorandum so that the defendant could call Whitehurst as a witness to elicit any of the information in the memorandum.

b. Discussion

(1) Hahn

Because Hahn was unaware of the Whitehurst Memorandum when he testified in the first trial, he cannot be faulted for failing to include it in his testimony.

Regarding Hahn's testimony in the second trial, Whitehurst alleges that Hahn committed perjury by reciting the MAU results without supplementing or amending them with the information in the Whitehurst Memorandum. Although we find no perjury, we conclude that the testimony was incomplete.

When one Laboratory examiner testifies to the results or conclusions of another examiner, the testifying examiner has a duty to report the results accurately and completely--whether he agrees or disagrees with his colleague's opinions. Although in 1990 Whitehurst concluded that RDX and PETN were on the fuel bladder and that, according to his dictation, he reached no other conclusions regarding explosives residue, Whitehurst stated in 1994 that he reached additional conclusions from a review of the data. It was beyond Hahn's expertise as an EU examiner, and beyond his discretion as a witness purporting to recite the results of another examiner, to selectively omit the 1994 conclusions because Hahn thought they were speculative or otherwise meritless. What was requested of Hahn on the witness stand was not his evaluation of Whitehurst's conclusions but merely a factual restatement of them. When Hahn was asked to state the MAU results, a complete answer would have been that the MAU chemist found RDX and PETN in 1990 but on a further review in 1994 also found that the data did not prove but was consistent with an ammonium nitrate explosive and thought that the significance of the data for RDX and PETN could not be determined without answering certain questions about contamination. Since Hahn believed that in 1994 Whitehurst reject[ed] the scientific findings made in 1990, Hahn's testimony about the 1990 findings was potentially misleading without the caveat that the author of the 1990 findings now had misgivings and additional findings.

We recognize that Whitehurst neither withdrew the original dictation nor submitted a supplemental dictation. Nor do we consider the Whitehurst Memorandum a complete rejection of Whitehurst's dictation. Nevertheless, when Hahn testified in the second trial, Hahn was aware that Whitehurst had reached additional conclusions supplementing those reflected in his 1990 dictation. To ignore the Whitehurst Memorandum because it lacked the form of a supplemental dictation would be an elevation of format over substance. At a minimum, Hahn had an affirmative duty to obtain explicit permission from a supervisor before he omitted reference to the Whitehurst Memorandum, because such omission was potentially incomplete and misleading. He failed to obtain such supervisory approval.

That Bender was comfortable with the original dictation is immaterial. Bender was a technician. Whitehurst, as the examiner, was responsible for the MAU results and conclusions. Moreover, all Bender could say was that the instrumental results were accurate--something Whitehurst never disputed. The Whitehurst Memorandum concerned additional conclusions concerning an ammonium nitrate explosive and the significance of the instrumental results--matters on which Bender was unqualified to comment.

Similarly, that Hahn believed there was no contamination did not justify omitting language Whitehurst used to qualify his conclusions.

Finally, that the defense may have had the Whitehurst Memorandum does not mean Hahn could ignore it in his testimony. Regardless of what the defense possesses, an examiner has a duty to present accurate testimony. By not testifying to the information in the memorandum, Hahn gave

testimony that was incomplete. Moreover, Hahn did not know for a fact that the memorandum was disclosed. Although Hahn told us I'm certain the prosecutor gave the memorandum to the defense, he also told us, A So, I mean, I don't really know, but I imagine that [Cheryl Pollak, the prosecutor] recognized that it was incumbent upon her to provide it [to the defense] and she discharged her duties. I have no reason to presume otherwise.

When one examiner testifies to another examiner's conclusions, the testifying examiner is only a messenger. He has no discretion to omit language supplementing or qualifying the conclusions, even if he believes the language is speculative or groundless. We recognize that Hahn was presented with a very unusual and difficult situation and that he received no guidance from his supervisors. We nevertheless conclude that he had an affirmative duty to resolve the controversy before he gave potentially incomplete and misleading testimony and that he therefore erred when he testified, without explicit supervisory approval, as though the Whitehurst Memorandum did not exist.

(2) Kearney

Although Hahn erred in his testimony, Kearney contributed to that error. Kearney told us he believed that the Whitehurst Memorandum would not affect the Laboratory results or Hahn's testimony. Yet Kearney recognized that in the memorandum Whitehurst was attempting to qualify his initial results, and Kearney thought that Whitehurst should have testified to his examination and results at trial. Had Whitehurst testified, the qualifications] to his initial results would have been put before the jury. Yet Kearney took no action either to cause Whitehurst to testify in the second trial or to tell Hahn to include the qualifications] in his own testimony if Hahn was asked to restate Whitehurst's conclusions.

Moreover, Corby supported much of Whitehurst's analysis, but we can detect no steps taken by Kearney to consult with other qualified experts to resolve the scientific issues. Without further review of the technical and scientific issues that had been raised, we do not see a valid basis for Kearney's decision to dismiss the concerns raised by the Whitehurst Memorandum.

One example of a scientific issue in the memorandum that Kearney dismissed without proper consideration related to Whitehurst's observations concerning the VOD necessary to cause pitting and cratering. Despite Corby's support for Whitehurst's position, Kearney apparently rejected Whitehurst's position without thorough scientific research and analysis.

The most glaring mistake made by Kearney was his failure to communicate to Hahn or Whitehurst, and document, any decisions he did make. Whitehurst waited but was never called as a witness in the first trial. He was not even informed of the second trial. Hahn heard nothing regarding his complaints about the memorandum and thus proceeded to the second trial with no further guidance on how to handle any questioning on this topic. If the memorandum had been turned over to the defense, questions regarding it were certainly possible at the second trial. Kearney should have informed Hahn of his reasoning in dismissing the concerns in the memorandum so that Hahn could be prepared to respond to defense questions. Instead, management left Hahn and Whitehurst totally unprepared for the embarrassing situation in which they might be forced to take the stand and contradict each other.

In sum, we conclude that Kearney erred in not properly resolving the issues raised by the Whitehurst Memorandum and not communicating his decisions to Hahn and Whitehurst.

3. Secondary Explosion

Hahn testified in both trials that, after the explosive device was detonated on the Avianca aircraft, a fire started resulting in a secondary explosion, which he described as a fuel-air explosion, that destroyed the aircraft. In the first trial he stated that Awe reached the conclusion as to what happened. By implication, this meant that Hahn reached the conclusion in consultation with the FAA and NTSB representatives at the crime scene. In contrast, in the second trial Hahn stated that the scenario he described was Amy conclusion. This statement of the conclusion is problematic because Hahn is not an expert in fuel-air explosions.

When asked by the OIG what experience he had in linking particular damage with the occurrence of a fuel-air explosion, Hahn stated, The FAA has conducted experiments where they've done fires on board an aircraft fuselage and have had areas of flashover, and I've seen videos of that. And other than that, and being aware of fuel-air explosions, I don't have any experience. Hahn further explained that he based his testimony on other experts and things that he had read about fuel-air explosions. Hahn readily admitted to the OIG that he was not an expert in fuel-air explosions.

We find Hahn's testimony in the second trial regarding fuel-air explosions to be beyond his own experience and expertise. As proof of his lack of expertise, we cite the fact that Hahn interchangeably refers to the secondary explosion as a fuel-air explosion or a flash fire. These two phenomena are not the same, and Hahn's use of the two descriptions interchangeably is incorrect. Hahn admitted that he was using the two words to mean the same thing; however, he clarified that what he was really talking about was a flashover or the point at which matter suddenly burns explosively. This distinction was not made in his testimony at trial.

Walter Korsgaard was the FAA representative who investigated the Avianca crash; he is an expert on fuel-air explosions on aircraft. Like Hahn, Korsgaard concluded that a fuel-air explosion occurred on the Avianca flight. Korsgaard's opinion as to what happened, however, differed from Hahn's in certain respects. Korsgaard's report states:

Based on the above evidence and various eye witness accounts, the following sequence of events can be developed:

- [1] IED [improvised explosive device] detonates in area under seat number 14F and frame station 783 on passenger cabin floor.
- [2] Passenger cabin floor penetrated.
- [3] Passenger cabin fuselage skin and top of center fuselage fuel tank middle bladder section penetrated.
- [4] Passenger cabin relatively slowly begins to decompress and pressurize[d] center fuselage fuel tank.
- [5] A fuel/air explosion and fuel ignition is initiated in top of center fuselage fuel tank spreading rapidly thru [sic] vent holes to right and left number 2 fuel tank wet wing sections and back into passenger cabin as pressure in fuel tank exceeds cabin pressure.
- [6] Structure integrity of center fuselage wing box section and right and left wet wing fuel tank sections of number 2 fuel tank bulkheads are violated.
- [7] Fuel in wet wing fuel tanks numbers 1 and 2 is ignited.

-- [8] The APU [auxillary power unit] located at rear of center fuselage wing box section is blown to rear of aircraft by the force of the fuel/air explosion within this center section fuel tank.

Korsgaard continues the sequence of events by describing how the aircraft broke up and came to the ground.

In the two trials and in his OIG interview, Hahn testified to a scenario different from Korsgaard's. Hahn agreed with the first three events described by Korsgaard: an IED detonated under seat 14F, breaching the center fuselage fuel bladder tank and the side of the aircraft. Then their accounts diverge. Hahn made no mention, as Korsgaard did (Event 4), that the passenger cabin relatively slowly beg[an] to decompress and pressurizes center fuselage fuel tank. In fact earlier in Hahn's testimony in the second trial he said that certain aircraft damage indicated rapid depressurization of the cabin.

The next event, according to Korsgaard (Event 5), was that a fuel/air explosion and fuel ignition is initiated in top of center fuselage fuel tank. According to Hahn, on the other hand, the next event is a fire that burned Adirty, throwing a lot of hot gaseous material into the air, a lot of hot matter into the air. According to Hahn, the fuel-air explosion did not come until later:

[W]hat I believe happened is that a small explosive device functioned, breaching the aircraft, opening the side of the fuselage, opening up the bladder box or the bladder fuel cells inside the wing, blasted and started a fire.

That fire burned for a number of seconds, probably in the neighborhood of a minute, at which point in time the hot gases and hot particula[te] matter from that fire caused the secondary explosion of fuel air explosion. That broke the aircraft apart.

Moreover, according to Hahn, the fuel-air explosion did not occur in the fuel tank, as Korsgaard stated, but rather inside the fuselage (first trial). As Hahn described it in his OIG interview:

So the fire [that was set off by the explosive device] is burning as that fuel is venting and it's burning not only fuel, but it's going to be burning carpeting and seat cushions and fabrics, rugs, whatever is there on board that aircraft. . . . [E]ventually it reaches a point where you have enough heat and hot gasses and hot flammable gasses and particulate matter in the air where it flashes over, and when it flashes over, the aircraft comes apart.

In the first trial and in the OIG interview, Hahn compared the fuel-air explosion in Avianca to a fuel-air explosion in a grain elevator, in which small particulate matter from the grain is suspended in the air. Korsgaard said nothing about particulate matter from the interior of the cabin playing a role in the fuel-air explosion.

Thus, Hahn's theory regarding a fuel-air explosion differed from Korsgaard's in three principal respects. The first difference related to the sequence of events: Korsgaard thought the event that followed the detonation of the IED was the fuel-air explosion and the fire, whereas Hahn testified that the detonation led to a fire that burned probably for about a minute and then the fuel-air explosion occurred. The second difference related to the location of the fuel-air explosion: the center fuel tank (Korsgaard) as opposed to the fuselage (Hahn). Finally, Korsgaard did not say, as Hahn did, that particulate matter played a role in the explosion.

Because Hahn is not an expert in fuel-air explosions, he should have simply testified to the opinion of Korsgaard (or to the opinion of another qualified expert)--with an attribution and without embellishment. Hahn ventured beyond his expertise when he developed and testified to his own theory of a fuel-air explosion.

4. Injuries to Passengers

Hahn testified in both trials that certain injuries observed on the passengers' bodies--hard, burnt skin and skulls that had been cracked open--supported his theory of a secondary explosion. In the first trial he stated that these injuries were consistent with extreme heat, flash-fire type of damage. In the second trial he stated the injuries were consistent with a flash fire or a fuel-air explosion. We conclude that this testimony was beyond Hahn's expertise and was incorrect.

Hahn told us that he drew the connection between these injuries and the flash fire because the only other place he had heard of the same type of injuries was in lectures regarding a flash fire at Dupont Plaza in Puerto Rico. He also told us that he was familiar with the subject matter because he attended lectures on fire damage by a former agent where this was discussed and had read articles about these same types of injuries and their causes. We conclude that this experience was inadequate to make him an expert on the relationship between the injuries and an explosion.

In fact, the injuries are not consistent with a flash fire or fuel-air explosion, which are of short duration. Rather, the injuries indicate that the bodies were subjected to substantial heat for a significant period of time. When we pressed Hahn on this point, he acknowledged that the injuries to the bodies did not justify the opinion that a fuel-air explosion occurred but rather that there was a hot fire burning for a continuous period of time. Hahn admitted that it might have been more accurate for him to say that the injuries to the bodies were consistent with his theory of how the fuel-air explosion came about--that is, that there was a preexisting condition (the continuous hot fire) which could have led to a fuel-air explosion. As Hahn also admitted, however, this preexisting condition would not always result in a fuel-air explosion, and a fuel-air explosion would not always require a fire such as the one he believed occurred in this case. Essentially, the injuries to the bodies told Hahn nothing about whether a fuel-air explosion occurred; they only told him that an intense fire burned for a period of time. This is quite different from his testimony that the injuries to the bodies were consistent with a flash fire or fuel-air explosion.

Hahn told us he thought he could render opinions about matters if AI know more than a layman, which is your test of whether or not you're an expert. He also stated that Aif I know the answer it would be permissible for him to respond to questions outside his expertise. As exemplified by this case, Hahn's views are incorrect and dangerous. All educated laymen are not experts. That a witness thinks he knows the answer to a question does not mean he does. To assure that erroneous and unreliable information is not presented in court, a Laboratory examiner must only answer questions within his expertise.

In sum, we conclude that Hahn's testimony about the injuries was misleading, inaccurate, and outside his area of expertise. We further conclude that he improperly used this testimony to support his theory of a fuel-air explosion.

5. Other Allegations

Concerning Hahn's testimony, Whitehurst makes numerous other allegations, which we will address summarily. Because Whitehurst makes the same basic criticisms to Hahn's testimony in both trials, the references below are to the second trial unless otherwise noted.

a. Whitehurst contends that Hahn misstated his qualifications and background. We conclude that only one contention has merit. Hahn was not required to volunteer his major in college (English), and, when Hahn testified to his participation in scores of bombing cases, he was not required to volunteer the percentage relating to aircraft explosions.

Hahn also testified that A[m]y experience includes being called upon to do crime scene processing and make assessments of such notable causes of explosives [sic] in criminal cases such as Pan Am 103 over Lockerbie, Scotland and the World Trade Center in New York. This testimony overstated Hahn's experience. In the Pan Am 103 case, Hahn's only involvement in explosive assessments was that he examined the passengers' personal effects for blast damage. In the Trade Center case, Hahn's role was limited to management of the crime scene and did not include analysis of the evidence.

b. During his testimony Hahn was shown numerous photographs (most of which he took) of the aircraft wreckage and debris and a diagram of the aircraft, and he was asked to state his observations. Regarding one photograph he stated that Aon the inside wall of this fuselage is where we actually found charring and heat damage, which told us that, again, this side of the aircraft from the outside was not on fire, but inside smoke was filling out, circulating throughout the fuselage, and heating up terribly, melting down things on the inside of the aircraft on the left-hand side. (Emphasis added.) Although Hahn may not be an expert on fire damage to aircraft, his testimony here implicitly meant that the other experts at the scene, who do have expertise on this subject, participated in the assessment. Accordingly, we do not fault this testimony.

Regarding another photograph Hahn testified:

That is a wing of the aircraft and it show[s] very severe fire damage. That fire damage is very evident here (indicating) where you see this white area on the far right-hand side of the photograph, but that is actually where the aluminum has become oxidized from the heat. Cooked, if you will, almost to a boiling point.

We conclude that this testimony exceeded Hahn's expertise and was inaccurate. Hahn had no expertise in the oxidation of aluminum. Without a scientific examination of the white area, Hahn could not say categorically that it was the result of oxidation. In his OIG interview Hahn told us that the oxidation would not occur just from heat, as he testified at trial, but from the burning process in the presence of air (oxygen). Hahn had no scientific basis for saying that the aluminum was A[c]ooked . . . almost to a boiling point.

Regarding the diagram and other photographs, Hahn commented on the structure of the aircraft. Kearney felt Hahn drifted outside his expertise on some of this testimony. Some of Hahn's comments were merely descriptive, requiring no special expertise (debris at the crime scene, main landing gear). Other testimony, however, appears to require expertise that Hahn lacked (position on aircraft of fuel tanks, position and function of Awing box). Also, Hahn commented on what he perceived as non-explosive damage (deformation of fuselage by depressurization of aircraft). In these examples, Hahn should have made clear that he was basing his testimony on information received from other experts. In contrast, regarding the lack of information from the voice data recorder, Hahn testified that A[w]e believe the lines were cut by the detonation of the explosive device (emphasis added), implying that the assessment came, at least in part, from the aircraft experts at the scene.

c. We reject Whitehurst's contention that an EU examiner such as Hahn, because he is not a metallurgist, is unqualified to testify about his observations of unique explosive damage such as

pitting and cratering. Such observations and conclusions are within a qualified EU examiner's expertise. Similarly, Hahn was qualified to say that (1) a portion of the emergency exit was probably in . . . many pieces because it was situated near the seat of the explosive device, (2) certain damage was Aprobably impact rather than explosive pitting, and (3) the explosive pitting would occur within a certain distance of the explosive. We do not consider the latter comment fabricate[d] testimony, as Whitehurst claims.

d. We conclude that Hahn was beyond his expertise and inaccurate in his use of certain terms (the gas causing pitting and cratering was in the form of a plasma, the metal in the pits was crystallized, the explosive Semtex contains a butylene binder). These terms were unnecessary to Hahn's presentation and should have been avoided.

e. Contrary to Whitehurst's claims, Hahn, in our opinion, did not give fabricate[d] explanations of brisant explosives and the functioning of a high explosive (A[h]igh explosives function not by burning, but by molecular breaking apart). These were not unacceptable lay explanations for these matters.

f. We find no fault with Hahn's testimony about the uses of PETN and RDX and the composition of Semtex. In fact, these explanations track Whitehurst's dictation. Similarly, Hahn's testimony that Semtex and C-4 are not, and nitroglycerine is, impact sensitive was accurate.

g. Hahn testified as to how his duties differed from the duties of the NTSB and FAA representatives, by saying that his assignment was to determine whether an explosive device functioned on the aircraft and the duties of the others were primarily to determine whether the crash resulted from a mechanical failure. We think this testimony was slightly inaccurate. Needless to say, if it was determined that the crash resulted from a criminal act, the FBI would have been the exclusive agency of the United States to investigate the crime. But the NTSB and FAA are, without limitation, mandated to determine the cause of the crash, which would include an inquiry by them as to whether an explosive device was used.

h. Whitehurst expressed concern that Hahn's testimony showed that his presence at the DAS crime scene may have led to contamination of the Avianca evidence. Hahn, however, told us that he had sent the Avianca evidence to the Laboratory before the DAS Building was bombed.

i. In the first trial, after Hahn testified to the findings of RDX and PETN, he was asked whether those chemicals would be found in any other part of the plane other than an explosive device --in, for example, the seats or the paneling. Hahn replied:

They are both extremely unstable molecules, as any explosive would be. And they, in fact, they can break down with something as simple as sunlight. You would not find them in the environment, no.

This answer was partially inaccurate. Although RDX and PETN do not occur naturally in the environment, they are not extremely unstable and would not readily break down from sunlight under normal circumstances.

B. Whitehurst's Conduct

As explained below, we conclude that Whitehurst's conduct in this case was deeply flawed in several respects.

1. Overload

discredit the Confessor's claim that an ammonium nitrate gelatin dynamite was used on the aircraft. As Whitehurst told Hahn on June 4th, and as Whitehurst acknowledged in his memorandum, he would have expected to find residues of nitroglycerine (NG) on the evidence if a dynamite had detonated on the aircraft. (NG is a primary component of dynamite. See n.98, supra.) According to the Whitehurst Memorandum, however, no residues of NG were found on the specimens Whitehurst examined. Nevertheless, Whitehurst concluded in the memorandum that he could not disprove the dynamite claim. One of the reasons for this conclusion was that Whitehurst noticed in his 1994 review that the liquid chromatography test (LC) for PETN was overloaded, which may have obscured the presence of NG. Because, therefore, NG may have been present but not detected due to the overload, Whitehurst asserted in the memorandum that he could not eliminate the possibility of a dynamite.

What Whitehurst overlooked in his 1994 review, however, was that, in addition to the LC test, a thin layer chromatography test (TLC) was conducted. The TLC would have detected NG if present. It did not. A thorough review of the file by Whitehurst would have revealed this information. When we confronted Whitehurst with the TLC results, he admitted that he erred in not reviewing the TLC data in 1994 and in concluding that due to the overload he could not exclude the presence of NG. Thus, we fault Whitehurst for failing to conduct an adequate review of his own file prior to issuing his memorandum, a review that would have invalidated his theory that NG may have been present and was obscured by the overload.

With respect to his original 1990 examination, we also fault Whitehurst for failing to recognize the overload and run a second test.

2. Misstatement of the June 4th Conversation and of the Pertinent Issue

The Whitehurst Memorandum began with a summary of Whitehurst's June 4, 1994, conversation with Hahn about the Confessor. The summary, however, misstates the conversation on a material point. According to the memorandum, Hahn said in this conversation that the Confessor claimed to have used an ammonium nitrate based explosive (emphasis added) and that the damage was not consistent with an ANFO type explosive. (ANFO consists of ammonium nitrate and fuel oil.) In fact, as Whitehurst acknowledged in his OIG interview, Hahn said that the Confessor claimed to have used an ammonium nitrate based dynamite. When Whitehurst wrote the memorandum, he, of course, knew the claim concerned a dynamite, since he discussed dynamite throughout the memorandum, and he attached to the memorandum one of the Confessor's statements, which described the use of a dynamite.

One important difference between an ammonium nitrate based explosive and an ammonium nitrate based dynamite is NG, which is an essential component only of the latter. By misstating the June 4th conversation by omitting reference to a dynamite and by including reference to ANFO, Whitehurst made it seem that the important issue to be addressed in the memorandum was the use of an explosive that may not contain NG. As noted, Whitehurst detected no residues of NG on the evidence.

In the second paragraph of the memorandum, Whitehurst stated the following conclusion:

It is my opinion at this time that the data we acquired from analysis of the evidence provided to us in this matter does not disprove the use of an ammonium nitrate based high explosive and in fact is consistent with but not proof of the use of such an explosive.

Later in the memorandum, Whitehurst stated the basis for this conclusion:

The presence of white powder in the pits and the initial data consistent with the presence of nitrate and nitrite ions is consistent with though not proof of the presence of an ammonium nitrate based explosive.

This conclusion tracked Whitehurst's misstatement of the June 4th conversation and begged the real question in the case--namely, whether the data disproved or was consistent with the use of an ammonium nitrate based dynamite. As Whitehurst stated in his interview, The question that [Hahn] asked me was essentially, was an ammonium nitrate gelatin based dynamite used, or can you discredit that.

Because Whitehurst detected no NG residue, it would have been difficult for him to conclude that the evidence in fact is consistent with the use of a dynamite. We are unable to find that Whitehurst deliberately misstated the June 4th conversation to avoid that difficulty but still render an opinion that the evidence was consistent with a large class of explosives that would appear to include an ammonium nitrate dynamite. In any event, the conclusion about an ammonium nitrate explosive did not address the exact question asked by Hahn. Nowhere in the Whitehurst Memorandum does the author say that the data is consistent with an ammonium nitrate dynamite.

Whitehurst may have rendered an opinion that the data was consistent with an ammonium nitrate explosive because he thought this was the only conclusion justified by the evidence and he thought, in good faith, that he should set forth any conclusions he could reach. If so, he should have stated explicitly that he could not conclude that the data was in fact consistent with an ammonium nitrate dynamite, the Confessor's alleged explosive. As written, the conclusion is, at best, confusing, because it erroneously suggests that Whitehurst thought the data was consistent with the Confessor's story.

3. Validity of Opinions

a. Ammonium Nitrate Explosive

As noted, Whitehurst opined that the data (1) does not disprove, and (2) in fact is consistent with, an ammonium nitrate based high explosive. The first part of the opinion appears valid. Indeed, because all the remnants of the aircraft were not recovered and because the recovery did not begin until several days after the crash, it would have been virtually impossible to disprove the use of any explosive based on the residue analysis. Finding one or more explosives on the recovered residue (e.g., RDX and PETN) would not preclude the possibility that the residue of another explosive either was on an unrecovered remnant or, before the recovery began, was washed away by rain, was dislodged by the crash, decomposed, etc. The failure to find residue of an ammonium nitrate explosive, therefore, would not constitute proof that the explosive was not used on the aircraft.

In contrast, Whitehurst's opinion that the data in fact is consistent with an ammonium nitrate explosive is an overstatement by any reasonable measure. Whitehurst stated in the memorandum: The presence of white powder in the pits and the initial data consistent with the presence of nitrate and nitrite ions is consistent with though not proof of the presence of an ammonium nitrate based explosive. Whitehurst's technician found white powder in certain pits on the fuselage. This white powder possibly could have been ammonium nitrate. The technician, however, attempted to examine this powder instrumentally and was unable to determine what it was. The identity of the white powder is unknown.

As for the ions, Whitehurst's technician produced initial data consistent with the presence of nitrate and ammonium ions on specimen Q13. A second test, however, could not confirm[] the presence of the ions. Accordingly, it is not certain that the ions were in fact present. In any event, because nitrate and ammonium ions occur naturally in the environment, the mere detection of them has only very limited probative value.

Whitehurst himself later maintained that similar results were not significant when he criticized certain work by David Williams in the Oklahoma City case. There, Williams stated in his report that A[a]mmonium ions and nitrate ions were found to be present on specimen Q171. This statement was apparently made in support of Williams' theory that ANFO was the main charge in the explosive device. Whitehurst had this to say about Williams' statement:

Why is Mr. Williams being allowed to introduce this into his report. He knows perfectly well that that means absolutely nothing at all. But the prosecutors will not. After an explosion the presence of nitrates are ubiquitous. Before an explosion nitrates are ubiquitous, everywhere. We are only now conducting background studies to determine just how prevalent. Many explosives give off ammonium. It means nothing, UNLESS TAKEN OUT OF CONTEXT.

(Capitalization in original; emphasis added.) When confronted with the contradiction between his comments about ions in the Avianca and Oklahoma City cases, Whitehurst could provide no explanation.

The laboratory notes in the Avianca case for specimen Q13 state that the ammonium and nitrate ions could not be reasonably associated because ammonium nitrate was not detected on a particular test and both ions could be formed by other than ammonium nitrate explosives. In his dictation, neither did Whitehurst mention the ions, nor did he say the data was consistent with an ammonium nitrate explosive.

Because (1) the white powder could not be identified, (2) the presence of the ions could not be confirmed, and (3) the ions have been found to occur naturally in the environment, we conclude that Whitehurst's statement that the data is consistent with the use of an ammonium nitrate explosive is overstated and suggests too strongly that such an explosive may have been used on the aircraft.

b. Ammonium Nitrate Dynamite

In his memorandum Whitehurst also opined that the data we have at this time cannot be used to successfully disprove the statement that a gelatin dynamite was used in this bombing. This opinion is valid for the reasons stated above concerning the inability to disprove the use of an ammonium nitrate explosive (failure to recover all remnants of the aircraft, etc.).

In his OIG interview Whitehurst addressed whether the data was consistent with the presence of an ammonium nitrate dynamite. He stated there was a weak consistency. He stated that the bases for this opinion were the factors discussed above regarding an ammonium nitrate explosive (the white powder and ions) and the fact that the presence of NG might have been obscured by the instrumental overload. As discussed above, Whitehurst's overload theory was invalid. Given Whitehurst's failure to detect NG residue and given the weakness of the data showing the use of an ammonium nitrate explosive, we conclude that Whitehurst's data did not warrant the opinion (given in his OIG interview) that the evidence was consistent with the use of an ammonium nitrate dynamite.

Whitehurst's data only allowed him to opine: (1) the data does not disprove the use of an ammonium nitrate dynamite; (2) no data points to the use of a dynamite; (3) some data (the unconfirmed presence of ions and the unidentified white powder in the pits) have very limited probative value; (4) the ions (if they were present) could have come from an ammonium nitrate dynamite or from numerous other explosives or from the environment, and he cannot say which alternative is most likely; and (5) the unidentified white powder could have been ammonium nitrate or some other white substance, and he cannot say which alternative is most likely.

Thus, Whitehurst's opinion that the data was consistent with the use of an ammonium nitrate explosive was not only overstated but begged the real question--namely, whether the data was consistent with the use of an ammonium nitrate dynamite (the explosive the Confessor said he used). As to that question, we conclude that Whitehurst's data did not justify an opinion that the evidence was consistent with any dynamite. Accordingly, Whitehurst's conclusion in the second paragraph of the memorandum--that the data in fact is consistent with an ammonium nitrate explosive--was not only overstated, but also misleading, because it suggested, without a valid scientific basis, that Whitehurst's data supported the Confessor's story.

4. Contamination

Although not directly relevant to the discrediting of the Confessor's story, Whitehurst addressed in the memorandum whether possible contamination prevented the Laboratory from determining the significance of the data identifying the presence of RDX and PETN. In his original dictation Whitehurst stated:

Chemical analysis of specimen Q15 identified the presence of RDX and PETN high explosive. These two explosives are used in conjunction in the explosive SEMTEX. They also can be used in separate components of explosive systems.

It is the opinion of this examiner that the RDX and PETN identified on specimen Q15 originated either from an explosive such as SEMTEX or from a combination of components of an explosive system containing both PETN and RDX.

The Whitehurst Memorandum sets forth a series of questions about possible contamination at the crime scene, in transit, and at the Laboratory. See n.115, supra. Unlike Whitehurst's dictation, in which he opined that the RDX and PETN came from Semtex or an explosive system, in the memorandum he raised the question whether the RDX and PETN may have come from contamination rather than from the aircraft remnants before they were recovered in Colombia. Whitehurst asserted that the contamination questions need to be answered before we can determine the significance of the data -- that is, before it could be determined whether the RDX and PETN came from the aircraft or from contamination.

Whitehurst told us that when he wrote the memorandum, AI had no evidence at all about contamination. He stated, So what you've asked me is, do I know there was contamination. No, but I don't know there wasn't contamination. Whitehurst acknowledged that the contamination questions he raised were not specific to the Avianca case, but applied to any case involving organic explosives like APETN, RDX, TNT, nitroglycerine. Nevertheless, at the time of Whitehurst's March 1996 OIG interview, he had never raised these questions in any of his numerous cases, before or after Avianca, unless there was specific evidence of contamination.

Despite Whitehurst's assertion that he had no evidence at all about contamination when he wrote the memorandum, we think the circumstantial evidence available to him pointed to the unlikelihood

that the PETN and RDX were present as a result of contamination. The RDX and PETN were both found on the same specimen, and none of the other eight specimens contained either explosive. According to Whitehurst's original dictation, and the prosecution's theory, the substances were found together because they were components of Semtex or an explosive system used in the bombing. If, instead, the specimens had been contaminated by RDX and PETN, it would have been likely that the contaminants would have been randomly distributed on the specimens, producing contamination with either or both of the explosives on more than one specimen. In an OIG interview Whitehurst cited a 1995 contamination study in the Laboratory to show the real possibility of contamination there, but in that study, of the four locations that contained either RDX or PETN, none contained both substances. Although it is of course possible that there was contamination of a single specimen with two separate explosives and no other specimen was affected by either contaminant, this is not the likeliest scenario.

We question the manner in which Whitehurst raised the issue of contamination. We do not fault an examiner for raising a relevant issue at a late date if it does not occur to him earlier, and vigilance concerning contamination should be an integral part of the work of a forensic scientist. Here, however, the contamination questions raised in the Whitehurst Memorandum could and should have been addressed within the Laboratory before the memorandum was disseminated to a prosecutor in the middle of a trial. Hahn was knowledgeable about the procedures followed at the crime scene and how the evidence was transported to the Laboratory. Other personnel could have explained how the evidence was processed once it arrived at the Laboratory. Whitehurst should have addressed the contamination questions to these people before he disseminated the memorandum outside the Laboratory. Finally, Whitehurst should have noted in his memorandum that the lack of a random distribution of the RDX and PETN was indicative of the absence of contamination.

Since (1) the contamination issue was only indirectly relevant to contradicting the Confessor's story, (2) there was no affirmative evidence of contamination, (3) the circumstantial evidence was indicative of a lack of contamination, and (4) Whitehurst never wrote a memorandum with questions like these in any other case before or since Avianca, we conclude that Whitehurst erred when he raised the issue, in the manner that he did, for the first time in an ongoing trial.

Corby told us he would not have authorized the release of the information in the Whitehurst Memorandum to the prosecutor had he known Whitehurst had not contacted Hahn first. Nevertheless, it is apparent from the face of the memorandum that Whitehurst had taken no steps within the Laboratory to determine the validity of any of the contamination issues raised in the memorandum. We therefore conclude that Corby erred when he told Whitehurst to provide the information in the memorandum to the prosecutor without also directing Whitehurst to make the necessary contamination inquiries in the Laboratory first.

5. Circumvention of Hahn

Whitehurst wrote the memorandum on June 7, 1994, and gave it to Corby the next day. Corby reviewed it overnight and told Whitehurst on June 9, 1994, to give the memorandum to the prosecutor. That day Whitehurst gave the memorandum to an agent working on the case; he in turn gave it to the AUSA. Whitehurst did not consult with Hahn, or give him a copy of the memorandum, before it was disseminated outside the Laboratory.

Whitehurst justified his failure to consult with Hahn, or send him a copy of the memorandum, on his assertion that Hahn is a bully, will not listen to any reason at all, and does not receive information. We have already noted Whitehurst's error in failing to discuss the contamination

questions with Hahn before disseminating the memorandum to the prosecutor. More generally, we conclude that Whitehurst's failure to consult with Hahn on any issue, or at least send him a copy of the memorandum, before releasing it outside the Laboratory was unprofessional.

IV. Conclusion

A. Hahn

We conclude that in the Munoz trials Hahn did not commit perjury, fabricate evidence, or intend to mislead the court. We also conclude that he committed several errors: he erroneously testified in the first trial that no dynamite could have caused the pitting and cratering on the aircraft; he gave scientific opinions correlating the pitting and cratering with a VOD range that were unsound and not justified by his experience; before the second trial, he made no inquiries about the validity of his jetting theory, even though the literature attached to the Whitehurst Memorandum conflicted with that theory; he gave incomplete testimony concerning the MAU results; he testified incorrectly and outside his expertise concerning a fuel-air explosion, the injuries to passengers, and other areas; and he slightly overstated his experience. Hahn's conduct exemplifies the need (discussed in Part Six, infra) to train examiners to base conclusions on confirmed findings and validated theories and to testify within their areas of expertise.

B. Whitehurst

We conclude that Whitehurst committed several errors in connection with the Whitehurst Memorandum: he reached an invalid conclusion that an instrumental overload may have obscured the presence of NG; this error occurred because he neglected to thoroughly review the Laboratory file including the TLC results; he misstated his June 4, 1994, conversation with Hahn on a material point; he rendered a misleading and overstated opinion that suggested that his data was consistent with a potential defense; he raised questions whether contamination may account for his original findings of RDX and PETN, although there was no affirmative evidence of contamination, the circumstantial evidence was indicative of a lack of contamination, and he made no inquiries inside the Laboratory to determine whether his contamination concerns might have validity; and he released the memorandum outside the Laboratory without consulting with Hahn or at least sending him a copy. Finally, he also erred in his 1990 examination by failing to recognize the instrumental overload and run a second test. All of the errors in the memorandum tended to create problems for Hahn, the FBI, and the prosecution in an ongoing trial.

C. Kearney

We conclude that SAS Chief Kearney erred by not properly resolving the controversy raised by the Whitehurst Memorandum and by not communicating his decisions to Hahn and Whitehurst. After the second trial Kearney reviewed Hahn's testimony in that trial and felt Hahn testified outside his expertise regarding the construction of the aircraft and the injuries to the passengers. Kearney also erred by failing to discuss these matters with Hahn, and define and document the corrective action taken, to avoid such problems in the future.

D. Corby

We conclude that Corby erred when he authorized Whitehurst to release the information in the memorandum to the prosecutor without also directing Whitehurst to address the contamination questions to personnel inside the Laboratory first.

Air India Flight 182

Report on the accident to Boeing 747-237B VT-EFO, Air India Flight 182,
off Cork, Ireland on 23 June 1985
by John Barry Smith,
Independent Aircraft Accident Investigator

Appendix C Comet Accidents (Unofficial)

Source: <http://www.tech.plym.ac.uk/sme/FailureCases/FAILURE.htm>

Professor M Neil James - Web page <http://www.plym.tech.ac.uk/sme/uoa30/structur.htm>

Comet Airliner

Jet transportation age began in on May 5 1952 when the De Havilland Comet 1 began scheduled flights from London to Johannesburg. In April 1953, a Tokyo to London service was inaugurated – flying time for the 10 200 mile distance dropped from 85 hours to 36 hours. The Comet had a cruising speed of 490 mph at 35 000 feet and a range of 1 750 miles with a payload of 44 passengers.

Power came from 4 De Havilland Ghost turbojet engines of 5 000 lbf thrust. Engines were mounted in the wing root – this minimises yaw accompanying loss of engine on take-off, but poses a hazard in the event of engine fire/disintegration and does not allow for easy uprating of engines (cf. hanging engine pods under wing) – poor design for development. Fuel consumption of turbojets is lower at high altitude.

The cabin was pressurised to maintain a pressure equivalent to 8 000 feet at an aircraft altitude of 40 000 feet, which was required for efficient operation of the engines. This gave a pressure differential of 8.25 psi (56 kPa) across the fuselage – twice the value previously used. De Havilland conducted ‘many tests’ to ensure structural integrity of the cabin. Other innovations included high pressure refuelling, hydraulic actuation of control surfaces and cabin air conditioning. It seemed that the future was bright for the British aircraft industry, with orders from France, Canada and the UK.

However, a series of 3 accidents occurred where Comet aircraft disintegrated in flight:

G-ALYV after leaving Calcutta – May 1953. Violent storms were thought to be involved and some wreckage was recovered. No firm conclusions drawn as to cause.

G-ALYP over Elba – January 1954 after 1 286 cabin pressurisation cycles. Little wreckage was recovered and no major problems found in fleet inspection. Fire was assumed the most likely cause and modifications made to improve fire prevention and control. Aircraft returned to service.

G-ALYY flying as SA 201 after leaving Rome – April 1954.

A more intensive effort was made to recover the wreckage of G-ALYP using underwater television cameras for the first time. About 70% of the aircraft was recovered and reconstructed at Farnborough. The engines were recovered more-or-less intact, showing that engine disintegration was not the cause of the accident, and neither was any evidence of fire found.

Comet G-ALYU, which had experienced 3 539 flying hours and 1 221 cabin pressurisation cycles, was subjected to full-scale flight simulation testing at Farnborough. The fuselage was hydraulically pressurised in cycles, while the wings were flexed with jacks to simulate the flight loads. Water

was used for this pressurisation because calculations had indicated that the energy release under cabin rupture with air as the pressurisation medium was equivalent to the explosion of a 500 lbf bomb in the cabin. The cabin was also supported in water to avoid extraneous weight effects. After the equivalent of a total of 3 057 (1836 simulated cycles) flight cycles a 2 mm crack near the escape hatch grew to failure (Hatch Sketch). This was repaired and after 5 46 flight cycles a 4.5 m section of the cabin wall ruptured due to fatigue cracking. It was concluded that explosive cabin failure had caused the loss of the 3 Comet aircraft. Developing a detectable crack 6 mm long consumed some 95% of the cyclic life.

The Royal Navy was charged with getting the relevant fuselage piece of G-ALYP from the sea (using simulation trials, based on the way the aircraft was now thought to break up in flight, to establish the likely position of this part of the aircraft on the seabed. This was recovered within a few hours of searching and showed, in the language of the coroner, the 'unmistakable fingerprint of fatigue'. The fatigue crack was associated with the stress concentrations of the rather square rear ADF window cutout (stress of 315 MPa at edge of window), and with a bolt hole around the window (although the stress at the bolt position was only 70 MPa).

The Chief Designer at De Havilland had wanted to glue the windows in position, but the tooling for the square shape was too difficult to make. A lower stress concentration shape would have been easier to manufacture.

The manufacturer had performed fatigue tests of the forward cabin area at about 10 psi (with cracking occurring at 18 000 cycles), but these were carried out after static tests of to up to 16.5 psi (twice operating pressure) had previously been applied. Cracks were also known to be present after manufacture, and the remedy was to drill 1.6 mm holes at the crack tip to 'arrest' them (such an arrested crack was present near the rear ADF window, which had not propagated until the final failure).

Modifications were made to the design of the aircraft and the Comet 4 re-entered service in October 1958 on the trans-Atlantic route with 80 passengers. A few weeks later the Boeing 707 flew the same route with 120 passengers and a safer, more flexible design engine design. The loss of 6 years to the Comet problems may have been instrumental in losing the lead in future jet transportation to the US. Parity in sales of passenger aircraft was established only in 1999 between Airbus and Boeing.

Technological Outcomes:

Full-scale testing of aircraft structures utilised in future aircraft.

Better understanding of fatigue testing achieved, i.e. match service and test loads (no previous over-pressurisation cycles first).

Attention drawn to detectability/critical size issues for fatigue cracks in aircraft structures.

Concept of 'one-bay' crack tolerance in fuselage probably formulated.

Causes:

1. New technology introducing new load cases (high altitude flight for turbojet engines requiring cabin pressurisation).
2. Mis-match between service loads and fatigue test procedure.
3. Possible contribution from out-of-plane bending loads (bi-axial stresses).

Design Failures:

Improperly understood failure mode assessment procedures necessitated by implementation of new technology.

Poor configuration due to wing root engine placement (very few other aircraft have had engines in this position), affecting uprating potential, fire hazard, and structural integrity in the event of engine disintegration.

References:

1. P A Withey (1997) Fatigue failure of the De Havilland Comet 1 Engineering Failure Analysis Vol. 2 No. 4 pp147-154.
2. J F Lancaster (1996) Engineering catastrophes: causes and effects of major accidents Woodhead Publishing.
3. Johannesburg Sunday Star Review, March 22 1992 p.11 Super-fast jet takes a dive.
4. <http://www.hq.nasa.gov/office/pao/History/SP-468/ch13-2.htm>
5. <http://surf.to/comet> (Note that some of the information here with respect to crashes is inaccurate, e.g. fatigue is referred to as 'crystallinity').

Air India Flight 182

Report on the accident to Boeing 747-237B VT-EFO, Air India Flight 182,
off Cork, Ireland on 23 June 1985
by John Barry Smith,
Independent Aircraft Accident Investigator

Appendix D DC-10 Accidents (Unofficial 1973 through 1996)
<http://www.taxiways.net/DC-10/history/52-37.html>

DC-10 losses

Date:	Registration:	DC-10 type:	Msn:	Fn:	Airline:
731217	EC-CBN	DC-10-30	46925	87	Iberia
740303	TC-JAV	DC-10-10	46704	29	Turkish Airlines
751112	N1032F	DC-10-30CF	46826	109	Overseas National Airways
760102	N1031F	DC-10-30CF	46825	81	Saudi Arabian Airlines
780301	N68045	DC-10-10	46904	44	Continental Airlines
790525	N110AA	DC-10-10	46510	22	American Airlines
791031	N903WA	DC-10-10	46929	107	Western Airlines
791128	ZK-NZP	DC-10-30	46910	182	Air New Zealand
810203	AP-AXE	DC-10-30	46935	172	Pakistan Airlines
820123	N113WA	DC-10-30CF	47821	320	World Airways
820913	EC-DEG	DC-10-30CF	46962	238	Spantax
831223	HL-7339	DC-10-30	46960	237	Korean Airlines
860810	N184AT	DC-10-40	46751	36	ATA (American Trans Air)
870110	5N-ANR	DC-10-30	46968	243	Nigeria Airways
870917	82-0190	KC-10A	48212	382	US Air Force
880521	N136AA	DC-10-10	47846	69	American Airlines
890719	N1819U	DC-10-10	46618	118	United Airlines
890727	HL-7328	DC-10-30	47887	125	Korean Airlines
890919	N54629	DC-10-30	46852	93	UTA
921221	PH-MBN	DC-10-30CF	46924	218	Martinair
930414	N139AA	DC-10-30	46711	105	American Airlines
960613	PK-GIE	DC-10-30	46685	284	Garuda Indonesia
960905	N68055	DC-10-10F	47809	191	Federal Express

Service Bulletin 52-37

Service Bulletin 52-37 was issued by Douglas on July 3rd 1972, three weeks after the Windsor incident in which the rear cargo door blew off and caused severe damages to the aircraft structure. These modifications suggested by Douglas included a completely new door locking system for the infamous cargo door. Several facts are still unknown, but neither Douglas nor the operators of the DC-10 took this service bulletin too serious. At this time, 49 aircraft were already manufactured and operated by following airlines:

<http://members.tripod.com/vicondisa/dc10acc.htm>

June 12, 1972

McDonnell Douglas DC-10-10 N103AA (fsn 46503/fn 05), American Airlines
Over Windsor, Ontario

Mechanical Failure due to Design Flaw/Human Error

Occupants: 67

Fatalities: 0

Following takeoff from Detroit, the rear cargo door blew off due to a door latch system that had been damaged by ground crew members. The loss of pressurization caused the cabin floor to buckle and damaged the hydraulic control lines of the aircraft. The captain, having trained himself in simulator sessions to fly the aircraft using its throttles (a method called “differential thrust steering”), made an emergency landing in Detroit.

November 3, 1973

McDonnell Douglas DC-10-10 N60NA (46700/14), National Airlines

Over Albuquerque, New Mexico

Mechanical Failure due to Operator Error

Occupants: 128

Fatalities: 1

At 39,000 feet over Albuquerque the cockpit crew experimented with the autothrottle system of their DC-10. Their experiments overspeeded the fans of the no. 3 engine, subjecting them to unusually high stresses and causing them to burst through their casing. Fragments of the shattered engine pierced the fuselage and depressurized the cabin, sucking one passenger to his death.

December 17, 1973

McDonnell Douglas DC-10-30 EC-CBN (46925/87), Iberia

Boston-Logan International Airport, Massachusetts

Wind Shear

Occupants: 168

Fatalities: 0

The DC-10 approached Boston Runway 33L in bad weather and reduced visibility. The aircraft struck approach lights 500 feet short of the threshold and collided with a dike. The right main landing gear was sheared off; the aircraft then skidded and came to a rest 3000 feet from the threshold. The aircraft descended fast due to wind shear, which had not been noticed by the crew during the landing.

McDonnell Douglas photo

March 3, 1974

McDonnell Douglas DC-10-10 TC-JAV (46704/29), Turk Hava Yollari - THY

Outside Paris, France

Mechanical Failure due to Design Flaw/Human Error

Occupants: 346

Fatalities: 346

The latch mechanism of the aft cargo door, the design of which was susceptible to damage, had been damaged before the accident. Before takeoff the door had not been secured properly. Shortly after takeoff from Paris, the door failed. The resulting depressurization led to the disruption of the floor structure, causing six passengers and parts of the aircraft to be ejected, rendering No.2 engine inoperative, and impairing the flight controls so that it was impossible for the crew to regain control of the aircraft.

November 12, 1975

McDonnell Douglas DC-10-30CF N1032F (46826/109), Overseas National Airways

New York-John F. Kennedy International Airport

Fire due to Foreign Object Damage and Mechanical Failure

Occupants: 139

Fatalities: 0

Shortly after accelerating through 100 knots, but before reaching takeoff speed, a flock of birds rose from the runway. The aircraft struck the birds, damaging the no. 3 engine's fan blades and causing rotor imbalance. This caused a failure of the engine casing and started a fire in the right wing. Partial loss of hydraulic power to the plane's systems from the failure of the no. 3 engine meant that the aircraft could not be stopped on the runway. The pilot-in-command steered the aircraft off the runway at a 40-knot speed; the main undercarriage collapsed and the aircraft came to rest against the shoulder of the taxiway.

January 2, 1976

McDonnell Douglas DC-10-30CF N1031F (46825/81), Saudia

Istanbul, Turkey

Weather

Occupants: 373

Fatalities: 0

Heavy landing in fog; careened off the runway.

March 1, 1978

McDonnell Douglas DC-10-10 N68045 (46904/44), Continental Airlines

Los Angeles International Airport, California

Mechanical Failure

Occupants: 200

Fatalities: 2

During acceleration for takeoff, an engine exploded. The flight crew did not believe the plane would be able to stop on the remaining length of runway and steered it off the runway during deceleration. During the turn one of the main landing gear struts broke off and the airplane caught fire in this area.

May 25, 1979

McDonnell Douglas DC-10-10 N110AA (46510/22), American Airlines

Chicago O'Hare International Airport, Illinois

Mechanical Failure due to Maintenance Error

Occupants: 271

Fatalities: 271 + 2 third-party fatalities = 273

The No. 1 engine and pylon, its mountings damaged by an improper maintenance procedure, fell from its position on the left wing just before aircraft rotation. The engine loss resulted in a loss of hydraulic pressure to the left-wing slats. The uncommanded slat retraction, combined with damage inflicted to the leading edge during the engine separation, created a condition of asymmetrical lift. When the damaged wing lost its lift the plane rolled on its side and crashed into a trailer park less than a mile from the end of the runway.

October 31, 1979

McDonnell Douglas DC-10-10 N903WA (46929/107), Western Air Lines

Mexico City-Benito Juarez International Airport, Mexico

Landing Accident due to Weather/Human Error

Occupants: 88

Fatalities: 72 + 1 third party fatality = 73.

The DC-10 crashed after a landing descent through foggy conditions. Cleared to land on Runway 23R, it instead touched down on 23L, which had been closed for repairs. The aircraft struck excavation equipment and suffered substantial damage before crashing into a building.

November 11, 1979

McDonnell Douglas DC-10-30 XA-DUH (46937/152), Aeromexico

Luxembourg, Europe

Improper climb procedures/operator error

Occupants: 311

Fatalities: 0

While climbing to 31,000 feet the aircraft entered a sustained stall, from which it recovered at 18,900 feet. The aircraft suffered mild damage to its outboard elevators and portions of the lower aft fuselage.

Jon Proctor collection

November 28, 1979

McDonnell Douglas DC-10-30 ZK-NZP (46910/182), Air New Zealand

Mt. Erebus, Antarctica

Navigational Error

Occupants: 257

Fatalities: 257

On a sightseeing flight over Antarctica, the aircraft deviated from its course by 1.5 miles east of its intended position and crashed into the slope of Mt. Erebus. The aircraft was destroyed by impact and fire. Later investigation placed blame on the airline for changing the computer track of the aircraft without notifying the flight crew.

February 3, 1981

McDonnell Douglas DC-10-30 AP-AXE (46935/172), Pakistan International Airlines

Karachi, Pakistan

Ground fire

Occupants: 0

Fatalities: 0

Destroyed in a hangar fire.

January 23, 1982

McDonnell Douglas DC-10-30CF N113WA (47821/320), World Airways

Boston-Logan International Airport, Massachusetts

Landing accident due to weather and human error

Occupants: 212

Fatalities: 2

The aircraft touched down on an ice-covered runway 2,800 feet past the displaced threshold. When it became clear that the aircraft would not stop on the runway the crew turned the aircraft off at the end of the runway. The aircraft rolled into shallow water and the nose section separated.

September 13, 1982

McDonnell Douglas DC-10-30CF EC-DEG (46962/238, ex-N1034F), Spantax

Malaga, Spain

Landing Gear Failure/Fire

Occupants: 394

Fatalities: 50

The crew aborted the takeoff above rotation speed due to strong vibration. The aircraft overran the runway, crashed into a railway embankment and caught fire. The source of the vibration was later determined to be a failure of the recapped tread of the right nose wheel.

December 23, 1983

McDonnell Douglas DC-10-30 HL-7339 (46960/237, ex-N1033F), Korean Air Lines
Ground Collision due to Weather/Human Error

Anchorage, Alaska

Occupants: 3

Fatalities: 0

Under foggy conditions the DC-10 crew taxied onto the wrong runway and collided head-on with a Piper PA-31.

August 10, 1986

McDonnell Douglas DC-10-40 N184AT (46751/36, ex-N142US), American Trans Air
Chicago-O'Hare International Airport, Illinois

Ground Fire

Occupants: 0

Fatalities: 0

A mechanic, improperly handling a loose oxygen generator from a damaged passenger seat-back in the forward cargo hold, set off the generator. This ignited the seat covers, along with oil stored in the forward cargo hold. The fire eventually burned through the cabin floor.

January 10, 1987

McDonnell Douglas DC-10-30 5N-ANR (46968/243), Nigeria Airways

Ilorin, Nigeria

Training Accident

Occupants: 9

Fatalities: 0

While practicing touch-and-go landings, the aircraft overshot the runway and caught fire.

September 17, 1987

McDonnell Douglas KC-10A 82-0190 (48212/382), United States Air Force

Barksdale Air Force Base

Ground Fire

Occupants: 17

Fatalities: 1

Ground fire.

May 21, 1988

McDonnell Douglas DC-10-30 N136AA (47846/69, ex-ZK-NZL), American Airlines

Dallas-Fort Worth International Airport, Texas

Take-off Accident

Occupants: 254

Fatalities: 0

During the takeoff roll, the flight crew received indications that the flaps and slats were not in takeoff position. The crew attempted to stop the plane but ran out of runway space. The nose gear collapsed, causing major damage to the underside of the forward fuselage. The aircraft was removed from service and used for parts.

[View photos of the damage](#)

July 19, 1989

McDonnell Douglas DC-10-10 N1819U (46618/118), United Air Lines

Sioux City-Gateway, Iowa

Mechanical/Hydraulic Failure due to Engine Failure

Occupants: 298

Fatalities: 111

During cruise at 37,000 feet the number 2 engine suffered an uncontained failure due to an unnoticed fatigue crack in the stage 1 fan disk. The explosion sent shards flying through the rear of the plane, rupturing its hydraulic flight control lines. With the help of a secondary air crewman the flight crew was able to control the aircraft through differential thrust steering of the remaining engines, and eventually descended for an emergency landing at Sioux City. During the final approach the nose pitched downward and the right wing dropped; the aircraft skidded to the right, rolled inverted, caught fire and cartwheeled.

McDonnell Douglas photo

July 27, 1989

McDonnell Douglas DC-10-30 HL-7328 (47887/125, ex-HS-VGE), Korean Air

Tripoli International Airport, Libya

Landing Accident due to Weather

Occupants: 199

Fatalities: 75 + 4 third party fatalities = 79.

The aircraft approached in conditions of poor visibility and crashed short of the airport.

photo courtesy of Greg Drawbaugh

September 19, 1989

McDonnell Douglas DC-10-30 N54629 (46852/93), Union de Transportes Aeriens (UTA)

Over Sahara desert in Niger

Sabotage

Occupants: 171

Fatalities: 171

During climb on this flight from N'Djamena to Paris, a bomb planted in the baggage hold went off.

photo courtesy of Greg Drawbaugh

December 21, 1992

McDonnell Douglas DC-10-30CF PH-MBN (46924/218), Martinair Holland

Faro, Portugal

Landing Accident due to Weather/Human Error

Occupants: 340

Fatalities: 56

During approach, when the aircraft was switched from autopilot to manual mode, the airspeed fell and could not be restored before the aircraft touched the runway. The main gear struck the runway very hard, causing the right wing to separate and the aircraft to slide down the runway. It was later determined that the high rate of descent, coupled with a crosswind, exceeded the structural limitations of the aircraft.

April 14, 1993

McDonnell Douglas DC-10-30 N139AA (46711/105, ex-N80NA), American Airlines

Dallas-Fort Worth International Airport, Texas

Landing Accident due to Weather/Operator Error

Occupants: 202

Fatalities: 0

During landing in poor weather the aircraft was caught in a crosswind. The first officer wanted to perform a go-around but the captain took control and landed the aircraft. The plane drifted off the runway and came to rest in mud; the nose and left main gear struts collapsed.

Read the abstract of the NTSB report

November 26, 1993

McDonnell Douglas DC-10-30 YV-135C (46791/258), Viasa

Buenos Aires, Argentina

Landing accident

Occupants: unknown

Fatalities: unknown

Damaged extensively while overshooting the runway on landing at Buenos Aires. Put into storage.

June 13, 1996

McDonnell Douglas DC-10-30 PK-GIE (46685/284), Garuda Indonesia Airways

Fukuoka, Japan

Engine failure

Occupants: 275

Fatalities: 3

Immediately after takeoff the first stage fan of the number 3 engine separated. The takeoff was aborted and the DC-10 skidded off the runway. The landing gear and number 1 engine separated from the aircraft.

September 5, 1996

McDonnell Douglas DC-10-10CF N68055 (47809/191), Federal Express

Newburgh-Stewart International Airport, New York

Fire

Occupants: 5

Fatalities: 0

At 33,000 feet during a flight from Memphis to Boston, a fire began in the cargo area. The crew made an emergency landing at Newburgh 20 minutes later and evacuated the aircraft. Because of the cargo arrangement, the firemen could not reach the source of the smoke. An hour after it started, the fire burned through the fuselage and the tail separated.

Air India Flight 182

Report on the accident to Boeing 747-237B VT-EFO, Air India Flight 182,
off Cork, Ireland on 23 June 1985
by John Barry Smith,
Independent Aircraft Accident Investigator

Appendix E Boeing History (Unofficial) (AP)

1910: William Boeing buys Heath's shipyard on the Duwamish River. It becomes his first airplane factory. The first airplane flight is made over Seattle.

1915: Boeing has a hangar built beside Lake Union.

1916: Pacific Aero Products is incorporated, and Boeing buys 998 of the company's 1,000 shares. He moves the operation to his shipyard on the Duwamish River.

1917: Pacific Aero Products is renamed the Boeing Airplane Co.

1918: Boeing signs a contract with the U.S. Navy to build 50 HS-2Ls, a patrol flying boat.

1919: The B-1 mail plane, the first Boeing-designed commercial aircraft, makes its first flight.

1921: The company wins a contract to build 200 Thomas Morse MB-3A pursuit fighters.

1922: Edgar N. Gott, general manager of the Boeing Aircraft Co., tells workers they will each receive a \$500 insurance policy as a New Year's gift, the first known non-wage benefit at Boeing.

1926: The Army orders 25 PW-9C fighters, a version of the PW-9 with a heavier fuselage. The production version of the FB-5 carrier fighter makes its first flight. The 27 ordered by the Navy are rolled onto barges and taken to the USN Langley.

1927: Boeing Airplane signs a contract with the U.S. Postal Service to fly airmail between Chicago and San Francisco. The Boeing Air Transport, predecessor of United Airlines, is founded to operate the mail routes and run the new airline.

1928: Boeing Air Transport acquires 73 percent of Pacific Air Transport's stock and runs an airline up and down the West Coast.

1929: The stock markets crash and the Depression begins. Ellen Church, a registered nurse, joins the crew of a Model 80A flight headed to San Francisco and becomes the first woman flight attendant.

1931: Boeing Air Transport, National Air Transport, Varney Air Lines and Pacific Air Transport combine to become United Air Lines, providing coast-to-coast passenger and mail service. One way takes 27 hours.

Military contracts

1932: The P-26 Peashooter makes its first flight. It becomes known as the fastest air-cooled

pursuit fighter in the world.

1934: The U.S. Army corps asks for a design for a very heavy long-range experimental bomber. Boeing engineers begin work on the XB-15. Bill Boeing sells his shares, angry over the government forcing him to sell off the fledgling United Airlines and other parts of his empire.

1935: Model 299 (XB-17), prototype of the B-17, makes its first flight at Boeing Field. Reporters dub it the "Flying Fortress." A Model 299 makes a nonstop test flight from Seattle to Dayton, Ohio. A few months later, a Model 299 crashes in Dayton.

1936: Boeing buys 28 acres on Marginal Way in Seattle, between Boeing Field and the Duwamish Waterway. The International Association of Machinists Local 751 signs its first working agreement with Boeing Airplane.

1938: The Model 307 Stratoliner, the first American pressurized commercial transport, makes its first flight.

1939: The Civil Aeronautics Authority grants Pan American Airways permission to use the Model 314 Clipper for commercial service.

1940: Pan American Airways takes delivery of its first Model 307 Stratoliners.

1941: The U.S. Navy chooses a site in Renton as its new manufacturing facility. It later trades the facility to the Army Air Corps, and 1,119 B-29s are built there in record time. Engineering starts for 264 service-model B-29s. The first B-17s fly into combat with the British Royal Air Force. Japan bombs Pearl Harbor on Dec. 7, drawing the United States into World War II.

1942: The luxurious Stratoliners are stripped of their civilian finery and pressed into military service as C-75s. The first flights carry antitank ammunition and medical supplies to British forces in Libya. The Model 345, or B-29, bomber makes its first flight.

1943: Boeing builds branch plants throughout the Puget Sound area, in Aberdeen, Bellingham, Tacoma, Chehalis and Everett.

1945: The war ends and 30,000 Boeing employees lose their jobs.

Commercial jets

1952: At its Renton plant, Boeing begins building the Model 367-80, the jetliner and jet tanker prototype that becomes the Dash 80, or 707.

1958: Pan American World Airways takes delivery of the country's first commercial jet airliner, a 707-120. That same year, the U.S. Air force selects Boeing to assemble and test the Minuteman intercontinental ballistic missile.

The space race

1963: NASA selects Boeing to build eight Lunar Orbiter spacecraft. Boeing also helps develop a number of space projects, including the Saturn V rocket.

1964: Boeing begins building a space center in Kent. It competes with Lockheed to design the

SST, or supersonic transport.

1966: Boeing celebrates its 50th anniversary. It announces plans for a 490-passenger 747 jetliner and begins construction on a new plant in Everett. It wins the design contract for the SST.

1968: The first 747-100 is rolled out during ceremonies at the new Everett plant. Launched by Saturn V, Apollo 8 takes the first astronauts around the moon.

1969: The 747-100 makes its first flight, and Apollo 11 astronauts Neil Armstrong and Edwin Aldrin are the first humans to walk on the moon. President Nixon approves the construction of two SST prototypes by Boeing. Boeing also begins building the Lunar Roving Vehicle.

1970: Boeing begins work on the Airborne Warning and Control System planes, or AWACS.

1971: The "Boeing Depression" hits the Seattle area, caused by a recession, high costs for the 747 and cancellation of the SST. The company cuts its area work force from 80,400 to 37,200 in two years, prompting the famous billboard that read, "Will the last person leaving Seattle turn out the lights." But the company also begins to diversify.

1974: Boeing's work on NASA programs continues as it wins a contract to build components of the Hubble Space Telescope.

1975: Boeing introduces its personal rapid transit system in Japan. It carries 3 million people by the year's end. It delivers its first modified B-52D to the Strategic Air Command.

1977: Boeing delivers a modified 747 for use as a delivery vehicle for the space shuttle. It also begins work on the world's largest wind turbine.

1979: The Chinook CH-47D helicopter makes its first flight.

1982: The 757-200 jetliner makes its first flight.

1985: Boeing begins preliminary designs for the international space station.

1986: Boeing and Bell Helicopter Textron start building six prototypes of the V-22 Osprey tilt-rotor aircraft.

1987: Boeing wins a contract to build the living and working quarters for the international space station.

1989: The V-22 Osprey and the B-2 stealth bomber make their first flights.

1992: Phil Condit becomes president of the Boeing Co.

Mergers

1996: Boeing merges with Rockwell's aerospace and defense units. They are renamed Boeing North American and are to operate as a subsidiary.

1997: Boeing merges with McDonnell Douglas Corp.

2000: The company lays off nearly 30,000 workers from July 1998 to July 2000. In October, Boeing acquires the former Hughes Space & Communications Co. of El Segundo, Calif., from Hughes Electronics Corp. and renames it Boeing Satellite Systems.

2000: Boeing, which has endured a number of lengthy strikes, is hit with a 40-day walkout by its engineers and technical workers.

January 2001: Boeing confirms it is considering closing the Renton plant and consolidating some of its aircraft manufacturing in Everett.

February: Boeing hints it may move its headquarters. Company Chairman and CEO Phil Condit, fresh from economic meetings in Davos, Switzerland, says Boeing cannot be too reliant on one region -- or one national economy -- for its future.

March 7: Boeing says that wings for the proposed 747X jumbo plane will be made in Japan.

March 21: Boeing announces it will move its corporate headquarters from Seattle. It is looking at sites in the Chicago, Denver and Dallas-Fort Worth areas.

Sources: Boeing's Web site: www.boeing.com; The Associated Press

747: BOEINGS MASTERPIECE by Patrick Hoeverler

Today modern aviation is unthinkable without the Boeing 747, of which 1,193 aircraft have up to date been delivered. This unique giant has transported 2.2 billion people, which equals 40 percent of the world's population. 30 years ago only few experts believed in this monumental success. In those days the Jumbo Jet was seen as an exotic creature among the other planes, and it was even thought that the Boeing Company was risking financial ruin.

The 747 came into existence after Boeing lost the competition for a strategic airlifter for the US Air Force. The Air Force needed a strategic long-haul airlifter capable of transporting troops and heavy weaponry to Europe. The very desirable contract was, however, given to Lockheed in 1965 and led to the creation of the C-5A Galaxy. From today's point of view this was a stroke of luck for Boeing, because the company now had resources for a new "Mega"-Airliner. By the way, Lockheed only built 131 models of them Galaxy.

The 747 saga began in spring 1965, when Pan American World Airways, Pan Am, asked Boeing to develop a lengthened version of the 707, with a capacity for 250 passengers. However, this could not be done for technical reasons.

During talks with Boeing representatives Pan Am Boss Juan Trippe demanded a commercial airliner, which could transport 400 passengers over a distance of 5,000km. The new jet was also be used for the transportation of cargo, because Trippe was convinced that aviation was to be dominated by supersonic airliners ten years from then. In that case the 747 was to be an excellent cargo liner. A few days later Boeing President William Allen telephoned Trippe and asked whether he had been serious with this unusual idea. Trippe, who had throughout the development of the 707 proved to be a friend of technological innovations, just responded by saying, "I am serious." In December 1965 both men met to negotiate details. Thus the foundation to build this giant was laid.

On 13 April 1966 Allen and Trippe signed a sales contract for 25 aircraft costing of \$550 million. This was up to then the biggest single contract of any airline. Pan Am's decision was courageous, since the competition doubted vehemently the economic viability of the giant jet. It has to be added that the then 71-year old Juan Trippe ordered the 747 during a booming air traffic. An annual growth rate of 15 per cent in passenger rates was predicted. It was Pan Am's plan to beat the competition with the 747, which could carry three times as many passengers as the 707. The recession in 1970, which was completely unexpected, and the oil crisis foiled these plans. The 747 created over-capacities, which are every airliner's nightmare. Most carriers preferred smaller aircraft: They were, however, afraid that the competition might buy the giant and in this way dominate on international routes. This is why mainly non-American airlines were queuing up outside the Seattle works.

Here Boeing Boss Allen appointed Mel Stamper to be head of the world's biggest aircraft-project. For four years Stamper was in charge of the approx. 50,000 staff working on this program. He only took one day off, one Christmas Eve. The work load was so immense that he was often unable to return home and had to spend the night on a conference table in his office. Because of his leadership style his co-workers remembered him as a drill sergeant of the US Marines rather than as a manager.

In August 1965 Joseph Sutter joined the team as Chief Designer. After the program launch in March 1966 Sutter and his team looked at 50 different designs with two decks. The double-decker design was not ideal, because passengers could not be evacuated in the time prescribed by the American Aviation Authority FAA. After viewing an improvised mock up of a cabin, which was uncovered, Trippe discarded the double deck idea. The view from the improvised top deck had given almost everybody present vertigo. It is obvious why everyone involved, apart from one Pan Am pilot, refused to use the attached emergency escape slide. After this sobering experience Trippe wanted to look at the 1:1 model of a conventional single deck, which was still being constructed. This design already had the famous hump, which was to be the trade mark of the 747. It goes without saying that the hunchback attracted many sarcastic comments. It was alleged that Boeing designed the hunchback to enable wealthy captains to sit on their thick wallets and not bump their heads.

There was a practical reason for the distinctive curve. Trippe had asked for the cockpit to be situated above the cabin. This was going to make loading easier. The space behind the cockpit was allocated to the air conditioning system and other instruments. However, businessman Trippe had other ideas. "This space is reserved for passengers. Couldn't we install a bar there?" Sutter agreed with this idea, but other ideas like glass nose for first class passengers only caused everyone to shake their heads. Impressed with the size of the cabin, there were many suggestions as to how to use it, i.e. a restaurant, cinema, hairdressing salon or even a casino.

The aircraft of the superlatives was now in need of a production hangar of equally breathtaking dimensions. The existing works like Renton, in which the 707, 727 and 737 were assembled, were not big enough. The search for a suitable location had started as early as October 1964; it was intended for the planned for C-5. A commission examined 50 locations to their suitability, until Bill Allen decided on a site in Everett, which is located north of Seattle in Washington State. All along Everett had only ranked on fifth place. It did have an existing airport, Fairfield, but there was no rail link. The second steepest rail track in the USA had to be built at a cost of \$5 million dollars. With the launch of the 747 the start of the world's biggest industrial building was given. It was big enough to house 40 football fields measuring 5.5 million sq m. Over 2,800 workmen battled against the elements, months of rainfalls and snowstorms made the building works extremely difficult. During rains lasting 68 days, an enormous mud slide covered part of the site. It cost

another \$5million dollars to clear up the mess. In order to stay within the tight schedule, the construction of the 747 was started, although the factory had not been finished.

The 747 team was under enormous pressure to succeed, not only because the factory had cost \$200 million. There was an Anti-Jumbo-Lobby, which questioned the safety of the big aircraft, arguing that a single crash of one of the new Boeing models would cause as many casualties as all airliner accidents in any one year. Some "experts" even demanded that the 747 should only be allowed to fly in storm free corridors, because it would not be able to weather any turbulence because of its size.

In order to cut down any accident risk, Boeing used the so-called "Fault Free Analysis". A team of five engineers was occupied for months and compiled diagrams examining the effects of a failing instrument or the effect of one fault on all systems. According to Sutter safety was given the utmost priority, even the coffee makers on board were checked thoroughly. Never before had Boeing invested so much time and money into laboratory and wind channel tests. Amongst other things the engineers built two 747 models of three meter length, which corresponded with a complete Douglas DC-6. The wind channel test program was supposed to take 15,000 hours.

After basic design work and more than 75,000 construction drawings, which were carried out by hand, had been completed, the 4.5 million parts of the first 747 had to be assembled. Workmen very often cursed the monster, which they had to build. However, they were also proud of the product and their own achievement. Stamper was most impressed by their thirst for action and suggested to call the team in Everett the "Incredibles". To Stamper's amazement this nickname soon appeared on helmets and coats worn by the employees. Stamper remembers, "It was the most motivated workforce I have ever seen. Some chaps even worked two shifts one after the other without being asked."

The "Incredibles" had indeed performed a miracle. Less than three years after the contract was signed Jumbo 001 left the hangar in Everett with a big fuss on 30 September 1968. To celebrate the day 26 stewardesses, who were responsible for the first customers "beheaded" bottles of champagne and christened the first 747 "City of Everett". A Boeing 707, 727 and 737 flew overhead and made the celebrations perfect.

747-100 prototype rolls out

Prior to her maiden flight Jack Waddell, head of the test program, had made a movable mockup in order to simulate the way the 747 would roll on the ground, since a cockpit more than 10 meters above ground was very unusual in those days. The monstrosity was jokingly named "Waddall's Wagon" by Boeing employees. Strain trials, which were carried out to take the wind out of the critics' sails, went quite spectacularly. In one test the wings of a static plane were being bent upwards and only broke at 7.9 meters.

On 9 February 1969 it became obvious that the \$1 billion cost for developing the 747 had been worthwhile. Jack Waddell, Brial Wygle and Jesse Wallick took to the skies in Jumbo N7470 only two months behind schedule. Pilot Waddell was enthusiastic about the aircraft's flight properties, "This plane is the answer to every pilot's dream." And it was said beforehand that the aircraft was simply too big to fly safely. One was even concerned that the 747 might damage the tarmac because of its weight.

During test flights it became apparent that there were grave problems with the original version of the Pratt 7 Whitney JT-9D. During the 1,400 hours flight and 1,013 flights of the test program, the

engines were exchanged 55 times. However, the Jumbo finally received its certification through the FAA on 30 December 1969. When the "Baby Boeing" 737 was being tested, there was only engine change. Four of the five test aircraft were later fitted with airline interior and supplied to customers. The first 747 stayed with Boeing for further test purposes.

Pan Am took her first 747 into service on 21 February as scheduled. "Clipper Young America" was supposed to fly 336 passengers from New York to London. However, an "obstinate" door and problems during loading the cargo made the flight late. When the Jumbo finally rolled out to take off, one of the engines overheated. The aircraft finally had to be replaced. The substitute 747 took off after a delay of seven hours. This would not be one off occurrence. Delays and cancelled flights soon gave the 747 the nickname "Dumbo Jet", the flying white elephant. At the beginning of the 70s problems with the engines went so far that up to 30 completed Jumbos had to be stored in Everett with concrete blocks instead of engines under their wings. Moreover there were rising costs and delays in supplying the aircraft. The tight schedule was to blame for this, because it was simply unrealistic to build up a new organisation, a new production plant and a new aircraft all at the same time in only 34 months.

Boeing's bad luck did not seem to change. The company's vital nerve was hit badly by the 747 crisis, the discontinuation of the super sonic airliner program SST and declining orders. It was initially planned for the profits of the 707s and 727s to keep the 737 and 747 projects afloat. However, the Board of Directors in Seattle were not able to predict the impending recession. The result was debts amounting to \$1 billion. Boeing reduced its staff from 100,000 in 1968 to 38,000. This rigorous reduction and the sales success of the 727-200 led Boeing back on the road of success.

Pratt & Whitney was finally able to remedy the existing engine problems. As a result the Jumbo's reliability increased impressively. Half a year after its service, the 747-Fleet had already transported one million passengers. From 1970 Boeing expanded its program by taking on the 747-200 with wider range and bigger payload. It also offered the aircraft with different engines, i.e. Pratt & Whitney JT9D, General Electric CF6 and Rolls Royce RB524. The 747-200 became the most popular model with 393 models and was only beaten by the 747-400. Later the 747SP Special Performance followed for extremely long distances and the 747-300 with lengthened upper deck for up to 69 passengers. The program has for now been brought to a conclusion with the 747-400 with two-man cockpit, modern avionics and more powerful engines.

During the Superjet's 30th anniversary celebrations Sutter, now retired Executive Vice Director, said, "From the beginning the 747 was intended to be versatile. That is why she did adjust to new technologies and our customers' requirements over decades. This flexibility contributed towards the plane's success and makes it legendary." Currently Boeing is investigating the 747-400X with an increased take-off weight of 409.5 tons. This version can fly 740 km further than the ordinary 747-400. According to Ed Renouard, Vice President and General Manager of the 747/767 Program, who spoke during the celebration in Everett, lengthened versions are being considered. "The 747's evolutionary possibilities will without doubt enable us to continue building versions of the Jumbo for the next 30 years," explained Renouard.

Although orders are currently receding because of the Asian economic crisis, the Boeing 747 remains the flagship of the world's largest constructor. It is possible that the introduction of the Airbus A3XX in 2005 will take the lead of the Jumbo Jet. Until then the Boeing 747 is and remains a prime example for technological performance.

Instantly recognized by passengers around the world, the Boeing 747 is in a class by itself. The

747-400 continues the 747 family legacy by integrating advanced technology into one of the world's most modern and fuel-efficient airliners. Currently, the only model in production, the 747-400 incorporates major aerodynamic improvements over earlier 747 models, including the addition of winglets to reduce drag, new avionics, a new flight deck and the latest in-flight entertainment systems.

The improved and advanced 747-400 delivers more range, better fuel economy and lower operating costs than the previous 747 models. The 747-400 has a range of approximately 8,300 statute miles (13,360 km) and the lowest cost per seat-mile of any twin-aisle airplane offered by any manufacturer. It has a dispatch-reliability rate of 98.8 percent.

Boeing delivered the first 747-400 in 1989 to Northwest Airlines. Since the first 747 delivery in 1969, Boeing has delivered more than 1,230 747s, of which 500 are high-technology 747-400s. The 747's longevity and popularity are based on its unbeatable low seat-mile costs, flexibility, long-range dominance, unmatched comfort options and ability to integrate new technology.

Aerodynamics and Structural Materials

The 747-400's most noticeable aerodynamic improvement is the 6-foot longer wing with a 6-foot-high winglet angled upward and slightly outward. This change reduces fuel burn and extends the airplane's range. While designing the 747-400, Boeing engineers discovered that the kind of wing shape needed by the airplane created a whirling pattern, called a vortex, at the wingtip while the airplane moved through the air at cruising speed. The top part of that whirling movement of air actually pushed down on the top of the wing, creating drag.

Initially, it was thought that the problem could be solved by adding several feet to the wing, but that would make it difficult to navigate increasingly crowded airport taxiways and ramps. Longer wings also would reduce the number of airport terminal gates available to the 747-400. The acceptable solution came in the form of a compromise that involved lengthening the wing by 6 feet and adding the winglet.

The winglet provides the effect of having an even greater wingspan without outgrowing the standard airport slot. The wingtip extension and winglet offer a fuel mileage improvement of about 3 percent, which during the lifespan of an airplane amounts to considerable savings for the airlines and their passengers. The durable and lightweight winglets are made of graphite-epoxy materials, currently used on the Boeing 737, 757, 767 and 777 airplanes. The composite and aluminum winglet saves 60 pounds (27 kg) per airplane compared to an all-aluminum structure.

Boeing also recontoured the wing-to-body fairing for drag improvement and achieved additional efficiency from newly designed nacelles and struts for the airplane's advanced engines: the General Electric CF6-80C2, the Pratt & Whitney PW4000 and the Rolls-Royce RB211. These engines provide up to 62,000 pounds of thrust.

Use of advanced materials allows considerable structural weight reductions throughout the 747-400. Metal flooring, previously used in the passenger cabin, has been replaced by light, tough graphite composite floor panels.

Structural carbon brakes are standard on the 747-400's 16 main landing-gear wheels. They provide improved energy absorption characteristics and wear resistance, as well as an estimated 1,800-pound (816 kg) weight savings over previous brakes.

The 747-400 also achieved weight savings of approximately 4,200 pounds (1,900 kg) by using higher-strength aluminum alloys with improved fatigue life. These alloys, introduced on the 757 and 767, are incorporated in the 747-400's wing skins, stringers and lower-spar chords.

Flight Deck

The 747-400 flight deck provides flexibility that is being incorporated in more models across the Boeing fleet. The 747-300 three-crew analog cockpit was transformed into a fully digital, two-crew flight deck with cathode ray tube (CRT) displays. Six 8- by 8-inch (200 by 200 mm) CRTs

are used to display airplane flight control, navigation, engine and crew-alerting functions. They allow more information to be displayed with fewer instruments. The number of flight deck lights, gauges and switches was reduced to 365 from the 971 on the 747-300. Flight crew workload is designed to be one-half to one-third that of former 747 models.

In the event of an individual CRT failure, automatic or manual display switching is used as a backup. The Engine Indicating and Crew Alerting System (EICAS) can call up the status or schematics of various systems at any time on one of the CRTs. Crews now can obtain an update of the airplane's mechanical condition while in flight, whereas before the information only was available to maintenance workers when the airplane was parked.

Interior Design

Boeing redesigned the interior of the 747-400 to improve passenger comfort, convenience and appeal. Ceiling and sidewall panels were recontoured with new, lighter-weight materials that provide an open, airy look. Passenger stowage capacity increased to 15.9 cubic feet (0.4 m³) in each 60-inch (152 cm) outboard stowage bin, or 2.9 cubic feet (0.08 m³) per passenger.

New laminate materials were designed to meet Boeing fireworthiness goals. A new thermoplastic blend reduces smoke and toxicity levels in the event of fire, and upper-deck ceiling panels are made of improved polyester and phenolic sheet molding materials instead of polyester.

Interior flexibility allows airline operators to relocate class dividers and galley and lavatory modules more quickly to serve market requirements. Lavatory installation is simplified by a vacuum waste system, and additional locations for galleys and lavatories are available. These "quick-change features" allow major rearrangement within 48 hours, while seats and compartments can be changed overnight.

Boeing also revised the 747-400 air-distribution system. This increases the main deck cabin air distribution zones from three to five, which allows ventilation rates in each zone to be regulated based on passenger density.

For the first time on any airliner, an optional cabin crew rest area uses space in the rear of the fuselage above the aft lavatories. This area, which can be configured for eight bunks and two seats, provides privacy as well as comfort for off-duty flight attendants. By relocating the crew rest to this area, 10 more profit-making seats are available on the main deck of the aircraft.

Increased Range and Flexibility

An optional 3,300-U.S.-gallon (12,490 L) fuel tank in the horizontal tail boosts the 747-400's range an additional 400 statute miles (650 km). The 747-400 also has a new 1,450-horsepower auxiliary power unit (APU) that provides an estimated 35 percent to 40 percent reduction in fuel consumption, better air pressurization performance on hot days, higher electrical output and reduced noise levels. Mounted in the rear fuselage, the APU supplies pressurized air for air conditioning and engine starting while the airplane is on the ground, plus electrical power to operate lights and other requirements during stops. The new APU also can be retrofitted to earlier 747s.

The 747-400 is available in passenger, combi, freighter and domestic configurations. The 747-400 Combi is two airplanes in one, carrying both passengers (forward) and cargo (aft) on the main deck. The 747-400 Freighter is the largest commercial cargo transport in service, and the 747-400 Domestic is a high-capacity (568 passengers) airplane that incorporates structural improvements to accommodate the increased takeoff and landing cycles of short-range operations. Because it does not need the drag-reducing capabilities of the 747-400's longer wing and winglet, the 747-400 Domestic uses the same wings as the 747-100, -200 and -300 models.

Boeing 747 marks 30 years in service

Jan. 21 marks the 30th anniversary of the Boeing 747. To date, 1,238 have been delivered, more than any other widebody jet in history. Eleven-hundred are still in service, 500 of which are the high-technology 747-400. In November 1999, the 747 received its own U.S. postage stamp,

recognizing its place as one of the top three aviation achievements of the 20th century. Parts of the aircraft are made in Wichita.

The first 747, the 747-100, rolled out of the Seattle works on 30th September 1968, and flew on 9th February 1969. The first commercial flight was with Pan Am between London and New York on 22nd January 1970.

The 747-200 is a heavier version, which entered service with KLM Royal Dutch Airlines (the oldest name in the airline business, incidentally) in February 1971. Its increased weight and improved range stemmed mainly from an increase in the fuel load. A freight version, the -200F, appeared in April 1972, together with a short-range high-capacity version for the Japanese domestic market, the 747SR. This carries 523 passengers.

1973 saw the start of planning for the 747SP, the first example appearing on 19th May 1975 with the first flight on 4th July. This is a special performance version, produced for services where the prodigious passenger-carrying capacity of its longer sisters is unnecessary. The aircraft is nearly 14.5 m shorter than the standard version, the tailfin some 1.5 m taller, and the tailplanes 3 m longer. Pan Am was the first customer for this, too. The last example of 45 was built in 1982.

In 1982 the upper deck of the -200 was stretched by 7 m to produce the 747-300. This first flew on 5th October 1982, and the initial customer was Swissair. The modification was also applied to existing 747's. The current production version (pricelist on Boeing's website - some \$170 million - delivery included?) is the 747-400. Built with a fully EFIS cockpit (i.e. electronic instruments and fly-by-wire technology; pictured right) it needs two flight crew rather than three, and is lighter than its predecessors because of the widespread use of composite materials. It might look like aluminium.... The winglets are a characteristic feature, there is a long upper deck, and there is increased fuel capacity compared with previous versions. The high capacity -400D takes 566 passengers and is the present version of the 747SR. There is also a freight variant, the -400F.

The mid-1960s was a propitious time to begin developing a large airplane. Helped by affordable fares, air-passenger traffic was growing explosively. Increasingly crowded skies and the availability of large-thrust engines added to the incentive for creating the giant 747.

Boeing had a start on the design and technology of such an airplane because the company had bid on, but lost, the contract for a gigantic military transport, the C-5A.

When Boeing approached the airlines about a 550-seat jetliner in 1966, Pan American placed a \$525 million order for the new 747 almost immediately.

To build the new plane, Boeing constructed a \$200 million plant in Everett, Wash., 30 miles north of Seattle. The world's biggest airliner would be assembled in the world's largest building (by volume).

The 747 was truly monumental in size. The fuselage of the original 747 was 225 feet long; the tail as tall as a six-story building. Pressurized, it carried a ton of air. The cargo hold had room for 3,400 pieces of baggage and could be unloaded in seven minutes. The total wing area was larger than a basketball court. Yet the entire global navigation system weighed less than a modern laptop computer.

Later, derivatives of the basic 747 were offered. The 747-200 can carry approximately 440 passengers about 5,600 nautical miles. The 747-300 has an extended upper deck and is designed to

be more cost-effective to operate than the 747-200.

The latest model, the 747-400, rolled out in 1988. The largest of all commercial jetliners, it uses advanced technology throughout, especially in the all-digital flight deck, where only two crew members are needed instead of the usual three. The wingspan has been increased by 18 feet to a total of 212 feet, with 6-foot-high "winglets" on the wing tips. The 747-400 also is produced as a freighter, as a combination freighter and passenger model, and in a special domestic version, without the winglets, for shorter-range flights.

BOEING 747-200B

No. of passengers: 281-372

Crew: 8-15

Engines: Four 21 300 kp

Pratt & Whitney turbofan

Cruising speed: 890 kmph

Range: 10 400 km

Remarks: Long-range aircraft

Period of operation for SAS: 1971-1983

4 x 244 kN Pratt & Whitney JT9D-7R4G2

Dimensions and Weights

Span	59.6 m	Landing gear track	11.0 m	Max ramp weight	379,210 kg	Max payload	
(kg)	69,400						

Length	70.7 m	Wheelbase	25.6 m	Max take-off weight	377,850 kg	Range	w/ max
payload							payload
							11,000

Height	19.3 m	Turn radius	42.8 m	Max landing weight	255,830 kg	Max fuel (kg)	43,110
--------	--------	-------------	--------	--------------------	------------	---------------	--------

Wing Area	512 m ²	Wing Sweep	37.5°	Max zero-fuel weight	238,820 kg	Range	
w/ max fuel (km)	13,690						

Empty weight	170,400 kg	Max fuel (litres)	198,380
--------------	------------	-------------------	---------

Performance

FAR Field Lengths Speeds

Take-off	Landing				
ISA sea level	3,190 m	ISA sea level	1,890 m	V2 speed	177 kt

ISA +20°C sl	3,610 m	ISA +20°C sl	1,890 m	VAT speed	141 kt
--------------	---------	--------------	---------	-----------	--------

ISA 5,000 ft	2,130 m	VNO speed	375 kt	MNO speed	M 0.92
--------------	---------	-----------	--------	-----------	--------

ISA +20° 5,000 ft	2,130 m	ISA = International Standard Atmosphere			
-------------------	---------	---	--	--	--

Cruise Performance and Accommodation

Cruise Long range Cabin Cargo compartments

Max speed	507 kt	Max speed	484 kt	Max seats	550	Hold volume	175 m ³
-----------	--------	-----------	--------	-----------	-----	-------------	--------------------

Altitude	35,000 ft	Altitude	35,000 ft	Seat pitch	76 cm/30.4"	No of	
holds	3						

Fuel cons./h	12,990 kg	Fuel cons./h	10,700 kg	Abreast	10	Press	diff
(bar)	0.60						

BOEING 747-400 COMBI

No. of passengers: 209-230

Crew: 8-10

Engines: Four 24000 kp

Pratt & Whitney turbofan

Cruising speed: 890 kmph

Range: 10400 km

Remarks: Boeing 747 with cabin divided and the aft section used for cargo.

Long-range aircraft

Period of operation for SAS: 1977-1987

4 x 254 kN Pratt & Whitney PW4056 or 251 kN General Electric CF6-80C2B1F or 264 kN Rolls Royce RB.211-524H

Dimensions and Weights for Pratt & Whitney powered aircraft

Span 64.5 m Landing gear track 11.0 m Max ramp weight 397,730 kg Max payload (kg) 49,140

Length 70.7 m Wheelbase 25.6 m Max take-off weight 396,830 kg

Height 19.3 m Turn radius 42.8 m Max landing weight 285,710 kg

Wing Area 511.2 m² Wing Sweep 37.5° Max zero-fuel weight 256,240 kg Range w/ max fuel (km) 12,390

Empty weight 184,080 kg Max fuel (litres) 216,852

Performance for Pratt & Whitney powered aircraft

FAR Field Lengths Speeds

Take-off

Landing

ISA sea level 2,073 m

ISA +20°C sl 2,073 m

ISA = International Standard Atmosphere

Cruise Performance and Accommodation

Cruise Long range Cabin Cargo compartments

Max speed 496 kt Max seats 266 Hold volume 170.7 m³

Altitude 35,000 ft Seat pitch 81 cm/32.4" No of holds 3

Abreast 10 Press diff (bar) 0.60

Air India Flight 182

Report on the accident to Boeing 747-237B VT-EFO, Air India Flight 182,
off Cork, Ireland on 23 June 1985
by John Barry Smith,
Independent Aircraft Accident Investigator

Appendix F Cargo Door Incidents
(FAA, NTSB databases)

Detail Primary Flight Type: SCHEDULED AIR CARRIER
 Secondary Flight Type: PASSENGERS
 Type of Operation: AIR CARRIER/COMMERCIAL
 Registration Number: 854TW
 Total Aboard: 98
 Fatalities: 0
 Injuries: 0 Landing Gear:
 Aircraft Weight Class: OVER 12500 LBS
 Engine Make:
 Engine Model:
 Engine Group:
 Number of Engines: 3
 Engine Type:
 Environmental/Operations Information Primary Flight Conditions: UNKNOWN
 Secondary Flight Conditions: WEATHER NOT A FACTOR
 Wind Direction (deg):
 Wind Speed (mph):
 Visibility (mi):
 Visibility Restrictions:
 Light Condition: DAY
 Flight Plan Filed: INSTRUMENT FLIGHT RULES
 Approach Type:
 Pilot-in-Command
 Pilot Certificates: AIRLINE TRANSPORT
 Pilot Rating: AIRPLANE SINGLE, MULTI-ENGINE LAND
 Pilot Qualification: QUALIFIED Flight Time (Hours) Total Hours:
 Total in Make/Model: 0
 Total Last 90 Days: 0
 Total Last 90 Days Make/Model: 0
 FAA INCIDENT DATA SYSTEM REPORT

 General Information

Data Source: FAA INCIDENT DATA SYSTEM
 Report Number: 19861208079879C
 Local Date: 12/08/1986
 Local Time: 08:45
 City: MEMPHIS
 State: TN
 Airport Name:
 Airport Id:
 Event Type: INCIDENT - AIR CARRIER

Mid Air Collision: NOT A MIDAIR
Aircraft Information
Aircraft Damage: NONE
Phase of Flight: CLIMB TO CRUISE
Aircraft Make/Model: BOEING B-727-223
Airframe Hours: 33354
Operator Code: AALA
Operator: AMERICAN AIRLINES INC - AALA
Owner Name: AMERICAN AIRLINES INC

Narrative

UNABLE TO CONTROL CABIN PRESSURIZATION IN AUTO OR MANUAL MODE.
FOUND

CARGO DOOR SEAL OUT OF THE TRACK.

Detail

Primary Flight Type: SCHEDULED AIR CARRIER
Secondary Flight Type: PASSENGERS
Type of Operation: AIR CARRIER/COMMERCIAL
Registration Number: 847AA
Total Aboard: 74
Fatalities: 0
Injuries: 0 Landing Gear:
Aircraft Weight Class: OVER 12500 LBS
Engine Make:
Engine Model:
Engine Group:
Number of Engines: 3
Engine Type:

Environmental/Operations Information

Primary Flight Conditions: UNKNOWN
Secondary Flight Conditions: WEATHER NOT A FACTOR
Wind Direction (deg):
Wind Speed (mph):
Visibility (mi):
Visibility Restrictions:
Light Condition: DAY
Flight Plan Filed: UNKNOWN
Approach Type:

Pilot-in-Command

Pilot Certificates: AIRLINE TRANSPORT
Pilot Rating: AIRPLANE SINGLE, MULTI-ENGINE LAND
Pilot Qualification: QUALIFIED Flight Time (Hours) Total Hours:
Total in Make/Model: 0
Total Last 90 Days: 0
Total Last 90 Days Make/Model: 0 FAA INCIDENT DATA SYSTEM REPORT

General Information

Data Source: FAA INCIDENT DATA SYSTEM

Report Number: 19861227081709C
 Local Date: 12/27/1986
 Local Time: 09:11
 City: CHICAGO
 State: IL
 Airport Name: CHICAGO O'HARE INTL
 Airport Id: ORD
 Event Type: INCIDENT - AIR CARRIER
 Mid Air Collision: NOT A MIDAIR
Aircraft Information
 Aircraft Damage: MINOR
 Phase of Flight: CLIMB TO CRUISE
 Aircraft Make/Model: DOUG DC-8-73F
 Airframe Hours:
 Operator Code: TAGA
 Operator: ORION LIFT SERVICE INC - TAGA
 Owner Name: ORION AIR INC

Narrative

CARGO DOOR OPENED ON TAKEOFF. RETURNED WITH DOOR LIGHTS ON.

Detail

Primary Flight Type: ALL CARGO CARRIERS
 Secondary Flight Type: CARGO
 Type of Operation: AIR CARRIER/COMMERCIAL
 Registration Number: 808UP
 Total Aboard: 0
 Fatalities: 0
 Injuries: 0 Landing Gear: RETRACT TRICYCLE
 Aircraft Weight Class: OVER 12500 LBS
 Engine Make:
 Engine Model:
 Engine Group:
 Number of Engines: 4
 Engine Type:

Environmental/Operations Information

Primary Flight Conditions: UNKNOWN
 Secondary Flight Conditions: WEATHER NOT A FACTOR
 Wind Direction (deg):
 Wind Speed (mph):
 Visibility (mi):
 Visibility Restrictions:
 Light Condition: DAY
 Flight Plan Filed: INSTRUMENT FLIGHT RULES
 Approach Type:

Pilot-in-Command

Pilot Certificates: AIRLINE TRANSPORT
 Pilot Rating: AIRPLANE SINGLE, MULTI-ENGINE LAND

Pilot Qualification: QUALIFIED Flight Time (Hours) Total Hours:
 Total in Make/Model: 0
 Total Last 90 Days: 0
 Total Last 90 Days Make/Model: 0
 FAA INCIDENT DATA SYSTEM REPORT

General Information

Data Source: FAA INCIDENT DATA SYSTEM
 Report Number: 19870408025949C
 Local Date: 04/08/1987
 Local Time: 07:08
 City: GREAT FALLS
 State: MT
 Airport Name: GREAT FALLS INTL
 Airport Id: GTF
 Event Type: INCIDENT - AIR CARRIER
 Mid Air Collision: NOT A MIDAIR
 Aircraft Information
 Aircraft Damage: NONE
 Phase of Flight: CLIMB TO CRUISE
 Aircraft Make/Model: BOEING B-737-222
 Airframe Hours:
 Operator Code: UALA
 Operator: UNITED AIR LINES INC - UALA
 Owner Name: UNITED AIRLINES INC

Narrative

A CARGO DOOR WARNING LIGHT CAME ON DURING CLIMB. THE AIRCRAFT RETURNED TO THE AIRPORT. DOOR IMPROPERLY LATCHED.

Detail

Primary Flight Type: SCHEDULED AIR CARRIER
 Secondary Flight Type: PASSENGERS AND CARGO
 Type of Operation: AIR CARRIER/COMMERCIAL
 Registration Number: 9051U
 Total Aboard: 39
 Fatalities: 0
 Injuries: 0 Landing Gear:
 Aircraft Weight Class: OVER 12500 LBS
 Engine Make:
 Engine Model:
 Engine Group:
 Number of Engines: 2
 Engine Type:

Environmental/Operations Information

Primary Flight Conditions: UNKNOWN
 Secondary Flight Conditions: WEATHER NOT A FACTOR
 Wind Direction (deg):

Wind Speed (mph):
Visibility (mi):
Visibility Restrictions:
Light Condition: DAY
Flight Plan Filed: INSTRUMENT FLIGHT RULES
Approach Type:

Pilot-in-Command

Pilot Certificates: AIRLINE TRANSPORT
Pilot Rating: AIRPLANE SINGLE, MULTI-ENGINE LAND
Pilot Qualification: QUALIFIED Flight Time (Hours) Total Hours:
Total in Make/Model: 0
Total Last 90 Days: 0
Total Last 90 Days Make/Model: 0 FAA INCIDENT DATA SYSTEM REPORT

General Information

Data Source: FAA INCIDENT DATA SYSTEM
Report Number: 19870430022259C
Local Date: 04/30/1987
Local Time: 07:45
City: COLUMBUS
State: OH
Airport Name: PORT COLUMBUS INTL
Airport Id: CMH
Event Type: INCIDENT - AIR CARRIER
Mid Air Collision: NOT A MIDAIR

Aircraft Information

Aircraft Damage: NONE
Phase of Flight: TO INITIAL CLIMB (1ST POWER REDUCTION)
Aircraft Make/Model: BOEING B-737-204
Airframe Hours:
Operator Code: PDLA
Operator: PRESIDENTIAL AIRWAYS INC - PDLA
Owner Name: PRESIDENTIAL AIRWAYS INC

Narrative

THE AIRCRAFT WOULD NOT PRESSURIZE AND THE AIRCRAFT RETURNED TO AIRPORT.

INOP. CARGO DOOR UNLATCHED. WARNING LIGHT

Detail

Primary Flight Type: SCHEDULED AIR CARRIER
Secondary Flight Type: PASSENGERS
Type of Operation: AIR CARRIER/COMMERCIAL
Registration Number: 313XV
Total Aboard: 31
Fatalities: 0
Injuries: 0 Landing Gear:

Aircraft Weight Class: OVER 12500 LBS
 Engine Make:
 Engine Model:
 Engine Group:
 Number of Engines: 2
 Engine Type:

Environmental/Operations Information

Primary Flight Conditions: UNKNOWN
 Secondary Flight Conditions: WEATHER NOT A FACTOR
 Wind Direction (deg):
 Wind Speed (mph):
 Visibility (mi):
 Visibility Restrictions:
 Light Condition: DAY
 Flight Plan Filed: INSTRUMENT FLIGHT RULES
 Approach Type:

Pilot-in-Command

Pilot Certificates: AIRLINE TRANSPORT
 Pilot Rating: AIRPLANE SINGLE, MULTI-ENGINE LAND
 Pilot Qualification: QUALIFIED Flight Time (Hours) Total Hours: 8400
 Total in Make/Model: 830
 Total Last 90 Days: 160
 Total Last 90 Days Make/Model: 160

FAA INCIDENT DATA SYSTEM REPORT

General Information

Data Source: FAA INCIDENT DATA SYSTEM
 Report Number: 19870310025169C
 Local Date: 03/10/1987
 Local Time: 10:25
 City: LONDON, UNITED KINGDOM
 State: OF

Airport Name:
 Airport Id:
 Event Type: INCIDENT - AIR CARRIER
 Mid Air Collision: NOT A MIDAIR

Aircraft Information

Aircraft Damage: NONE
 Phase of Flight: CLIMB TO CRUISE
 Aircraft Make/Model: BOEING B-747-121
 Airframe Hours: 68950
 Operator Code: PAAA
 Operator: PAN AMERICAN WORLD AIRWAYS INC - PAAA
 Owner Name: PAN AMERICAN WORLD AIRWAYS INC

Narrative

THE AIRCRAFT RETURNED TO AIRPORT WHEN UNABLE TO PRESSURIZE THE

CABIN.
WORN. CARGO DOOR LATCH TORQUE TUBE

Detail

Primary Flight Type: SCHEDULED AIR CARRIER
Secondary Flight Type: PASSENGERS
Type of Operation: AIR CARRIER/COMMERCIAL
Registration Number: 740PA
Total Aboard: 245
Fatalities: 0
Injuries: 0 Landing Gear:
Aircraft Weight Class: OVER 12500 LBS
 Engine Make:
 Engine Model:
 Engine Group:
Number of Engines: 4
 Engine Type:

Environmental/Operations Information

Primary Flight Conditions: UNKNOWN
Secondary Flight Conditions: WEATHER NOT A FACTOR
 Wind Direction (deg):
 Wind Speed (mph):
 Visibility (mi):
 Visibility Restrictions:
Light Condition: DAY
Flight Plan Filed: INSTRUMENT FLIGHT RULES
 Approach Type:

Pilot-in-Command

Pilot Certificates: AIRLINE TRANSPORT
Pilot Rating: AIRPLANE SINGLE, MULTI-ENGINE LAND
Pilot Qualification: QUALIFIED Flight Time (Hours) Total Hours:
Total in Make/Model: 0
Total Last 90 Days: 0
Total Last 90 Days Make/Model: 0 FAA INCIDENT DATA SYSTEM REPORT

General Information

Data Source: FAA INCIDENT DATA SYSTEM
Report Number: 19841101064029C
Local Date: 11/01/1984
Local Time: 20:43
 City: DETROIT
 State: MI
 Airport Name:
 Airport Id: SVM
Event Type: INCIDENT - AIR CARRIER
Mid Air Collision: NOT A MIDAIR
Aircraft Information

Aircraft Damage: NONE
 Phase of Flight: NORMAL CRUISE
 Aircraft Make/Model: LKHEED L-188-A
 Airframe Hours: 40607
 Operator Code: ZIAA
 Operator: ZANTOP INTERNATIONAL AIRLINES INC - ZIAA
 Owner Name: ZANTOP INTERNATIONAL AIRLINES

Narrative

CREW DOOR PORTION OF FORWARD CARGO DOOR SEPARATED DROM AIRCRAFT
 OVER
 LAKE ERIE. RETURNED FOR LANDING.

Detail

Primary Flight Type: ALL CARGO CARRIERS
 Secondary Flight Type: CARGO
 Type of Operation: AIR CARRIER/COMMERCIAL
 Registration Number: 346HA
 Total Aboard: 0
 Fatalities: 0
 Injuries: 0 Landing Gear:
 Aircraft Weight Class: OVER 12500 LBS
 Engine Make:
 Engine Model:
 Engine Group:
 Number of Engines: 4
 Engine Type:

Environmental/Operations Information

Primary Flight Conditions: UNKNOWN
 Secondary Flight Conditions: WEATHER NOT A FACTOR
 Wind Direction (deg):
 Wind Speed (mph):
 Visibility (mi):
 Visibility Restrictions:
 Light Condition: NIGHT
 Flight Plan Filed: INSTRUMENT FLIGHT RULES
 Approach Type:

Pilot-in-Command

Pilot Certificates: AIRLINE TRANSPORT
 Pilot Rating: AIRPLANE MULTI-ENGINE LAND
 Pilot Qualification: QUALIFIED Flight Time (Hours) Total Hours:
 Total in Make/Model: 0
 Total Last 90 Days: 0
 Total Last 90 Days Make/Model: 0 FAA INCIDENT DATA SYSTEM REPORT

General Information

Data Source: FAA INCIDENT DATA SYSTEM
 Report Number: 19860128014289C

Local Date: 01/28/1986
 Local Time: 10:13
 City: ST LOUIS
 State: MO
 Airport Name: LAMBERT-ST LOUIS INTL
 Airport Id: STL
 Event Type: INCIDENT - AIR CARRIER
 Mid Air Collision: NOT A MIDAIR
 Aircraft Information
 Aircraft Damage: NONE
 Phase of Flight: TO INITIAL CLIMB (1ST POWER REDUCTION)
 Aircraft Make/Model: CVAC CV-340-XXX
 Airframe Hours:
 Operator Code: GAIA
 Operator: KITTY HAWK AIRCARGO INC - GAIA
 Owner Name: GENERAL AVIATION INC

Narrative

FORWARD CARGO DOOR OPENED AS AIRCRAFT TOOK OFF. OBJECTS DROPPED
 OUT.
 RETURNED. FAILED TO SEE WARNING LIGHT.

Detail

Primary Flight Type: ALL CARGO CARRIERS
 Secondary Flight Type: CARGO
 Type of Operation: AIR CARRIER/COMMERCIAL
 Registration Number: 453GA
 Total Aboard: 0
 Fatalities: 0
 Injuries: 0 Landing Gear:
 Aircraft Weight Class: OVER 12500 LBS
 Engine Make:
 Engine Model:
 Engine Group:
 Number of Engines: 2
 Engine Type:

Environmental/Operations Information

Primary Flight Conditions: UNKNOWN
 Secondary Flight Conditions: WEATHER NOT A FACTOR
 Wind Direction (deg):
 Wind Speed (mph):
 Visibility (mi):
 Visibility Restrictions:
 Light Condition: DAY
 Flight Plan Filed: INSTRUMENT FLIGHT RULES
 Approach Type:

Pilot-in-Command

Pilot Certificates: AIRLINE TRANSPORT
 Pilot Rating: AIRPLANE SINGLE, MULTI-ENGINE LAND
 Pilot Qualification: QUALIFIED Flight Time (Hours) Total Hours: 6000
 Total in Make/Model: 500
 Total Last 90 Days: 0
 Total Last 90 Days Make/Model: 0

<<>>

FAA INCIDENT DATA SYSTEM REPORT

General Information

Data Source: FAA INCIDENT DATA SYSTEM
 Report Number: 19831229069289C
 Local Date: 12/29/1983
 Local Time: 22:15
 City: CHICAGO
 State: IL
 Airport Name: CHICAGO O'HARE INTL
 Airport Id: ORD
 Event Type: INCIDENT - AIR CARRIER
 Mid Air Collision: NOT A MIDAIR

Aircraft Information

Aircraft Damage: NONE
 Phase of Flight: CLIMB TO CRUISE
 Aircraft Make/Model: BOEING B-747-131
 Airframe Hours:
 Operator Code: TWAA
 Operator: TRANS WORLD AIRLINES INC - TWAA
 Owner Name: TRANS WORLD AIRLINES INC

Narrative

AFT CARGO DOOR LIGHT ILLUMINATED ON CLIMBOUT. DOOR DIFFERENTIAL
 FLAPPER

DOOR OPEN DUE TO ICED UP MASTER LOCK PIN.

Detail

Primary Flight Type: SCHEDULED AIR CARRIER
 Secondary Flight Type: PASSENGERS AND CARGO
 Type of Operation: AIR CARRIER/COMMERCIAL
 Registration Number: 93108
 Total Aboard: 0
 Fatalities: 0
 Injuries: 0 Landing Gear:
 Aircraft Weight Class: OVER 12500 LBS
 Engine Make:
 Engine Model:
 Engine Group:
 Number of Engines: 4
 Engine Type:

Environmental/Operations Information

Primary Flight Conditions: UNKNOWN
 Secondary Flight Conditions: FREEZING TEMPERATURE
 Wind Direction (deg):
 Wind Speed (mph):
 Visibility (mi):
 Visibility Restrictions:
 Light Condition: NIGHT
 Flight Plan Filed: INSTRUMENT FLIGHT RULES
 Approach Type:

Pilot-in-Command

Pilot Certificates: AIRLINE TRANSPORT
 Pilot Rating: AIRPLANE SINGLE, MULTI-ENGINE LAND
 Pilot Qualification: QUALIFIED Flight Time (Hours) Total Hours:
 Total in Make/Model: 0
 Total Last 90 Days: 0
 Total Last 90 Days Make/Model: 0

FAA INCIDENT DATA SYSTEM REPORT

General Information

Data Source: FAA INCIDENT DATA SYSTEM
 Report Number: 19840214010999C
 Local Date: 02/14/1984
 Local Time: 06:45
 City: JAMAICA
 State: NY
 Airport Name: JOHN F KENNEDY INTL
 Airport Id: JFK
 Event Type: INCIDENT - AIR CARRIER
 Mid Air Collision: NOT A MIDAIR

Aircraft Information

Aircraft Damage: MINOR
 Phase of Flight: FINAL APPROACH- INSTRUMENT FLIGHT RULES
 Aircraft Make/Model: DOUG DC-8-63F
 Airframe Hours:
 Operator Code:
 Operator:
 Owner Name: VIASA VENEZUELA

Narrative

FORWARD CARGO DOOR OPENED ON FINAL APPROACH. CAUSE OF THE DOOR
 OPENING
 COULD NOT BE DETERMINED.

Detail

Primary Flight Type: SCHEDULED AIR CARRIER
 Secondary Flight Type: CARGO
 Type of Operation: FOREIGN AIR CARRIER

Registration Number: 801WA
 Total Aboard: 0
 Fatalities: 0
 Injuries: 0 Landing Gear:
 Aircraft Weight Class: OVER 12500 LBS
 Engine Make:
 Engine Model:
 Engine Group:
 Number of Engines: 4
 Engine Type:

Environmental/Operations Information

Primary Flight Conditions: UNKNOWN
 Secondary Flight Conditions: WEATHER NOT A FACTOR
 Wind Direction (deg):
 Wind Speed (mph):
 Visibility (mi):
 Visibility Restrictions:
 Light Condition: DAWN
 Flight Plan Filed: NONE
 Approach Type:

Pilot-in-Command

Pilot Certificates: AIRLINE TRANSPORT
 Pilot Rating: AIRPLANE SINGLE, MULTI-ENGINE LAND
 Pilot Qualification: QUALIFIED Flight Time (Hours) Total Hours:
 Total in Make/Model: 0
 Total Last 90 Days: 0
 Total Last 90 Days Make/Model: 0

FAA INCIDENT DATA SYSTEM REPORT

General Information

Data Source: FAA INCIDENT DATA SYSTEM
 Report Number: 19840310022409C
 Local Date: 03/10/1984
 Local Time: 13:41
 City: DALLAS
 State: TX
 Airport Name: DALLAS/FORT WORTH INTERNATIONAL
 Airport Id: DFW
 Event Type: INCIDENT - AIR CARRIER
 Mid Air Collision: NOT A MIDAIR

Aircraft Information

Aircraft Damage: MINOR
 Phase of Flight: NORMAL CRUISE
 Aircraft Make/Model: BOEING B-727-123
 Airframe Hours: 50208
 Operator Code: AALA
 Operator: AMERICAN AIRLINES INC - AALA
 Owner Name: AMERICAN AIRLINES INC

Narrative

RAPID DECOMPRESSION AT CRUISE ALTITUDE. FOUND FATIGUE FAILURE OF THE FUSELAGE SKIN FORWARD OF THE AFT CARGO DOOR.

Detail

Primary Flight Type: SCHEDULED AIR CARRIER
 Secondary Flight Type: PASSENGERS AND CARGO
 Type of Operation: AIR CARRIER/COMMERCIAL
 Registration Number: 1993
 Total Aboard: 38
 Fatalities: 0
 Injuries: 0 Landing Gear:
 Aircraft Weight Class: OVER 12500 LBS
 Engine Make:
 Engine Model:
 Engine Group:
 Number of Engines: 3
 Engine Type:

Environmental/Operations Information

Primary Flight Conditions: VISUAL FLIGHT RULES
 Secondary Flight Conditions: WEATHER NOT A FACTOR
 Wind Direction (deg): 03
 Wind Speed (mph): 06
 Visibility (mi): GREATER THAN 10 MILES
 Visibility Restrictions:
 Light Condition: DAY
 Flight Plan Filed: INSTRUMENT FLIGHT RULES
 Approach Type:

Pilot-in-Command

Pilot Certificates: AIRLINE TRANSPORT
 Pilot Rating: AIRPLANE SINGLE, MULTI-ENGINE LAND
 Pilot Qualification: QUALIFIED Flight Time (Hours) Total Hours:
 Total in Make/Model: 0
 Total Last 90 Days: 0
 Total Last 90 Days Make/Model: 0

Air India Flight 182

Report on the accident to Boeing 747-237B VT-EFO, Air India Flight 182,
off Cork, Ireland on 23 June 1985
by John Barry Smith,
Independent Aircraft Accident Investigator

Appendix G: Wiring

NTSB AAR 00/03:

1.18.2 Information Regarding Electrical/Wiring Anomalies on
Airplanes

1.18.2.1 Accidents, Incidents, and Events Involving Electrical/Wiring
Components

During its investigation of the TWA flight 800 accident, the Safety Board examined its aviation accident/incident database for records of previous accidents and incidents involving transport-category airplanes in which the Board had used the words wire or wiring in the probable cause. In addition, the Safety Board reviewed other available records involving wiring- and/or fire/smoke-related air carrier events, including the following:

- Boeing laboratory reports, SBs, and SLs;
- AFRL reports;
- Safety Board preliminary, airworthiness factual, and accident brief reports;
- AIR 2000 air safety reports;
- British Air Accidents Investigation Branch (AAIB) reports;
- FAA service difficulty reports (SDR); 370 and
- a Civil Aviation Administration of China investigation report.

The results of these reviews are discussed in this section.

Wiring-Related Accidents/Incidents

In an October 21, 1996, fax, the Civil Aviation Authority of Singapore described an event that occurred on October 12, 1996, in which an operator reported that arcing in a wire bundle on a 747-200 cargo airplane had resulted in a fire at the aft bulkhead of the forward cargo compartment about STA 1000. The airplane was undergoing maintenance at the time of the fire, and subsequent inspection revealed damage to wire bundles W834, W846, W1524, and W370; the insulation blanket; the aft bulkhead of the forward cargo compartment; and (possibly) the CWT sealant. The operator removed the affected components from the airplane and shipped them to Boeing for examination and evaluation. A December 16, 1996, letter from Boeing stated that X-ray microanalysis and chemical identification of the damaged wire suggest that the insulation of the wire was damaged and that arcing had occurred between the damaged wires or that arcing between the damaged wires and ground had occurred.

From IASA: The International Aviation Safety Association is a non profit safety organization incorporated in New York.

Website at www.IASA.com.au .

Chairman: Mrs. Lyn Susan Romano

Description of High-Temperature Aircraft Electrical Wires. Only One, TKT MEETS FAA's FAR 25 STANDARDS. Sources; Industry Wire Experts. Contact jking1@mediaone.net

TypePropertiesSome Aircraft Used In

PVC/NYLON 592) 1979	<ul style="list-style-type: none"> *Heaviest and thickest at 6.8 lbs. per 1,000 ft. *Insulation burns readily creating <u>copious</u> smoke *Insulation turns to hydraulic acid when exposed to water. 	Early DC-9s (e.g., ValuJet 727s, 737s until
Poly-X (Aliphatic Polyimide)	<ul style="list-style-type: none"> *The first exotic blend of insulation (due to oil embargo) *Light weight, 4.7 lbs. per 1,000 ft. *Susceptible to solvents *Chafing resistant but cracks around Circumference *Copious smoke *Due to brittleness, 1" bare spots not uncommon * premature aging at just 4,000 hrs * Fails FAR 25 	Early 747s (e.g., TWA 800) and DC-10s
XL Tefzel (Spec 55) * Arc tracks * Soft as butter at rated 150 degrees C – not 200 C	<ul style="list-style-type: none"> * Copious smoke, density greater than 96% * Cracks easiest under vibration (ETEF Type) * Toxicity the worst (ETE Type) * Explodes in oxygen enriched areas * Fails FAR 25 	747s, 767s, 777s years?
Stilan 10s built 1970s * Fails FAR 25	<ul style="list-style-type: none"> *Light weight, 4.7 lbs. per 1,000 ft. *Insulation breaks down in hydraulic and de-icing fluid *Microscopic crazing problem seen by microscope *Cracks under stress *Found to arc over * Spurious signal generation 	747s and DC- in mid-to-late
Kapton some 747s (Aromatic 400s) 767s, DC-10s Polyimide and	<ul style="list-style-type: none"> *Very light weight, 4.5 lbs per 1,000 ft *Insulation burns fiercely creating <u>no</u> smoke *Known to arc over * Burns fiercely with arc over * Fails FAR 25 	727s, 737s, (MD-80, MD-11, A300-600 (with teflon top coat)
TKT built o n	<ul style="list-style-type: none"> *Light weight, 5.0 lbs. in per 1,000 ft. *Abrasion resistant 	737s and 757s late 1992 and

- *Superb insulation protection
- *High heat tolerance
- *Resists smoking when burning (less than 2% density)
- *Used on some aircraft since 1992.

FAR 25 states: that insulation material can not be used that is hazardous, unreliable, or contributes smoke/fire. No particular uses of insulation were further specified so insulation material includes; seat insulation, insulation blankets, rug insulation, and wire insulation. They are all types of insulation materials. Unless they are tested with an electrical fire (2,000 degrees) igniter to prove flammability proof, the material can not meet far 25 requirements. By their own (Limited) standards, the FAA has said, in fact, that most types of wire can not be used ! Only TKT wire insulation meets FAR 25 Standards.

IASA STUDY OF 270 WIRE RELATED ACCIDENTS/INCIDENTS

LAST REVISED. 3/2/2001 by jking1@mediaone.net. IASA Data

Specialist

Introduction

The following is a chronological list and brief summaries to aircraft "Wire" related events including significant systems failures, smoke and or fires. Some industry actions have also been added. This list is by no means intended to represent all such events known but rather is an attempt to focus more clearly on those where wire or wire types become known. Other IASA studies are available that broaden these number of events where "electrical" becomes the focus rather than just those where the word "wire" is more easily recognized. 109 additional such items to the 270 here may be found on page 14.

Identifying the various wire types or that the wires themselves have become directly causal is difficult because of the absence of such fault coding in the ATA coding system used throughout the commercial industry. The industry has now recognized this diminishing factor and recognized by the military some years ago.

Sources

The vast majority of events seen here come from the databases of the FAA's Office Of System Safety which include;

The FAA Incident Data Reporting System
 Aviation Safety Reporting System (ASRS)
 NTSB Accident/Incident Reports
 NTSB Recommendation Reports
 NTSB Monthly Reports
 And miscellaneous FAA Tech Reports/Letters

The URL source references and a guild to access them may be found at the back of this report. Also many other source URLs have been incorporated into the event description where economy of space allowed.

1. August 18, 1972 Lockheed L-1011. First recorded arc-tracking/arc-over event in commercial aircraft. 7 wires severed. Lockheed Report # 10 1973.
2. 6/30/77. TWA (W.B. Clark) objects to Boeing's continued use of Kapton wiring.

- 3.5/27/83. L-1011, TWA. Flight 111, Smoke and flames in the cockpit. Kapton wire damage. NTSB Accident/Incident Report # MKC83IA116.
- 4 6/2/83. DC-9-32. Air Canada. Near Cincinnati experienced an inflight fire and an Emergency landing at Cincinnati. Lav pumps, associated wiring and deterioration of wire insulation were inspected. NTSB Monthly Report # DCA83AA028.
5. 9/2/83. TWA acknowledges over 30 instances with Kapton wiring failures. Report 1702.
- 6 5/17/84. DC-10, Northwest Airlines. During climb saw sparks and smoke from the left side panel under his glare shield. Flight returned, and wire-bundle insulation and fabric sleeve around wire-bundle were found burned. Circuit breakers were tested, no cause found as to why they failed to open. NTSB Accident/Incident Report # CHI84IA196
- 7.4/6/84. FAA acknowledges considerable adverse experience with Kapton wiring among several operators, stating an investigation is warranted. States problem is under-reported. Memorandum FAA's Leroy Keith to all managers of ACOs.
8. 1/14/85. 757, Monarch Airlines. Loss of left generator due to flashover of Kapton feeder cables and lavatory leak. See 1/26/89 FAA/ Congressman Dingell letter and AD 85-12-08.
9. 5/10/85. Monarch Airlines 757. Kapton power feeders chafe and arc. Wire-bundle vaporized. Adjacent wire-bundles damaged. Boeing Alert Service Bulletin 757-24A0025.
10. 9/19/85. 727, Braniff Airlines. On landing noticed sparks from C/B Panel. Replaced wires, C/Bs, current sensing coils. FAA Incident Rpt # 19850919051729C.
- 11.10/18/85. L-1011, Royal Jordanian Airlines in-flight fire. Kapton wires arced and ignited a titanium air-duct. NTSB Recommendations Rpt # A-85-91.
- 13.7/12/87. Delta 767-232, Kapton wiring harness causes uncommanded go-around malfunction. NTSB Monthly, Ref <http://www.nts.gov/aviation/NYC/87A202.htm>.
- 14.3/88. DC-10, Northwest Airlines. Fire in electrical compartment, arcing cables, flames 1 to 2 feet high from ignited insulation blankets. Ref. DOT/FAA/CT-91/2 TechRpt.
15. 2/24/89. 747, United flight 811. Faulty Wiring and/or switch cause door to open in-flight. Nine passengers lost. NTSB Rpt. # AAR-92/02. (superceded Rpt. # 90/01).
- 16.12/30/89. 737, America West. Fire in wheel well due to arcing wire against a hydraulic line. All hydraulics lost. Overran runway. NTSB Monthly Rpt. # LAX90FA061.
- 17.1/18/90. MD-80, U.S. Air. Overheated wire insulation filled cockpit with smoke. Loose generator terminals found, no cause to cockpit smoke. Ref. DOT/FAA/CT-TN94/55.
18. 5/11/90. 737, Phillipine Airlines. Shortly after pushback aircraft exploded. 8 dead. Wiring caused explosion of center fuel tank. Ref. NTSB Rpt A-90-103. http://www.asy.faa.gov/asp/asy_searchus.asp Type in "A-90-103"
- 3/17/91. L-1011, Delta Airlines. Flames from the base of the cabin sidewall. Wires burned, 5 C/Bs tripped. Diverted to Goose Bay, Canada. Ref. DOT/FAA/CT-TN94/55.
- 8/2/91. 737, U.S. Air. While at cruise, lavatory smoke detectors activated and crew smelled smoke but stopped when C/Bs were pulled. FAA Incident # 199108020441799C.
- 9/28/91. MD-82, Continental Airlines. While taxing smoke came out of the instrument panel. Emergency evac. NTSB Monthly Rpt. # NYC91LA247 and ASRS Rpt. 190436.
- 9/11. ASRS Pilot Report (de-identified). Cabin reported light bulb pop and cabin crew saw smoke. Electrical fire behind light panel. Flight diverted. ASRS Rpt. # 190451.
- 10/91. ASRS Pilot Report (de-identified). On climb out smoke reported in cabin. Returned and fire department called. ASRS Rpt. # 190756.
- 11/13/91. DC-8, Flagship Express. Cargo door opened in flight. Damaged wires found in a wire-bundle. NTSB Accident/Incident Rpt. # NYC92IA030.
- 12/91. ASRS PILOT Report (de-identified). On climb-out attendant reported smoke in the cabin. Returned flight. ASRS Rpt. 197455.
- 2/12/91. Evergreen 747-100 experiences in-flight upset and lost 10,000 ft approaching supersonic speeds. Spurious signals caused uncommanded inputs to the autopilot. Poly-X wiring known for spurious signal generation to autopilots. Ref. TSB Report and NTSB Log # 2359, 4/30/92.

1/3/92. 737, United Airlines. Noticed electrical burning odor. Loud arc then heard with flames from aft cockpit panel. Short in a large wire-bundle. NTSB Rpt. # DEN92IA025.

3/92. ASRS Pilot Report. Smoke in cabin and return to gate. During next flight smoke re-occurred. Emergency return. This was the 5 th time in one month. ASRS Rpt. # 206023.

6/20/92. DC-8, Hawaiian Airlines. On ground, smoke from C/B Panel with spiking fire. Used fire extinguisher. FAA Incident Rpt. # 19920620024179C.

6/92. ASRS Pilot Report (de-identified). Cabin declared a fire odor and ceiling was hot. Diverted and declared a emergency. ASRS Rpt. # 214032.

7/22/92. 727, Northwest Airlines. Smoke in the cockpit, diverted to Fort Wayne. Found burned wiring above co-pilots upper window. FAA Incident Rpt.# 19920722033979C.

7/92. ASRS Pilot Report (de-identified). Crew noted sparks, arcing and smoke half way back left side. C/B popped, fire stopped. FAA made 2 inquires. ASRS Rpt. # 214781.

9/92. ASRS Pilot Report (de-identified). At gate, smoke became thicker from behind attendant jump seat with power off. Fire dept called. ASRS Rpt. # 220716.

1/93. ASRS Pilot Report (de-identified). While descending smoke came from C/B Panel behind captain. Emergency divert to BFL, evacuation on runway. ASRS Rpt. # 231385.

5/10/93. MD-11F. # 3 Engine surges with autopilot on or off because of broken wire. Unscheduled landing. Ref FAA SDR 1993051700120. (item 3).

8/6/93. MD-11F. Precautionary shutdown # 2 engine. Replaced # 2 engine wiring cable. Cable assy failed. Ref FAA SDR 1993081100261. (item 4).

9/93. ASRS Pilot Report (de-identified). At post flight, smoke in the cabin. Emergency evacuation. Claimed FAA follow-up-(Incident Data not found). ASRS Rpt.# 251342.

10/8/93. MD-11. Lost ground spoilers. During inspection found numerous burned and chafed wires in the fwd avionics bay. Ref FAA SDR 1993111000022. (item 5).

10/16/93. MD-81, Swissair. Heavy smoke from overhead panel after departing Munich. Emergency landing. Ref. NTSB Recommendation Rpts A-94-136 & A-94-133. German Investigations Unit identified a faulty Emergency Power switch.

11/2/93. MD-11. FADEC fault, return to Block. Suspect "spurious digital signal". Unable to duplicate. Ref FAA SDR 1993121300179. (item 6).

11/4/93. MD-87, Scandinavian Airlines. On landing crew noticed smoke in aft end. At the gate a fire erupted and extensively damaged the aircraft as arcing Kapton wires ignited flammable Mylar insulation blankets. Danish AAIB Rep # 2/96, SE-DIB.

4/11/94. A-320, Northwest Airlines. From cruise electrical wire insulation burning smell in cockpit. Diverted to Buffalo, replaced fan. FAA Incident Rpt. # 19940411012399C.

11/10/94. 737, China Airlines. After landing ground crew detected burning smell. Opened E/E bay and noted insulation blanket on fire under rack 2. Improper clamping allowed arcing Kapton wires to ignite flammable insulation blankets. Ref. FAA DOT/FAA/AR-97/58. Also see CAAC letter(7/24/96) to the FAA.

10/94. ASRS Pilot Report (de-identified). During cruise C/B Panel (P-18) behind captain emitted heavy smoke. C/B popped, smoke stopped. Emergency, diverted. ASRS #285007.

11/94 ASRS Pilot Report (de-identified). Departed LAX, aft cabin filled with smoke. Declared emergency, diverted. Met by FAA.. ASRS Rpt. # 288297.

11/94. ASRS Pilot report (de-identified). MD-80 aborted TO at O'Hare due to smoke/fumes in the cockpit and cabin.

12/8/94. Boeing 767 operator reports worn Kapton wires causing loss of passenger oxygen deployment, emergency lights, passenger signs, emergency evacuation signal and the fuel shutoff for the engine fire-handle switch. Ref. Boeing SB 767-35A0029.

1/8/95. MD-11F. Gear warning on climb out. Unscheduled landing. Found bad wire insulation to position indicator. Ref FAA SDR 1995011300722. (item 9).

1/11/95. DC-9, Columbian aircraft impacted the sea. 52 lost. Sparks and fire seen. Was first delayed because of electrical work. NTSB Monthly Rpt. # DCA95RA013.

50. 2/19/95. MD-11. Found galley power feeder wires arcing to L-3 door stop. (AD 98-25-11 addressed this 34 months later Ref FAA SDR 1995022400481. (item 11).

4/28/95. DC-10. Auto-pilot pitching violently, other deferred. Unscheduled landing. Same AGAIN on 4/29. Found shorts via pins 38-39 and for left outboard elevator. Ref FAA SDRs 1995060200120 and 1995060200121. (items 6 & 7).

4/29/95. MD-11. # 1 AC Buss Tie lock out, Return to gate. Wire # 3-16BL shorted to ground. Ref FAA SDR 19950551900452. (item 12).

5/95. ASRS Pilot Report (de-identified). Smoke in the cabin. Procedures did not stop smoke. Failure of Flap Indication and thrust reversers. FAA met A/C. ASRS # 305701.

5/10/95. 767. During layover found smoke in forward cabin from three shorted wires inside seat track 1C, 2C. Ref FAA SDR 1995051900313. (item 8).

5/17/95. 767. Lost right generator, unable to start APU. Unscheduled landing. Found short in IDG feeder. Ref FAA SDR 1995051900507. (item 10).

5/19/95. DC-10. C/Bs popped, lost # 1 and 2 generators. Unscheduled landing. Found burnt out wire-bundle in forward cargo ceiling. Ref FAA SDR 1995072100418. (item 9).

7/7/95. MD-11. Inspection found arcing and burning off of the pins in the automatic control PCU located in the recess of the Tail Fuel Tank. Concern is the proximity of this Fuel tank. Suspect faulty materials/ sealing. Ref FAA SDR 1995080400534. (item 13).

8/18/95. 767. During cruise found wire-bundle arcing along sidewall, seats 2A & 3A. Activated a fire extinguisher. Ref FAA SDR 1995082500003. (item 20).

8/6/95. MD-11, China Airlines. At gate, smoke came from E&E bay. Arcing Kapton wires ignited flammable Mylar batts. Ref. DOT/FAA/AR-97/58 & CAAC /FAA letter.

9/8/95. DC-10. A false warning to high engine oil temperature with engine shutdown and unscheduled landing. A bad wire to ground was found. Ref FAA SDR 1995091500033.

9/95. ASRS Pilot Report (de-identified). During cruise heavy smoke in the cabin. Emergency divert to Nassau. Claimed FAA Investigation. None found. ASRS # 315585.

11/2/95. MD-11. Found on Inspection two engine wire-harnesses chafed. Two incidents; this one -- Ref FAA SDR 1995111300460 And 1995111300461 on 11/6. (items 15,16)

11/13/95. 737, China Airlines. Mylar Insulation blankets set afire by hot drill chips from maintenance. Ref. DOT/FAA/AR-97/58 and CAAC / FAA Letter 7/24/96 (as above).

11/26/95. MD-82, Atitalia. Prior to TO, fire in the cabin from light ballast spread quickly through ceiling panels, wire-harnesses, insulation blankets. Ref. DOT/FAA/AR-97/58.

11/95. ASRS Pilot Report (de-identified). 737 on taxi-out saw smoke in the cockpit from generator control panel. Third event. FO required medical help. ASRS Rpt. # 321583.

11/95. ASRS Pilot Report (de-identified). MD-88 cabin advised of smoke alarm and odor in the cabin. Smoke in the cockpit. Returned to Atlanta. Cause unknown. ASRS 322428.

11/95. ASRS Pilot Report (de-identified). DC-10 recurring electrical fuel pump failures during fuel dump. Noticed hot electrical smell. Flight returned. ASRS Rpt. # 320312.

1/11/96. MD-11. During cruise had a # 1 engine generator warning. Found shorted and damaged feeder cables in the pylon. Ref FAA SDR 1996011200174. (item 19).

1996 the NTSB declares Air Force One, the President's aircraft, rewired due to concerns with Kapton wire. Ref. Center Public Integrity Rpt. "In The Unlikely Event", ISBN1882583-10-8.

1/16/96. 737. During inspection found chafed wire and arcing at E 3-2 Rack. Ref FAA SDR 1996012600172. (item 2).

2/25/96. DC-9. Aborted approach because could not get green gear light. Declared emergency. Faulty wire at switch. Ref FAA SDR 19960301000170. (item 10).

3/2/96. DC-9. A flash and smoke at row 5. Light disconnected due to chafed wires. Light okay. Ref FAA SDR 1996030800123. (item 13).

3/3/96. 737. During climb smoke came from the aft galley area. Unscheduled landing. Found shorted wire. Ref FAA SDR 1996052300102. (item 19).

3/8/96. 747. Leading edge warning during taxi. Found wiring shorted. Return to gate. Ref FAA

SDR 1996031500155. (item 4).

3/8/96. DC-9. Smoke while at the gate smoke from overhead near entry. Found burned wiring, scorched insulation. Ref FAA SDR 1996040500468. (item 22).

4/26/96. DC-10. In flight had smell of hot insulation by rows 14 to 18. Could not duplicate. Return to service. Ref FAA SDR 1996050200380. (item 21).

4/28/96. MD-11. Flight arrived with five Avionic C/Bs tripped. Found wire-bundle chafing. Ref FAA SDR 1996060600568. (item 25).

5/3/96. DC-9. At cruise fire annunciator and fire loop illuminated. Found wires W255A16 and 286A16N rubbing together. Ref FAA SDR 1996101000691. (item 41).

5/12/96. DC-9. No green gear light. Diverted to SYR. Replaced left down limit switch wire-harness. Ref FAA SDR 1996062000576. (item 31).

5/31/96. 747. On approach electrical burning smell in cockpit. Taxi light could not be turned off. Shorted witch and wire found. Ref FAA SDR 1996062700585. (item 15).

5/31/96. DC-9. During cruise, smoke in the aft cabin behind F/As seat. Found two burnt wires. Ref FAA SDR 1997010200195. (item 54).

6/1/96. 767. Inspection found numerous C/Bs tripped and chafed wires aft of CHILLER Unit in E/E compartment. Ref FAA SDR 1996061300112. (item 41).

6/5/96. DC-10. During takeoff had slat-disagree lights. Aborted TO. Found chafed wire and replaced sensor to prox box wires. Ref FAA SDR 1996061300092. (item 25).

6/12/96. 747. On climb out had flap lockout. Diverted flight. Found shorted wiring near P54 Panel. Ref FAA SDR 19960620001888. (item 11).

6/15/96. 747. During climb the red light for the nose gear “unsafe” came on. Repaired wire. Ref FAA SDR 1996062700006. (item 12).

6/17/96. DC-9. At the gate, had smoke in the cabin. Light ballast and charred wiring was replaced. Ref FAASDR 1996062000380. (item 30).

6/18/96. 737. On approach anti skid warning came on. Diverted to BWI. Replaced right main gear wire strut harness. Ref FAA SDR 1996071000673. (item 39).

6/23/96. 747. During climb the # 3 hydraulic overheat warning came on. Unscheduled landing. Repaired wire for indication problem. Ref FAA SDR 1996062700179. (item 13).

6/25/96. 767-332ER, Delta Airlines. Wires arced and severed one of two aileron cables. Lost right generator. Emergency landing. Ref. NTSB Monthly Rpt. NYC96IA131. SDR

7/21/96. DC-9. Inspection found the sidewall lights to be flickering. A wire burnt wire-harness was found. Ref FAA SDR 1996072500306. (item 36).

7/22/96. DC-9. Flight attendant reported no power to the forward coffeemaker. Inspection revealed melted wires to a terminal block. Ref FAA SDR 1996080200386. (item 38).

7/26/96. 747, TWA 800. High voltage Poly-X wiring outside the center fuel tank was bundled with the low voltage, split Teflon FQIS wiring inside the tank. A spark/arc transferred this energy into the tank through the wiring. Ref. NTSB AAR-00/03.

7/28/96. 767. During cruise wiring at seats 2A and others shorted and burned through. Ref FAA SDR 1996080200439. (item 52).

7/31/96. 737. Inspection found APU feeder harness and a stringer burnt. Ref FAA SDR 1996080800015. (item 43).

8/5/96. DC-9. At engine start smoke entered the cockpit. Burned wire found at the right heat-exchanger fan. Ref FAA SDR 1996080800520. (item 39).

8/13/96. 737. During cruise, left wing overheat light flickered. Unscheduled landing. Wire found chafed through and shorting. Ref FAA SDR. 1997013000457. (item 96).

8/31/96. 747. During taxi, primary display and C/B tripped. Returned to gate. Repaired chafed wire. Ref FAA SDR 19960905000421. (item 24).

9/3/96. 747. During cruise electrical arc and smoke came from galley work light. Found charred wiring insulation. Ref FAA SDR 1996092600668. (item 27).

10/7/96. 737. During cruise smoke came from behind cockpit overhead panel. Burnt wiring was

found. Ref FAA SDR 1996101700002. (item 63).

10/7/96. 737. During takeoff # 2 thrust reverser unlock light came on, aborted takeoff. Found chafed wire in pylon area. Ref FAA SDR 19961114000362. (item 72).

10/8/96. MD-11. Inspection found # 2 generator feeder cables chafed over right over wing exit. Ref FAA SDR 1996110100255. (item 28).

10/13/00. DC-9. Inspection found 24 lighting wires burnt, right side, station 1083 to 1205. Ref FAA SDR 1996101700537. (item 43).

11/4/96. DC-9. On approach, aft and forward fuel boost pumps C/Bs tripped. Found wire-bundle chafed in left wing. Ref FAA SDR 1996111400055. (item 47).

11/17/96. 737. Prior to takeoff, sparking, popping and smoke from compass and ignition switch area. Returned to gate. Saw chafed wire. Ref FAA SDR 199611200285. (item 74)

11/23/96. DC-9. During climb, burning odor in cabin. Unscheduled landing. Replaced damaged left ground power wire. Ref FAA SDR 1996121900609. (item 51).

12/10/96. 737. During inspection for ADI malfunction, lav water was found in wire-bundles feeding E/E compart connectors. Ref FAA SDR 1997032700535. (item 125)

12/11/96. 757, U.S. Air. Enroute, smoke and fire were visible in the aft floor and side wall area. Emergency and diverted. Examination of the burned area revealed an Audio-entertainment system cable had become shorted. Ref. NTSB Monthly Rpt. CHI97IA041.

12/14/96. 737. During inspection found left wing wire-bundle melted 15 of 32 wires. Ref Boeing service letter 737-SL-24-27. Ref FAA SDR 1996122600319. (item 82).

12/20/96. DC-10. At cruise, C/B for mid cabin reading lights popped. Reset, and burning smell began. Wiring found to be charred. Ref FAA SDR 1996122600432. (item 37).

12/20/96. 737. During climb # 1 engine surged. Declared an emergency and returned. Replaced engine PMC blue harness assembly. Ref FAA SDR 1997012300452. (item 93).

12/27/96. DC-9. After takeoff, right wing fuel boost pump C/B popped, then reset. Aft pump C/B popped, then forward again. Connector arcing, insulation damage in the fuel conduits was noted. Phase C/Bs popped. Ref FAA SDR 1997010200560. (item 55).

1/30/97. Several Boeing 767 Operators report loss of system failure(s) and/or fire due to Kapton wiring chafing on oxygen line fitting which could lead to electrical arcing. Boeing SB 767-35A00229, 6/25/98.

1/14/97. 737. During a inspection, fluid passing through a connector shorted out the rudder Power Control Unit solenoid. Ref FAA SDR 1997030600012. (item 114).

1/15/97. DC-10. During cruise, wing anti ice valves disagree light illuminated and then the # 3 manifold fail light. Found Wire-bundle burned. Ref FAA SDR 1997020600768.

1/20/97. 767. Inspection found strong electrical smell in aft galley. Unable to isolate. Suspect Chiller. Ref FAA SDR 1997013000095. (item 77).

1/20/97. DC-9, Northwest Airlines. Smoke from panel behind captain's seat. Charred wiring due to phase short and dust particles. NTSB Monthly Rpt. # CHI97IA072.

1/23/97. 767. Inspection found broken wire in cargo hold tripped a C/B. Resetting caused a small fire in the hold and in the insulation. Ref FAA SDR 1997122900005. (item 121).

1/27/97. 737. During cruise, lost series of systems including pressurization. Unable to reset C/Bs, Diverted. # 1 gen wire burnt. Ref FAA SDR 1997020600127. (item 105).

1/27/97. 737. On climb lost radar. Returned to gate. Found shorted Data A Buss B-wire. Ref FAA SDR 1997013000834. (item 104).

3/7/97. 737. While landing had flaps freeze. Found wire between connectors shorted to shield. Ref FAA SDR 1997032700165. (item).

3/8/97. 747. Inspection found # 1 APU generator feeder cables with split insulation and melted spacers. Ref FAA SDR 1997041700153. (item 44).

3/10/97. 737. In cruise, an uncommanded pressurization decent (manual). Unscheduled landing. Chafed wires near outflow valve. Ref FAA SDR 1997070300284. (item 171).

3/14/97. 737. Sparks under seat 9D. Found shorted wires. Ref FAA SDR 1997032700004. (item

121).

3/14/97. 747. Inspection found chafed wire-harness and a bare wire with signs of arcing at # 1 reserve tank and rib. Ref FAA SDR 1997040300806. (item 43).

3/30/97. DC-9. On climb had fault with right main gear unsafe light. Found high resistance of uplock to terminal wire. Ref FAA SDR 1999041000284. (item 61).

4/24/97. 747. Inspection found # 2 fuel boost pump wiring insulation failed due to conductive corrosion. Ref FAA SDR 1998011500139. (item 72).

4/28/97. 747-243, G-VIRGIN. Arcing Poly-X wires ignite cabin interior materials and destroy wire-bundles behind overhead panels in forward cabin. Ref, UK AAIB Rpt. # 5/2000 (EW/C98/1/3) Appendix G. (www.open.gov.uk/aaib/n653ua/n653ua.htm).

5/9/97. 737. Engine fire warning on touchdown. Fired extinguisher. Found badly chafed fire wire at a clamp. Ref FAA SDR 19970717000869. (item 174).

5/10/97. 737. While at cruise had # 1 transformer rectifier C/B tripping. Unscheduled landing. Found melted wires on C/B. Ref FAA SDR 1997052200816. (item 156).

5/24/97. DC-9. On approach, gear warning light would not go out. Found bare wires and water inside wire conduit. Ref FAA SDR 1997060500660. (item 63).

6/7/97. 737. Smoke and electrical smell near start switch., switch shorted to standby compass. Repaired five wires. Ref FAA SDR 1997 061900262. (item 163).

6/11/97. 747. Smoke and sparks at seat 2EF. Attendant used extinguisher. Repaired failed wiring. Ref FAA SDR 1998021100983. (item 76).

6/17/97. 737. On climb, engine EGT went to 1250 and then blank. Unscheduled landing. Found EGT wires shorted at engine harness. Ref FAA SDR 1997071000062. (item 172).

6/21/97. 767. At cruise had uncommanded IDG disconnect. Wire-harness failed. Ref FAA SDR 1997071700992. (item 95).

6/22/97. DC-9. On taxi out had elevator power fail. Return to gate. Replaced failed wire. Ref FAA SDR 1997072400064. (item 70).

7/3/97. DC-9. At cruise, something electrical is shorting in cockpit overhead panel. Wire shorted. Ref FAA SDR 19970722400519. (item 71).

7/5/97. DC-9, Northwest Airlines. At cruise smoke came from beneath glareshield. Shut off generators, declared emergency. Found burnt wires. NTSB Monthly CHI97IA195.

7/5/97. DC-9. At cruise smoke began filling cockpit from forward panel. Declared emergency. Found 4 feet of burned wires. Ref FAA SDR 1997071000444. (item 67).

7/15/97. DC-10. On climb had high oil temp, shut down # 2 engine. Unscheduled landing. Found shorted wire. Ref FAA SDR 1997081400787. (item 51).

7/28/97. 747. During cruise had sparks/smoke from seat 23-2. Replaced power cable and electronic unit. Ref FAA SDR 1997082100422. (item 58).

8/9/97. 747. On taxi had left wing overheat intermittent light on. Found shorted wire. Ref FAA SDR 1997081400977. (item 57).

8/14/97. DC-9. On approach main gear unsafe light fault. Found several failed wires at terminal block 53-66. Ref FAA SDR 1997100200689. (item 82).

8/25/97. DC-9. While in maintenance check, smoke and wire insulation damage was found near forward entry overhead. Ref FAA SDR 1997082800729. (item 76).

9/6/97. DC-9. On approach had gear warning fault, C/B found popped. Repaired wiring short. Ref FAA SDR 1997091100397. (item 78).

9/12/97. During taxi APU temp panel lights flickering and the smell of smoke in the cockpit. Found burned and chafed wires. Ref FAA SDR 1997091800828. (item 186).

9/21/97. 747. During climb had wing overheat light. Unscheduled landing. Found chafed wire at clamp. Ref FAA SDR 1997092500774. (item 61).

9/22/97. DC-10. During climb # 2 manifold fail light came on. Unscheduled landing. Replaced wires at manifold loop. Ref FAA SDR 19971000200322. (item 54).

9/25/97. DC-9. During climb had gear fault light. Replaced gear wiring harness and sensor. Ref

FAA SDR 19971000200331. (item 81).

9/29/97. 737. During cruise had APU fire warning. Pulled fire handle, light continued. Found wiring out of position. Ref FAA SDR 1997100200721. (item 189).

10/97. ASRS Report (de-identified). During preflight noticed light C/B popped. Sparks and wire arcing and worn insulation found. ASRS Rpt.# 382990.

10/15/97 767. Inspection found generator feeder cable chafed and burned near slat. Ref FAA SDR 1998012200841. (item 125).

152. 11/8/97. 767. During cruise left tank fuel quantity, and totalizer goes blank. Fault code included wiring. Ref FAA SDR 1997120400881. (item 117).

12/8/97. 767. During cruise left generator light flickering. Repairs to T-1 cable to IDG. Ref FAA SDR 1998011500726. (item 124).

12/30/97. 737. During climb unable to control pressurization. Returned to gate. Found C/B tripping, replaced PRSOV wiring. Ref FAA SDR 1998012200253. (item 203).

1/9/98 United Airlines flight 965, 767-322ER, arcing Kapton wires burned Cross-linked Tefzel wiring. Toxic gases emitted, wire-bundles burned. Ref. U.K. AAIB Rpt 5/2000 (EW/C98/1/3), para 1.12.3.8 and 1.18.2. (www.open.gov.uk/aaib/n653ua/n653ua.htm)

1/9/98. 767. During cruise had short circuit in P30 Panel near forward Chiller. Unshed landing. Severe wire-bundle damage. Ref FAA SDR 1998040800005. (item 129).

1/12/98. 737. Inspection found generator feeder cable and loom burnt due to arcing at the plug and socket. Ref FAA SDR 1998111300314. (item 276).

1/13/98. DC-9. On the gate the crew smelled smoke in the cockpit. Found broken wiring causing arcing at audio panel. Ref FAA SDR 199812200236. (item 84).

1/17/98. DC-10. During cruise # 1 start valve light illuminated. Unshed landing. Found chafed wiring near valve. Ref FAA SDR 1998012200529. (item 63).

1/18/98. DC-9. On taxi out had acrid electrical odor in cockpit. Light C/B popped. Return to gate. Suspect ballast or wiring. Ref FAA SDR 1998042900488. (item 99).

1/24/98. 737. During cruise a loud popping sound and a spark came out of cockpit overhead. C/B trips. Found shorted wire. Ref FAA SDR 1998031200994. (item 215).

1/25/98. 737. During cruise had engine fire faults. Reoccurring problem. Unshed landing. Engine core wiring harness faulted. Ref FAA SDR 1998022600675. (item 213).

6/27/98. 767. NTSB issues recommendations to the FAA on the Kapton wires on 767s due to the risk of in-flight fires or loss of control. The Kapton wires caused electricity to jump to control cables controlling the flight control surfaces. Ref A-98-1/2. (CNN 1/27).

1/29/98. DC-9. While at the gate smoke began coming in from battery compartment. Found broken wire. Ref FAA SDR 1998042900699 (item 100)..

3/1/98. Boeing declares arcing?sparking Kapton should be replaced with cross-linked Tefzel wire. Boeing Flight Summary Report 747-SRP-23-0057.

2/3/98. 767. During cruise flaps indicator jumps, also fault lights illuminated. Rewired at sensors and to wing root. Ref FAA SDR 1998043000009. (item 140).

2/6/98. 737. On climb gear would not raise. Unshed landing. Repaired wiring at gear logic shelf E11. Ref FAA SDR 1998031200971. (item 214).

2/8/98. DC-9. During decent had smoke in the cabin. Declared emergency. Repaired wire ends at S3-94. Ref FAA SDR 1998021900305. (item 87).

3/2/98. DC-9. During cruise a burning smell was detected in the rear cabin. Repaired broken wire at wire-bundle for lighting. Ref FAA SDR 1998043000771. (item 101).

3/6/98. 747. During cruise # 4 engine CSD over-temperature. Could Not Disconnect ! No cause found. Solder melted at disconnect. Ref FAA SDR 1998041701129. (item 83).

3/13/98. 747. On taxi out, # 4 engine start valve open light on. Returned to gate. Found wire insulation rotten at engine. Ref FAA SDR 1998032600261. (item 80).

3/15/98. DC-9. During climb the right engine start valve illuminated. Unshed landing. Repaired the engine wire-harness. Ref FAA SDR 1998043000860. (item 102).

- 4/10/98. 767. During cruise had electrical smell and haze at aft right galley. Only Chiller and fridge on. Repaired wiring. Ref FAA SDR 1998082800159. (item 140).
- 4/17/98. DC-10. Inspection found aft engine power feeder cables shorted at inlet duct panel # 364GR. Ref FAA SDR 199850100056. (item 74).
- 4/23/98. 737. During cruise # 2 slat transit light illuminated, a previous on 4/16. Unscheduled landing. Wire to be replaced. Ref FAA SDR 1998050100806. (item 230).
- 4/28/98. 737. Inspection found cockpit overhead wire-bundle chafed and burned. Ref FAA SDR 1998071700469. (item 242).
- 5/15/98. DC-9. During approach, nose gear downlock warning fault. Declared and emergency. Replaced gear wire-harness. Ref FAA SDR 1998052200834. (item 108).
- 5/16/98. MD11F. During taxi had # 3 engine vibration warning. Returned to gate. Found engine vibration wire-harness faulting. Ref FAA SDR 1998062000686. (item 45).
- 5/18/98. UPS 747-123 experiences uncommanded yaw inputs during cruise flight. Found to be a wire problem. Emergency landing. NTSB Monthly CHI98IA164.
- 5/20/98. DC-9. Inspection found APU power feeder cable shorted on a standoff. Ref FAA SDR 1998052900077. (item 109).
- 5/30/98. DC-10. After a smoke smell, found decoder harness and wires burnt under seat 22E. Ref FAA SDR 1998060500439.
182. 6/27/98. 737. After take off # 2 generator dropped off line. Could not reset. Unscheduled landing. Replaced generator wire-harness. Ref FAA SDR 1998120400507. (item 284).
183. 6/30/98. DC-9. Nose gear unsafe light illuminated. Replaced electrical harness. Ref FAA SDR 1998072400242. (item 112).
184. 7/15/98. DC-9. During cruise left generator tripped off. Losing hydraulics. Unscheduled landing. Wire arced through a hyd line. Ref FAA SDR 1998082100014. (item 114).
- 7/22/98. 747. Rejected takeoff due to cargo fire indication. Found chafed wire behind F/Es panel. Ref FAA SDR 1998080700341. (item 104).
- 8/14/98. 747. On taxi in C/B tripped for lights. Inspection found burnt and overheated wires and arcing. Ref FAA SDR 1998100900902. (item 112).
- 9/2/98. Swissair 111, MD-11- Investigation still ongoing, but Kapton and Tefzel wiring found that had arced. Mixed wiring types. Probable contributing factors may include incorrect routing/installation of the wiring.
- 9/24/98. 737. # 1 fuel heat valve came on, oil temp exceeded, shutdown engine. Returned to MCI. Found burned wire at valve. Ref FAA SDR 19981113000986. (item 278).
- 10/98. ASRS Pilot Report (de-identified). While in cruise, cabin crew noted smell of electrical fire. Diverted to alternate. ASRS Rpt. # 419315.
- 10/98. ASRS Pilot Report (de-identified). DC-10 dumped 85,000 lbs of fuel, declared emergency and diverted after smelling smoke in the cabin. ASRS Rpt. # 418250.
- 10/3/98. 767. While in cruise pax spilled drink in electric motor seat and shorted it out. Found chafed shorted wires near floor. Ref FAA SDR 1998100900432. (item 154).
- 10/8/98. MD-11, Delta Airlines. Two hours West of England enroute to Georgia experienced an electrical odor. Diverted to Ireland. NTSN Monthly # DCA99RA002. Also see FAA SDR 1998101600553; says "burned wiring to compressor" found. Item 51
- 11/98. L-1011 Kapton wiring arcs in cockpit behind circuit breaker panel. Emergency landing. Aircraft receiving conflicting electrical anomalies. Aircraft thought it was on the ground and in the air at the same time. Ref ASRS AB99:9/3-6
- 11/8/98. MD-11. Inspection found shorted wire in forward cargo which ignited Mylar insulation blanket. Ref FAA SDR 1998111301330. (item 52).
- 11/9/98. L-1011 Delta Airlines. Enroute between Honolulu and SFO, electrical fire in the cockpit. Numerous systems were lost. Emergency landing at San Francisco. Previous days had multiple electrical problems. NTSB Rpt. DCA99SA043 & ASRS Rpt. 419799.
- 11/9/98. DC-9. Inspection found smoke from lower EPC Panel. Found chafed and burned wires

near right AC relay. Ref FAA SDR 1998122400289. (item 124).

11/11/98. MD-11. At the gate a fire erupted in the forward cargo hold. Wiring damage led to a Mylar insulation blanket fire. Ref NTSB Recommendation Letter A-99-104 through 106, 12/15/99. See http://www.nts.gov/recs/letters/1999/A99_104_106.pdf

11/28/98. 747-400, Qantas Airlines. In flight fire in the E&E Bay. Arcing Kapton wiring ignites flammable insulation blankets. Emergency landing. Ref. NTSB Monthly Rpt. # DCA99WA014 and Ref. AAIB 5/200 (EW/C98/1/3), para 1.18.4 . Item 7.

11/28/98. 747. During climb saw equipment cooling caution. Found damaged and burned wiring & insulation blanket in fwd cargo area. Ref FAA SDR 1998011500351. item 117.

200. 11/30/98. MD-11F. During climb had faults; auto-pilot & throttles, Flt Dir, TAT, flaps, Press, Fan, etc. Returned, found 3 chafed wires. Ref FAA SDR 1998120400240. item 54.

12/25/98. DC-10. During climb had # 1 engine fire warning. Unscheduled landing. Found wire-harness at fault. Ref FAA SDR 1999010100129. (item 90).

12/22/98. L-1011, Delta Airlines. Before pushback, a passenger saw smoke and sparks from a sidewall vent. Two wire-bundles burned in the Mid Electrical Center. Wire to wire arcing, dust buildup and lav fluids were noted. A Delta Report said this was the fifth report of lav water, the eleventh report of wire to wire rubbing, the thirteenth report of excessive dirt buildup among Delta's 35 L-1011s. NTSB Monthly Rpt. # DCA99WA014.

12/29/98. DC-9. At gate, smoke in the cockpit and cabin. Crew saw an electrical Flash /Fire in comp left of door. Replaced wiring. Ref FAA SDR 1999010800058. (item 125).

1/29/99. 737. Inspection found chafed wires in center fuel tank level switch. Fuel found inside conduit. Ref FAA SDR 1999081200463. (item 357).

1/31/99. MD-11, American Airlines, smoke in the cabin. "Buzz" heard over PA system, C/B reset and then smoke seen in first class. Emergency declared, diverted to Seattle. Video system damaged, unknown connector failure. NTSB Accident Rpt. DCA99SA037

1/99. ASRS Pilot Report (de-identified). During cruise lost all pressurization, smoke in the cabin due to wiring caused electrical smoke. Emergency /divert. ASRS Rpt 424550.

2/13/99. MD-11. Inspection found electrical smell at row 13 and found electrical harness shorted out. Ref FAA SDR 1999021900341. (item 59).

2/16/99. DC-9. Inspection found left generator feeder cable shorting out in tail cone area. Bulkhead had a hole burned in it. Ref FAA SDR 1999022600217. (item 132).

2/99. ASRS Pilot Report (de-identified). DC-9 got failures of radio fan, GPWS, FDR, # 1 VHF, # 1 VOR, # 3 fuel boost pump, captain's ADI and CDI. Emergency decent to DTW. At gate, 11 more C/Bs popped.

2/99. ASRS Pilot Report (de-identified). DC-9-30 multiple unrelated electrical failures, most of left system lost but with no auto-transferring. Emergency landing. ASRS 428107.

2/23/99. MD-11. During overnight inspection aircraft would not accept power. Found wire burned and shorted in forward cargo bay. Ref FAA SDR 1999041700401. (item 63).

2/25/99. 737. On landing sparks and smoke in overhead panel behind fuel panel. Several C/Bs popped. Chafed wires behind panel. Ref FAA SDR 1999031200195. (item 327).

2/99. ASRS Pilot Report (de-identified). MD-11 U.S. While parked, a fire in a wire-bundle occurred. 14 wires found brittle and replaced. ASRS Rpt. 431017.

3/5/99. DC-10. Inspection found APU generator feeder cable shorting out at pressure bulkhead. Wire melted. Ref FAA SDR 1999031200607. (item 99).

3/99. ASRS Pilot Report (de-identified). 727 on TO had electrical smoke from the pilot's overhead panel. Pilot saw burned and charred wiring. ASRS Rpt. 429985.

3/29/99. MD-11, World Airways. During maintenance checks a Kapton wiring harness was found with chafed and arcing damage. Adjacent Mylar blankets also completely burned away. No cause listed. NTSB/Garvey letter, 12/15/99, NTSB Rpt. DCA99SA051.

3/31/99. DC-9. During climb had a loud pop and flash from the EPC C/B Panel, acrid smell. Found chafed power port feeder. Ref FAA SDR 1999043000409. (item 135).

4/9/99. 747. Inspection found # 2 main aft boost pump wiring insulation faulty. Ref FAA SDR 1999070900114. (item 134).

5/3/99. DC-9. During cruise the PSU oxygen masks dropped on the left side. Found wire shorted into forward lav pump under lav. Ref FAA SDR 1999051400001. (item 136).

5/10/99. 747. During inspection found C/B # 152 popped and smoked. Found wire chafing in overhead P5 Panel, wheel well fire Ref FAA SDR 1999061800610. (item 130).

5/16/99. DC-9. Aft left & fwd left fuel boost pump C/Bs popped, later the right side. Declared emergency. Damaged wire-bundle. Ref FAA SDR 1999062500762. (item 142).

5/18/99. 747. Inspection found trailing flap position wire in forward cargo ceiling shorted to ground. Ref FAA SDR 1999070900113. (item 133).

5/21/99. 737. During climb had smoke in the flight deck. Found wire chafed against bracket above P6-1 Panel. Ref FAA SDR 1999060400487. (item 337).

6/20/99. 737. During cruise faults with # 2 fuel gage. Replaced the # 1 and the # 2 wing tank harness assemblies. Ref FAA SDR 1999072300651. (item).

7/7/99. DC-10. Inspection found smoke/sparks in main gear bay. Wiring for # 2 Aux Hydraulic pump burned through but C/Bs not tripped. Ref FAA SDR 1999091000467.

7/8/99. 737. Inspection found 20 damaged wires in the vertical stabilizer and apparently damaged by hydraulic fluid near rudder PCU. Ref FAA SDR 1999081200849. (item 358)

7/27/99. 737. Inspection found system B hydraulic pump line chafing power wire-bundle causing short circuit. Ref FAA SDR 1999112500057. (item 391).

7/27/99. MD-11F. Inspection found forward cargo external power cable arcing below floor and bilge area insulation blanket burnt. Ref FAA SDR 1999073000464. (item 77).

7/31/99. 737. During cruise stabilizer trim actuator C/B pops. Found wires shorted to ground at bulkhead. Ref FAA SDR 1999081200236. (item 356).

8/3/99. MD-11. Inspection found seat 5G electrically inop. Found burned wire. Ref FAA SDR 1999081400461. (item 78).

8/10/99. 737. On takeoff left generator tripped. Smoke in cabin. Unscheduled landing. # 1 TR C/B tripped and generator feeder burnt. Ref FAA SDR 1999082000330. (item 361).

8/24/99. 737. During climb aircraft yawed. Unscheduled landing. Autopilot stabilizer trim wiring found damaged at aft bulkhead. Ref FAA SDR 1999102200599. (item 381).

8/27/99. 737. At climb interphone had ringing chimes, call lights flashing, smoke and flame at 3R Com panel. Wires replaced. Ref FAA SDR 1999102900318. (item 385).

9/2/99. 737. On takeoff # 2 bleed tripped off. Pressurization went to 9,500. Return to block. Wire Open to air bleed regulator. Ref FAA SDR 1999101300025. (item 374).

9/7/99. MD-88, Delta Airlines. During climb noted smoke in the cabin. Emergency and diverted. Mylar insulation burned 5 x 5 foot under floor. No cause. NTSB NYC99IA231. Also reference in NTSB/Garvey letter, 12/15/99 at ntsb.gov/recs/letters/1999/A99_104_106.pdf

9/21/99. MD-11. Inspection found sparks and smoke from under seat 11C. Wire-harness shorted to foot rest. Ref FAA SDR 1999100100110. (item 83).

9/25/99. 737. During climb had uncommanded right and left Yaw. Found a broken wire at forward end of E1 equipment rack. Ref FAA SDR 2000022900039. (item 417).

9/28/99. DC-9. Inspection found SELCAL system wire with burned insulation between station 110 to 160. Ref FAA SDR 1999100100341. (item 153).

10/9/99. 737. En route # 1 and 2 TRs tripped. Reset, tripped again. Electrical smell noted. Unshed landing. Replaced gen feeder harness. Ref FAA SDR 1999110500446. item 389

10/18/99. 737. During climb had smoke in aft galley. Unshed landing. Found shorted power wire behind galley. Ref FAA SDR 1999102900119. (item 384).

10/20/99. 737. Aborted takeoff after warning horn sound. Found chafing wire to # 4 SKEW sensor in wheel well. Ref FAA SDR 1999102900116. (item 383).

10/24/99. MD-11. Inspection found chafed and arcing wire at seat 3B, C/B did not pop. Replaced wiring harness. Ref FAA SDR 1999102900893. (item 85).

11/1/99. British 737-500 arcing kapton wiring in E/E bay, wire-bundle found completely charred. Ref . AAIB Rpt. 5/2000 (EW/C98/1/3) Para. 1.18.4.

11/2/99. 737. During climb both fuel flow indicators fluctuated. Unscheduled landing. Found chafed wire near # 1 engine. Ref FAA SDR 1999111100007. (item 390).

11/8/99. DC-10. During climb lost # 2 generator. Reset C/B. Smoke in the aft galley, gen off again. Found feeder wires shorted. Ref FAA SDR 1999111900011. (item 114).

11/9/99. DC-10. Inspection found fuel quantity fault. Wires in aux tank have insulation separation and damage. Ref FAA SDR 19991218000846. (item 119).

11/11/99. 737. During climb multiple C/Bs popped . Unscheduled landing. Found failure of the wire-bundle insulation at BS 410. Aircraft 772 wiring replaced. No system problems found for overload. Ref FAA SDR 1999122300026. (item 399). SEE NEXT.

11/11/99. 737. Alaska Airlines returned after popped C/Bs and low fuel lights. Follow up found additional C/Bs popped and heavily sooted and melted insulation in wiring bundles near cargo hold, station 410. NTSB Accident Rpt. SEA00IA019.

11/19/99. DC-9. During climb generator failed with AC cross lockout. Noted electrical odor. Unshed Landing. Feeder cable shorted. Ref FAA SDR 1999112500233. (item 156).

11/21/99. MD-11. Maintenance found arcing behind seat 13A caused by pinched cable. Ref FAA SDR 1999120400158. (item 88).

12/21/99. DC-10. Number 1 AC Bus C/Bs popping. Found burned wires in ceiling of forward compartment. Ref FAA SDR 1999011500634. (item 92).

1/10/00. 747. Inspection found APU generator feeder cable burned below cabin floor at BS 1450. Ref FAA SDR 2000042800255. (item 165).

1/18/00. DC-10. Inspection found electric hydraulic pump had 2 each shorted wires causing a fire. Ref FAA SDR 2000012900102. (item 122).

1/20/00. 737. During climb had fuel imbalance. Unscheduled landing. Replaced # 1 fuel quantity wire-harness. Ref FAA SDR 2000012000226. (item 407).

1/24/00. 737. During cruise generator tripped off twice. Third time could not reset C/B. Unscheduled landing. Replaced T1 wire. Ref FAA SDR 2000040800132. (item 425).

1/25/00. MD-11. During cruise coffee maker wire burned through but C/Bs did not pop. Ref FAA SDR 2000021200806. (item 91).

1/28/00. 737. While in climb aft lav smoke detector was sounding. Smell in cabin. Unscheduled landing. Found aged lav wire. Ref FAA SDR 2000050300165. (item 429).

1/31/00. 737. During climb fuel quantity indications decreased and erratic. Unscheduled landing. Repaired wires in right wing. Ref FAA SDR 2000022600044. (item 414).

2/2/00. 747. Inspection found generator feeder cable burnt at sta's 970, 980, and 985. Ref FAA SDR 2000022600048. (item 158).

2/8/00. DC-9. During pushback left pack fan C/Bs tripped. Found heat-exchanger wires chafing and shorted. Ref FAA SDR 2000021900295. (item 168).

2/8/00. 737. During decent # 1 generator Bus off light and systems loss. Declared emergency. Found chafed gen harness. Ref FAA SDR 2000042800409. (item 427).

4/16/00. 737. At climb pressurization fail light illuminated. C/B popped, no control. Wires damaged at controller and aft bulkhead. Ref FAA SDR 2000061000353. item 442.

4/17/00. 737. After liftoff wheel well C/B popped. Had previous repairs to wiring, and now found 20 wires burned at P18-3 panel. Ref FAA SDR 2000060300211. (item 440).

4/18/00. 737. During cruise left wing/body overheat light illuminated. Unscheduled landing. Found chafed shorted wire at APU. Ref FAA SDR 2000061000225. (item 441).

5/1/00. DC-9 On descent had smoke in the cockpit. Found a burnt wire going to map light. Ref FAA SDR 2000062400177. (item 177).

5/20/00.737, Electrical loom (bundle) arcing due to swarf in P6-4 C/B Panel. Overheated power receptacle, cause unknown. Ref . AAIB Rpt. 5/2000 (EW/C98/1/3) Para. 1.18.4.

6/10/00. 747. Inspection found wiring harness arcing at BS 520 in the forward cargo hold. Ref

FAA SDR 2000082200021. (item 172).

6/17/00. 737. Inspection found APU wiring melted behind starter connector and burned insulation in the E/E bay. Ref FAA SDR 200072500192. (item 466).

8/8/00. DC-9, Air Tran Airways. Flight returned to Greensboro with very dense smoke in the cockpit. Sparks and smoke seen the area of the forward FA jump seat. Emergency declared. Extensive wire damage in electrical panel behind captain's seat and blistering of the aircraft skin. Aircraft substantially damaged. NTSB Monthly # DCA00MA079.

10/1/2000, MD-80, Continental Airlines. Kapton arcing burns a fist sized hole in the cockpit. Cockpit filled with smoke. Emergency landing. NTSB Monthly ATL01IA001 and FAA Accident Rpt at http://www.faa.gov/avr/aai/D_1002_N.TXT.

John D. King, IASA Data Specialist at jking1@mediaone.net.

INSTRUCTIONS TO LOCATE SOURCE URSs AND AGENCIES IN THIS IASA STUDY

NTSB Monthly <http://www.nts.gov/aviation/months.htm> Search By Year And Date.

NTSB Recommendations http://nasdac.faa.gov/asp/asy_searchus.asp Search By Report Number.

NTSB Accident/Incident http://nasdac.faa.gov/asp/asy_ntsb.asp Search By Report Number.

FAA Incident Data System http://nasdac.faa.gov/asp/asy_fids.asp Search By Report Number.

Cross System Search to each of the above http://nasdac.faa.gov/asp/asy_crosssys.asp.

ASRS REPORTS At http://nasdac.faa.gov/asp/asy_asrs.asp Search By Report Number.

NASDAC's Aviation Safety Data Accessibility Study Index http://nasdac.faa.gov/safety_info_study

'Heinrich Pyramid' http://nasdac.faa.gov/gain/Presentation/GAIN_Brief.pdf ref page 7 of 42.

MILITARY WIRING ISSUES SEPARATED FROM ABOVE LIST 18 ITEMS

May 1995, Royal Air Force Nimrod, wires arc and fire starts. Aircraft lost.

July 20 1998, Army Command issued to all AH-64 helicopter users to inspect the Kapton wiring which could contribute to uncommanded inputs.

September 4, 1999 NASA's entire Shuttle fleet grounded for 6 months for Kapton wiring problems.

October 17, 1988, NASA's Magellan Spacecraft experiences \$87,000 electrical fire due to Kapton wiring.

1983 NASA's Columbia Shuttle orbiting earth experiences Kapton wire fire.

1985, NASA's Space Lab used in the shuttle, experiences Kapton wire fire.

March 30, 1987, F-18 Kapton wire fire nearly dooms \$32 million aircraft.

November 1982, Air Force's F-16 experiences Kapton arc-tracking. Pilot/Aircraft lost.

August 24, 1990 US Coast Guard's E-2C crashed due to Kapton wire fire.

November 2000- US Navy loses 153rd F-14 out of 600 produced. Requested \$360 million in FY 83 to rewire F-14s due to wire to wire shorts caused by premature aging and cracking of Poly-X wire type used in first 323 aircraft produced.

May 31, 1982-December1, 1981- In just six months the Air Force experiences 800 autopilot

May 31, 1982-December 1, 1981- In just six months the Air Force experiences 800 autopilot anomalies due to wiring.

March 1986-US Navy AV-8B in-flight electrical fire caused by Kapton wiring. Fourth occurrence in six month period.

1988 US Military, Canadian and British military ban Kapton.

March 1987, Vermont National Guard F-16, arcing Kapton caused nine wire-bundles to be destroyed.

May 1985, EF 111 Air force jet has a catastrophic explosion of Kapton wires. 92 wires damaged, 29 circuit breakers popped.

September 11, 1986 Marine AV-8B Harrier emergency landing, inoperative critical instruments, several burned bundles of Kapton wires.

January 27, 1982 US Navy F-4, Electrical in-flight fire in circuit breaker 10 inches from co-pilot's feet. Thick smoke in the cockpit/all electrical power lost. Emergency landing.

October 1987, US Navy A-6 aircraft lost at sea. Kapton wire only suspected cause.

--

15 ITEMS NOT POSTED DUE TO LACK OF OTHER SOURCES

11/28/00. DC-9, Air Tran. Flight 956 returned to Hartsfield, Ct after smoke was detected in forward galley and cockpit C/Bs tripped. Evacuation was made on the runway. Passengers were given 1,000 dollars each for lost luggage and claims of luggage damaged in the fire. News wire stories.

http://www.accessaltanta.com/partners/ajc/newsatlanta/airtran_1129.html

<http://www.ohio.com/dist/nf/021801.htm>

http://dailynews.yahoo.com/h/ap/20001201/bs/plane_fire_1.html

<http://www.herald.com/thispage.htm?content/archive/news/yahoo/digdocs/055368.htm>

11/16/00. 747, United Airlines. Smoke filled one of the kitchens. Emergency landing at Seattle-Tacoma. News wire story. www.airsafetyonline.com/news/200011/16/5.shtml

11/3/00. 757 American Airlines. 757 reported smoke in the cockpit. Emergency declared and landed in Miami Int'l airport. News

http://dailynews.yahoo.com/hwplg/20001103/lo/240762_1.html

10/19/00. 747 United Airlines diverted to Auckland because of electrical problems. News wire story

<http://www.pprune.org/ubb/NonCGI/Forum1/HTML/010545.html>.

10/18/00. 757, National Airlines. Flight 7002 returned and landed due to a fire in the galley. FAA Incident Reg 546NA. News wire story. http://www.faa.gov/avr/aai/D_1018_N.TXT

10/6/2000. MD-80, American Airlines. Denver to LA Flight 2821 diverted to Bryce Canyon Airport after reports of smoke in the cabin and oxygen masks were deployed. News wire story.

<http://more.abcnews.go.com/sections/travel/DailyNews/Emerglanding001006.html>.

9/27/2000. MD-80 (or 90), American Airlines. Returned to Omaha Airport after departing DFW and an occurrence of smoke in the cockpit. No further detail.

8/24/99. MD-90. Uni Air. On landing at Hualian, Taiwan flight 873 (Reg B-17912) heard a loud noise from the front of the cabin and thick black smoke poured from one of the overhead compartments on the right side. It took firefighters a half hour to control the blaze. 28 people were injured. News wire story. <http://aviation-safety.net/database/1999/990824-0.htm>

8/13/00. 757, Continental Airlines. Diverted into Ketchikan with electrical failures. Possible 'Red Eye' out of ANC. No details.

7/23/00. 757, British Airways. Possible cabin fire and divert to Heathrow (LHR). No details.

7/23/00. 757, British Airways. Possible cabin fire and divert to Heathrow (LHR) . No details.
 7/17/2000. MD-80, American Airlines. DFW to Orlando, flight 1258 diverted to Dallas Fort Worth after reports of smoke in the cockpit. Emergency over wing evacuation. AP Wire.

<http://more.news.abcnews.go.com/sections/travel/DailyNews/smokecockpit000717.html>

6/15/00. MD-80, Continental Airlines. According to FAA records “the 1981 MD80 has been repaired for small cracks, dents, fluid loss, burned wires and electrical problems”. News wire story. <http://www.bergen.com/news/lurch200006155.htm>

2/29/00. 747-300. Reg # PU-BUH. From EHAM (Amsterdam) to PANC (Anchorage) made a emergency decent into Prestwick (PIC) after report of a main cargo-deck fire. No detail.

7/16/99. American Airlines. Flight 2191 made a emergency landing at the naval station in the Florida Keys after the pilot said he smelled smoke aboard the Miami to Cancun flight with 162 aboard. AP Wire. No details.

3/12/99. 767, United Airlines. Flight 971 Washington to Milan. Smoke detected, emergency and diverted to Newfoundland. CNN News wire. END _____

10 MISCELLANOUS ITEMS NOT POSTED FOR LACK OF ADDITIONAL REFERENCES

1981. TWA asks the Boeing Company not to use Kapton on their 767s. Boeing refuses.

July 12, 1987. Boeing 767-232 has all three autopilots fail.

August 10, 1990. Delta 767-332 made an emergency landing due to loss of engine due to chafed Kapton wiring.

February 1, 1995. Monarch 757, Kapton wire-bundles arc, knocking out cockpit displays.

May 28 1998. Continental 737, arcing wires burn hole in conduit, explosive condition, All 737s grounded with more than 51% showing exposed conductors.

September 22, 1999. SAAB SF-340-B Emergency landing/Smoke in the Cockpit due to chafed wire from autopilot system.

November 1, 1999. Canada’s Transport Canada acknowledges Kapton wire problems. Ref British AAIB Report 52/87.

31 Jan 00. DC-9. Nightingale/Skytrain.Reg # MWT107 While parked at the gate pilot was advised of a fire in the aft Lav with minor damage. Passengers deplaned. FAA Incident *.

March 2, 2000. British Airways 747 Flt 179 experiences abrupt climb injuring 11, FAA determines, “The aircraft experienced an uncommanded autopilot climb”. (USA Today)

March 3, 2000. Kapton banned from use by Australian Airline.

109 ADDITIONAL ITEMS POTENTIALLY “WIRE” RELATED BUT NOT SPECIFICALLY MENTIONED

12/7/84, 727, Republic Airlines. TO aborted, smoke and arcing from P611 Panel. Heat and smoke damage near left ground blower. FAA Incident Rpt # 19841207070859C.

4/8/85. DC-9-82. American Airlines. During cruise, C/Bs opened for transformer rectifiers at AC Panel. FAA Incident Rpt # 19850408014749C.

12/31/85. DC-3, Private charter. Dense smoke in cockpit from fire originating in aft cabin. Ignition and fuel source undetermined. NTSB Recommendations Rpt # A-85-91.

8/10/86. DC-10, American Trans Air. Fire in the forward cargo hold on the ground. No probable cause determined. NTSB Monthly Rpt. # DCA86IA037.

11/26/86. 727, Continental Airlines. While on ground a cargo fire started. APU generator C/B found smoldering. FAA Incident Rpt. # 19861125069939C.

5/26/87. 737, Southwest Airlines. While in climb, smoke was seen in the aft galley. Pulled

5/26/87. 737, Southwest Airlines. While in climb, smoke was seen in the aft galley. Pulled breakers, unable to duplicate. FAA Incident Rpt. # 19870526022979C.

11/28/87. 747, South African Airways. Crashed into the sea with all 160 lost. Last ATC communication suggested an in flight fire. NTSB Recommendation Rpt. # A-88-61.

2/3/88. DC-9, American Airlines. Smoke in the cabin, soft/hot floor above cargo area. No causes to the fire were noted. NTSB Recommendation Rpt.# A-88-121 & A-88-128.

4/88. ASRS Pilot report (de-identified). While at cruise, smelled a strong electrical smell, Lost # 1 Main AC and generator. ASRS # 86076.

4/88. 737, Continental Airlines. On final, a fire in the ceiling continued to burn through insulation blankets and duct insulation. Fire department called. Ref. DOT/FAA/CT-91/2.

10/88. ASRS Pilot Report (de-identified). During pre flight a fire erupted in the center pedestal. Even with Halon and power off fire continued to burn. ASRS. # 96957.

1/89. ASRS Pilot Report (de-identified). Aborted TO after a loud noise from Main C/B Panel. 5 C/Bs popped. Tried again, 10 C/Bs popped. Declared Emer. ASRS # 101677.

2/2/89. DC-9, Swissair. Fire developed in the C/B Panel. Flt diverted and Emergency evacuated. Ref. Letter and FAA testimony Senate hearing (103-397) on 11/8/93.

4/89. ASRS Pilot Report (de-identified). Declared a emergency out of IAH and diverted back for Smoke in the cockpit. ASRSRpt # 109853.

4/89. ASRS Pilot Report. After push back at Fayetteville Regional crew advised of smoke in the cabin. Emergency evacuation followed. ASRS Rpt # 109801.

6/89. DC-10, Canadian Airlines. Apparent arcing of light fixture ignited surrounding insulation blankets and the fire spread to ceilings and walls. Ref. DOT/FAA/CT-91/2.

8/17/89. 737, Delta Airlines. While on final, electrical failures, Number 2 and Number 3 Power Transformer Rectifier C/Bs had tripped. FAA Incident Rpt.# 19890817052289C.

10/14/89. 727, Delta Airlines. While parked, a muffed explosion and flames came from the vent near seat 3D. No cause was found. NTSB Monthly Rpt. # DCA90MA002.

10/89. ASRS Pilot report (de-identified). Smoke in the cockpit and cabin, declared emergency. Same problem several days later. ASRS Rpt # 127334.

12/1/89. DC-9, American Airlines. At cruise, found electrical smell like an overheated electrical system. Found burnt terminals and C/B. FAA Incident # 19891201062979C.

1/10/90. 747, Northwest Airlines. Found heat damage around aft cargo mid-ship drain mast. Components tested but no probable cause. NTSB Monthly Rpt. # CHI90IA064.

1/90. ASRS Pilot Report (de-identified). Electrical shutdown and cockpit filled with smoke. Declared emergency and diverted. ASRS Rpt. # 134261.

4/6/90. DC-9, Midway Airlines. From cruise, electrical problems. Diverted, replaced C Phase C/B. FAA Incident Rpt. # 19900406022459C.

8/90. ASRS Pilot Report (de-identified). Near VUZ, AL heard loud "Pop" noise followed by the smell of electrical smoke. Informed ATC, continued to IAH. ASRS Rpt # 155020.

09/90. ASRS Pilot Report (de-identified). Immediately after TO from Cleveland Hopkins, smoke in the cabin, emergency declared and returned. ASRS Rpt. # 157942.

9/90. ASRS Pilot Report (de-identified). Left Denver gate, smoke filled cabin. Could not see past 1st class. PA did not work. Emergency evacuation. ASRS Rpt. # 157908.

2/1/91. DC-9, U.S. Air. On arrival experienced a fire in the aft cargo hold. Bags scorched but no sources within the hold were found. NTSB Monthly Rpt. # MIA91SA230.

11/93. ASRS Pilot Report (de-identified). Near St Louis Int'l at 23,000 attendant reported smoke and fumes in cabin. Declared emergency and landed. ASRS Rpt. # 256013.

11/93. ASRS Pilot Report (de-identified). On taxi out smelled smoke, returned. Next flight, cockpit began to fill with smoke. Emergency divert. ASRS Rpt. # 258014.

4/26/94. 737, Aloha Airlines. Gear position, PA, Interphone and thrust reversers not working. Cabin smoke, evacuation. Source not found. NTSB Monthly Rpt. # LAX94IA206.

6/94. ASRS Pilot Report (de-identified). Rancid cockpit odor on takeoff from Atlanta. Emergency

declared. Autopilot inop. Electrical smell noted. ASRS Rpt. # 276367.

7/94. ASRS Pilot Report (de-identified). 737 on takeoff, gear retract, TO warning, transponder, pressurization malfunctioned. Cabin odor. Diverted. ASRS Rpt. # 278033.

7/94. ASRS Pilot Report (de-identified). At cruise following systems failed or faulted; equipment cooling fan light, Dual DC fail IRS, Battery Buss, anti skid, both N1 and EGT indicators, Com 2, Capt ADI and HIS, autopilot, reverser lights, red gear lights, elevator feel light and PA system. Emergency, saw thick cabin smoke. ASRS # 278111.

9/94. ASRS Pilot Report (de-identified). 727 observed erratic fuel flows and then strong electrical odor in the cockpit. Emergency declared. Fire dept called. ASRS Rpt. # 282510

9/94. ASRS Pilot Report (de-identified). MD-11, both pilots saw smoke coming from overhead cargo test panel. Diverted to EWR.. ASRS Rpt. # 284198.

2/10/95. DC-9, TWA. Smoke in the cockpit, diverted to Omaha. Cause not determined. Aircraft returned to service. FAA Incident Rpt. # 19950210006589C.

2/16/95. DC9, Sunjet Int'l Airlines. At 27,000 experienced a pressurization problem with associated smoke in the cockpit Emergency decent. FAA Incident Rpt 19950216005639C

3/95. ASRS Pilot report (de-identified). Inflight, smoke, fumes and "pop". Possible window short. Ran checklist. Declared emergency, diverted to BNA. ASRS Rpt 299362.

3/13/95. 737, Delta Airlines. Crackling sound, brief fire, smoke and fumes upper right hand corner of R-1 window. C/Bs did not pop. FAA Incident Rpt. # 19950313006819C.

5/5/95. ASRS Pilot Report. At 27,500 United DC-10 lost all generators. Deployed emergency generator. Emergency landing. No cause found. ASRS Rpt. # 303757.

5/28/96 Martinair 767-31AER experienced repeated electrical anomalies, uncommanded auto-pilot disconnects, changes in airplane zero fuel weight, and blanking of transponder codes. Emergency landing. Kapton wiring suspected. Other anomalies observed on two other 767s. Ref. NTSB Monthly NYC96IA116.

5/15/96. 747. On descent noticed spark under seat 3B. One fire bottle used to extinguish the spark. Ref FAA SDR 1996071100004. (item 18).

9/95. ASRS Pilot Report (de-identified). During cruise heavy smoke in the cabin. Emergency divert to Nassau. Claimed FAA Investigation. None found. ASRS # 315585.

1/96. ASRS Pilot Report (de-identified). 727 at 29,000 smoke came from under FO forward panel. Divert to TLH. Same problem in another 727 weeks later. ASRS # 326301

1/96. ASRS Pilot Report (de-identified). 737 during cruise total loss of all electrical power. After APU start emergency divert to CMH. ASRS Rpt. # 326327.

1/96. ASRS Pilot Report (de-identified). 757 smoke in the cabin. Declared a emergency, landed in San Francisco. ASRS Rpt. # 325089.

2/9/96. DC-9. On take off EPR system C/B popped. Return to gate. Could not duplicate the problem. Ref FAA SDR 1996030800454. (item 14).

2/96. ASRS Pilot Report (de-identified). During climb smoke billowed out of aft galley. Emergency evacuation on ramp. Cause not determined. ASRS Rpt. # 328795.

2/25/96. DC-9. VALUJET. While sitting at the gate C/B trips for PA, Interphone, No Smoking and Fasten seat Belts. Smoke in cabin. Accomplished VJ E.O. DC-9-3396005. Ref FAA SDR 1996060600422. (item 29).

5/15/96. DC-10. During cruise multiplex system power shorted out and sparked with smoke in the cabin at seats 33DE. Ref FAA SDR 1996052300007. (item 22).

8/96. ASRS Pilot Report (de-identified). 767 East of Nova Scotia smoke in the cockpit. Declared emergency and landed overweight at Sidney. ASRS Rpt. # 344573.

8/14/96. DC-10 While at cruise a oxygen generator activated over Row 26-28. Right side of aircraft had strong electrical smell. Ref FAA SDR 1996082200603. (item 28).

8/30/96. 747. During landing sparks and smoke emitted from under seat 31-7. Cable shorted, activated fire extinguisher. Ref FAA SDR 1996102400370. (item 29).

9/4/96. 737, U.S. Air. Gear failed to retract, Air/ground C/B popped. Unable to duplicate the

problem. Aircraft returned to service. FAA Incident Rpt. # 19960904033669C.

9/5/96. DC-10, Federal Express. At 33,000ft smoke in the cabin cargo compartment. Emergency landing at Stewart. No cause found. NTSB Monthly Rpt. # DCA96MA079.

9/96. ASRS Pilot Report (de-identified). After TO cabin reported very strong electrical smoke. Emergency return to IAD. C/Bs did not trip, no cause found. ASRS Rpt.# 348982

9/8/00. DC-9. During cruise left engine overheat warning. Declared an emergency and landed. Found tripped C/B, no cause found. Ref FAA SDR 19960911200448. (item 40).

10/20/96. 737, U.S. Air. Smoke in the cockpit, diverted to Ithaca N.Y. FAA Ferry permit was issued. "Case considered closed". Ref. FAA Incident Rpt. # 19961020037309C.

10/29/96. DC-9. At cruise, B phase C/B popped and then all forward fuel boost pumps, then A phase & others. Unscheduled landing. Ref FAA SDR 1996110100943. (item 46).

11/96. ASRS Pilot Report (de-identified). While at cruise noted strange odor and fumes in cockpit. Equipment overheat light on. Declared emergency/landed. ASRS 353804.

11/16/96. DC-9. During cruise left AC Buss C/B popped. Numerous C/b trips and system loss followed. Unscheduled landing. Ref FAA SDR 1996121900650. (item 52).

12/96. ASRS Pilot Report (de-identified). While taxiing to gate, smoke came out from behind FO control panel. ASRS Rpt. # 355635.

12/19/96. DC-9. At takeoff, center aft fuel boost pump C/B popped. All quantity gages went blank. Reset failed. Unscheduled landing. Ref FAA SDR 1996122600330. (item 53).

1/97. ASRS Pilot Report (de-identified). 737 during cruise had multiple systems fail. Standby power and APU would not work. Emergency, divert. ASRS Rpt. # 358949.

1/97. ASRS Pilot Report (de-identified). DC-9 on ground had smoke coming from the E&E bay. Fire dept called. Batteries found smoking. ASRS Rpt.# 357142.

3/9/97. DC-10. Overhead cabin panels rows 25 to 26 began arcing and smelled smoke. Unable to find cause. Ref FAA SDR 1997031300703. (item 44).

5/97. ASRS Pilot Report (de-identified). 737 had cabin smoke and heat reported. Emergency declared, diverted to alternate. ASRS Rpt. # 369599.

5/97. ASRS Pilot Report (de-identified). MD-80 at 11,000 feet reported electrical smell in the cabin. Declared an emergency. ASRS Rpt. # 370087.

6/17/97. DC-10, Sun Country Airlines. Smoke in the aircraft. Emergency landing to Denver. Two crew members hospitalized. NTSB Monthly Rpt. # FTW97IA227.

10/97. ASRS Pilot Report (de-identified). While taxiing cabin reported increasing electrical smoke. C/Bs did not pop. Return to gate. Next flight same again. ASRS 382946

10/29/97. DC-9. During cruise lavatory door, when locked, shocked a passenger. Replaced wire. Ref FAA SDR 1998042800555. (item 98).

11/97. ASRS Pilot Report (de-identified). 767-200ER had electrical smoke. Declared emergency, returned to the Azores. Second such diversion/month. ASRS Rpt. # 385050.

12/19/97. 737, Singapore Airlines. Reg # 9V-TRF. Flight MI-185 exploded in mid-air. Ref. <http://www.airdiasters.co.uk/191297.htm>. No cause or Report available here.

12/19/97. MD-80, Alaska Airlines. Taxiing to gate when cabin filled with smoke. Over wing evacuation to the taxiway. Ref. www.nts.gov/Publictn/2000/SS0001.pdf "case 4".

12/25/97. 737, United Airlines. In flight smelled electrical burning and noted landing gear C/B popped. Left main gear collapsed on landing. Ref. www.nts.gov/Publictn/2000/SS0001.pdf "case 5".

1/7/98. MD-11F. Inspection found wiring burned up beneath center cargo floor. Also noted bellframe burned through. Ref FAA SDR 1998011500120. (item 40).

1/11/98. Boeing 767 Emergency landing, Kapton wires arced popping circuit- breakers and smoke in the cabin. Ref Boeing Service Message M-7200-98-00140, 6/21/98.

1/19/98. 737, Continental Airlines. Enroute, C/Bs for # 1 Main, aft boost in # 2 Main and both pumps in the center and aux fuel tank popped. Only 2 pumps remained operational Replaced C/B #65. Ref. FAA Incident Rpt. # 19980119002309C. Case closed.

- 1/19/98. 737, Continental Airlines. Enroute, C/Bs for # 1 Main, aft boost in # 2 Main and both pumps in the center and aux fuel tank popped. Only 2 pumps remained operational Replaced C/B #65. Ref. FAA Incident Rpt. # 19980119002309C. Case closed.
- 1/9/98. Boeing 767 emergency landing due to intermittent leading edge disagreement, electrical smoke and fumes in the cabin. Ref Boeing Service Message M-7200-98-00140, 6/21/98. (Ref NTSB Monthly DCA98RA016).
- 3/27/98. DC-9. Air Canada. On taxiout, experienced a electrical fire in the cockpit overhead panel. Source was ignition switch. NTSB Monthly Rpt. # CHI98A110.
- 3/30/98. 727 Royal Airlines. Ft Lauderdale. Before TO crew smelled smoke in the cockpit. Flames and smoke coming from the overhead panel. Evacuated using chutes. Ref. NTSB_ www.nts.gov/Publictn/2000/SS0001.pdf , "case 13".
- 4/4/98. 767, Britannia. Diverted by damaged sidewall heater and arcing electrical fire burned a hole in a panel and insulation blankets. AAIB of Iceland to investigate. NTSB Monthly Rpt. DCA98WA046.
- 4/98. ASRS Pilot Report (de-identified). At cruise, smelled strong electrical smell. Haze in the cabin. Made straight in landing. ASRS Rpt. # 40075.
- 4/98. ASRS Pilot Report (de-identified). C/B popped for left AC Buss. Reset but popped again. Could not reset again. Emergency and diverted to Detroit. ASRS Rpt.# 400849.
- 4/98. ASRS Pilot Report (de-identified). Enroute, Transfer Buss C/B popped. Would not reset. Lost instruments and pressurization control. Emergency / divert. ASRS # 400987.
- 5/15/98. Type ?, United Airlines. Smoke, sparks and flames from C/B Panel C787. Fire put out, flight landed and 411 passengers offloaded. FAA Incident # 19980515014099C.
- 5/98. ASRS Pilot Report (de-identified). Lost all cabin PA systems. Smelled electrical odor in cockpit. Called for emergency equipment and landed. ASRS Rpt. # 401039.
- 6/22/98. 757-2Y0, Air 2000 Ltd. Experienced a loud bang and sparks from cockpit overhead panel. Flight diverted. UK AAIB investigating. NTSB Monthly DCA98WA057.
- 7/98. ASRS Pilot Report (de-identified). 737 noted cracking sound behind C/B panel. Equipment and pressurization failures. Diverted to alternate. ASRS Rpt. # 408309.
- 8/98. ASRS Pilot Report (de-identified). 767-300 abeam of Nova Scotia had smoke in the cockpit. Declared emergency, landed overweight at Sydney, N.S. ASRS Rpt. # 344573.
- 3/22/99. DC-10. During cruise a loud spark arced, then several more times later in flight near the lower inst panel. No cause found. Ref FAA SDR 1999041700441. (item 104).
- 4/7/99. 737, Turkish Airlines. Became engulfed in fire shortly after TO and crashed. Ref. <http://www.airdiasters.co.uk/070499.htm> . No cause or Report found here.
- 6/22/99. 737, United Airlines. Enroute, smoke in the cabin. Diverted to Scottsbluff. Unable to find cause, returned to service. FAA Incident 19990622018839C. Case Closed.
- 7/31/99. 737. For Two Flights, during climb had engine overheat fault. Unscheduled landings. Replaced engine soft core harness. Ref FAA SDR 1999090300679. (item 366).
- 9/8/99. 747. During cruise lost 50 % electrical power. Unscheduled landing. Wire/water contaminated in galley. Ref FAA SDR 2000022300014. (item 157).
- 2/26/00. DC-9/80, U.S. Air. Reg # USA1248. At Indianapolis, Pilot declared smoke in the cockpit. Two Flight attendants hospitalized for smoke inhalation. FAA Incident*.
- 5/7/00. 717 Air Tran Airways. Smoke in the cockpit coming from near the fuel pump switches. Declared an emergency. No cause, switches sent for tests. NTSB MIA00SA147.
- 7/12/00. 727, Federal Express. Reg # FDX3106. Smoke in the cockpit. Declared an emergency and evacuated on the runway at Fort Worth. FAA Incident. Source; www.faa.gov/avr/aai/D_0717_N.TXT
- 7/12/00. 777-200, British Airways. Enroute Toronto to London reported smoke in the cockpit and declared a emergency, divert to Montreal. Cadors Rpt 2000A0378.
- 7/21/00. DC-9, Northwest Airlines. Reg # 671Mc. On TO had smoke in the cockpit. Returned and evac pax to the runway. FAA Incident faa.gov/avr/aai/D_0724_N.TXT

8/10/00. 767, Delta Airlines. DAL 139 enroute Manchester to N.Y. reported electrical smoke in the cockpit East of Labrador. Diverted to Goose Bay. Cadors Rpt # 2000A0454.

10/18/00. 757, National Airlines. Flight 7002 returned and landed due to a fire in the galley. FAA Incident Reg 546NA. http://www.faa.gov/avr/aai/D_1018_N.TXT

11/11/00. 737, U.S. Air. Reg # USA1862. Reported smoke in the cabin. Unknown. FAA Incident. http://www.faa.gov/avr/aai/D_1113_N.TXT

11/15/00. 747, United Airlines. Reg # UAL809. Flight 809 reported smoke in the galley. Emergency and diverted to Seattle. FAA Incident www.faa.gov/avr/aai/D_1116_N.TXT

11/20/00. A-300, American Airlines. At 16,000 feet neither pressurization controllers would work. F/A chimes sounded erratically and the forward lav smoke detector sounded. After landing, ram air switch would not depressurize aircraft. Captain then reported a fire and called to emergency evacuate. F/A opened a door and was expelled from the aircraft and killed. NTSB Monthly MIA01FA029.

11/29/00. MD-80, American Airlines. Flight 1683. Flight attendant report of smoke in the cabin. Emergency landing at Reagan Nat'l and evacuation to the ground using slides and chutes. FAA Incident http://www.faa.gov/avr/aai/D_1130_N.TXT

Limitations

The aircraft events listed here are limited to the larger types of commercial transports, all reports to the commuter-type craft (i.e. Beech, Saab, ATRs) were discarded even though they also operated under the same Part 121 commercial carrier rules and, as the same carriers seen in this report, shared the same materials in wiring insulation types and insulation blanket (batts) used in their 'big cousins'.

Under reporting is a big problem and as NASDAC had noticed, there are significant limitations to the self-reporting processes and such may apply in the Aviation Safety Reporting System Database (ASRS) Reports used here. The same limitations may well apply to the newly announced system by the White House in late January 2000 dubbed the Aviation Safety Action Program (ASAP). This encompasses virtually all of the claims cited for the creation of the earlier ASRS system in 1983, including immunity from prosecution and claims for heightened safety awareness and information sharing.

The NASDAC studies (see source on page 12) also noted that such aviation mishaps subject to self reporting often go unreported because of; (1) by themselves, they may appear insignificant, (2) the event wasn't intentional, (3) no one is hurt because of back up systems or (4) no collation is seen to other events. The latter may easily be attributed to lack of information sharing, which ironically, is why these programs were set up in the first place. Never-the-less, NASDAC agrees the actual calls placed to ASRS are but a fraction of the industry incidents and occurrences.

Moreover, NASDAC made note of the Heinrich Pyramid (see source on page 15) whereas for every given major accident, there will be 3-5 less significant accidents, and among 7-10 incidents, there may be at least several hundred unreported occurrences. Thus, with the ASRS voluntary reports here, unreported incidents may have ranged considerably higher.

The FAA's Service Difficulty Reporting Lastly, a separate IASA Study demonstrated that within the Office Of System Safety Databases, and all linked to a common search engine, that the FAA Incident Data System Reports reflected but less than 5 % of the combined reports from the other databases listed there.

Edited by jking1@mediaone.net.

John D. King
IASA Data Specialist

The International Aviation Safety Association is a non profit safety organization incorporated in New York.
See our website at www.IASA.com.au .

Chairman: Mrs. Lyn Susan Romano

Air India Flight 182

Report on the accident to Boeing 747-237B VT-EFO, Air India Flight 182,
off Cork, Ireland on 23 June 1985
by John Barry Smith,
Independent Aircraft Accident Investigator

Appendix H Miscellaneous Accidents (Unofficial)

A 50-Year Snapshot of Crash Causes

Accident Causes

1950s

1960s

1970s

1980s

1990s

Total

Pilot Error

38%

36%

26%

26%

26%

30%

Pilot Error (weather related)

10%

16%

14%

16%

4%

14%

Pilot Error (mechanical related)

5%

4%

4%

3%

2%

4%

All Pilot Error

53%

56%

44%

45%

42%

48%

Other Human Error

3%

8%

9%

6%

9%
7%
Weather
17%
11%
15%
17%
15%
15%
Mechanical Failure
21%
17%
20%
16%
23%
19%
Sabotage
6%
5%
10%
15%
10%
9%
Other Cause
0%
3%
2%
1%
1%
2%

Source: BACK Associates and PlaneCrashInfo.com database

Accident	Killed
1 March 27, 1977 Two Boeing 747s operated by Pan American and KLM collide at the airport on Tenerife in Spain's Canary Islands	582
2 Aug. 12, 1985 Japan Air Lines Boeing 747 crashes into a mountain on a domestic flight	520
3 March 3, 1974 Turkish DC-10 crashes northeast of	

- Paris
346
- 4
June 23,
1985
Air-India Boeing 747 crashes off the coast of Ireland. Investigators conclude a bomb caused the crash
329
- 5
Aug. 19,
1980
Fiery emergency landing of a Saudi Arabian L-1011 jet at the airport in the Saudi capital of Riyadh
301
- 6
July 3,
1988
Iran Air A300 Airbus shot down by USS Vincennes over the Persian Gulf
290
- 7
May 25,
1979
American Airlines DC-10 crashes on takeoff in Chicago
273
- 8
Dec. 21,
1988
Pan Am Boeing 747 crashes in Lockerbie, Scotland. A terrorist bomb was blamed
270*
- 9
Sept. 1,
1983
Korean Air Lines 747 shot down by a Soviet fighter after flying through Soviet airspace near Sakhalin Island
269
- 10
April 26,
1994
A China Airlines A300-600R Airbus exploded and burned during an aborted landing in Nagoya, Japan
262

* 259 people were killed on the plane, 11 on the ground

Source: The Associated Press

Civil Aviation Safety Documentation Archive - CASDA

This listing contains all jet airliners, involved in bombings:
The list contains the following information:

#	number	date	Type	registration	operator	no. of casualties (no. of occupants) + cas. on the ground	location of accident
---	--------	------	------	--------------	----------	---	----------------------

Bombings aboard jet aircraft

#1 22.05.62 Boeing 707-124

N70775 Continental Air Lines (USA)
45(45) Unionville; 6mls NNW (USA)

While on its way from Chicago to Kansas City at FL390, a bomb exploded in the right rear lavatory. Consequently, the tail section separated, and the aircraft crashed out of control.

CAUSE: Detonation of dynamite in a towel container.

#2 12.10.67 de Havilland DH-106 Comet 4

G-ARCO British European Airways - BEA (UK)
66(66) Rodhos, 100nm off; 35°55'N 30°01'E (Greece)

After a turnover of 1h 20mins at Athens, flight CY284 departed at 02.41h. Flying at FL290, a bomb exploded under seat 4A or 5A in the rear of the tourist cabin. At FL150 the Comet broke up and crashed into the sea.

#3 11.12.67 Boeing 727

N..... American Airlines (USA)
0(78) Alamosa, over (USA)

One hour and 42mins after take-off from Chicago, a small explosion occurred in the rear baggage compartment. The Boeing was able to make a safe landing.

CAUSE: Home made bomb exploded.

#4 19.11.68 Boeing 707-324C

N17325 Continental Air Lines (USA)
0(70) Gunnison; over (USA)

While descending through FL240 towards Denver, an explosion took place in the lavatory, followed by a fire. A safe emergency landing was made.

The passenger, seen leaving the lavatory just before the explosion, was arrested by the FBI.

#5 11.03.69 Boeing 707

Ethiopian Airlines

0(0) Frankfurt-Rhein Main APT (Germany)

On the ground, two explosions took place in the tourist class passenger compartment.

#6 21.02.70 Sud Aviation SE-210 Caravelle VIR

OE-LCU Austrian Airlines (Austria)

0(38) Frankfurt; nr. (Germany)

At FL100, 20mins after take-off from Frankfurt, an explosion in the forward freight hold blew a hole of 3'x2' through the bottom of the fuselage. The Caravelle safely returned to Frankfurt.

#7 21.02.70 Convair CV-990-30A-6

HB-ICD Swissair (Switzerland)

47(47) Zürich; nr. (Switzerland)

An explosion in the aft of the plane, about 9mins. after take-off. The Convair crashed, while returning to the airport.

#8 24.08.71 Boeing 707

Alia Jordanian Airlines

0(0) Madrid-Barajas (Spain)

An explosive device in the aft lavatory complex blew a hole in the top fuselage (3ft long). Luckily the aircraft was parked at the time.

#9 21.11.71 Sud Aviation SE-210 Caravelle III

B- 1852 China Airlines (Taiwan)

25(25) Penghu Island; nr. (Taiwan)

The aircraft crashed into the sea on a flight from Taipei to Hong Kong. CAUSE: Probably caused by a bomb explosion.

#10 26.01.72 McDonnell Douglas DC- 9-32

YU-AHT Jugoslovenski Aerotransport - JAT (Yugoslavia)

27(28) Krussne Hory Mt (Czech.)

An inflight explosion in the forward cargo hold of a homemade bomb at FL100 caused the DC-9 to break up and crash. The surviving crew member fell 15000ft in the tailsection!

CAUSE: Bomb placed on the aircraft by the Croatian extremists organisation 'Ustasji'.

#11 08.03.72 Boeing 707-331

N761TW Trans World Airlines - TWA (USA)

0(0) Las Vegas-McCarran IAP (USA)

A bomb exploded in the right rear part of the cockpit while the aircraft was

parked.

#12 25.05.72 Boeing 727-116
 CC-CAG LAN Chile (Chile)
 0(50) Cuba, nr ()

One hour and 18mins after take-off from Panama City a homemade pipe bomb exploded in the ice water fountain service compartment. A rapid decompression followed. A successful emergency landing at Montego Bay was made at 13.10h.

#13 15.06.72 Convair CV-880-22M-21
 VR-HFZ Cathay Pacific Airways (Hong Kong)
 81(81) nr Pleiku (Vietnam)

The Convair (Flight CX 700Z) took off from Bangkok at 04.55h GMT bound for Hong Kong. While flying at FL290 a bomb exploded, hidden in a suitcase under a passenger seat on the right side over the wing.

The bomb was put on the aircraft by a police officer whose daughter and fiancée were aboard.

#14 16.08.72 Boeing 707
 4X-A.. El Al (Israel)
 0(148) over Roma (Italy)

A bomb in a portable record player (stored in the aft baggage compartment) exploded shortly after take-off. The 200grams of explosive just caused a hole in the baggage compartment. The Boeing landed safely back at Roma.

#15 22.03.74 Sud Aviation SE-210 Caravelle III
 F-BRSY Air Inter (France)
 0() Bastia (France)

On the ground an explosion occurred in the forward landing gear compartment, causing substantial damage.

#16 26.08.74 Boeing 707
 Trans World Airlines - TWA
 0() Roma (Italy)

After landing in Roma, a fire was discovered in the aft baggage compartment. The fire was caused by an explosive device which malfunctioned.

#17 08.09.74 Boeing 707-331B
 N8734 Trans World Airlines - TWA (USA)
 88(88) Cephalonia; 58mls W off (Greece)

En route to Athens, a bomb exploded aboard TWA Flight 841. The Boeing entered a steep climb, went into a steep nose down spin and crashed into the Ionian Sea. The bomb was placed in the aft cargo compartment.

- #18 03.06.75 BAC One-Eleven 524FF
 RP-C1184 Philippine Air Lines (Philippines)
 1(64) nr Manila (Philippines)
 During descent into Manila (at FL200) a bomb exploded in the right lavatory in the rear of the plane. The explosion caused a hole in the fuselage of 1.3m x 4m. A successful emergency landing was made.
- #19 05.07.75 Boeing 707
 Pakistan International Airlines - PIA
 0() Rawalpindi (Pakistan)
 On the ground after a flight from Karachi a bomb, placed under a passenger seat, exploded. The explosion ripped a 3ft x 4ft hole in the fuselage.
- #20 01.01.76 Boeing 720-023B
 OD-AFT Middle East Airlines - MEA (Lebanon)
 81(81) Al Qaysumah; 20nm NW (Saudi Arabia)
 En route at FL370 from Beirut to Dubai, a bomb exploded in the forward baggage compartment. The aircraft crashed into the desert.
- #21 07.09.76 Boeing 707-328
 F-BHSH Air France (France)
 0(0) Ajaccio (France)
 Seven masked men set dynamite explosives aboard the aircraft and caused the explosion.
- #22 06.10.76 McDonnell Douglas DC- 8-43
 CU-T1201 Cubana (Cuba)
 73(73) Bridgeport; 5mls W off (Barbados)
 At 17.15h Flight 455 took off from Bridgetown Runway 09, heading for Kingston. Nine minutes later, the crew tried to turn back to Barbados due to an explosion. The DC-8 lost height rapidly and crashed in a nose down, right wing low attitude into the sea, 5 miles offshore.
 CAUSE: An explosive device detonated in the rear of the cabin, which resulted in an uncontrollable fire, possibly causing crew incapacitation.
- #23 17.08.78 BAC One-Eleven 524FF
 RP-C1184 Philippine Air Lines (Philippines)
 1(84) Sinara Island; over (Philippines)
 An explosion in the rear left lavatory blew a hole in the fuselage. The aircraft was flying at FL240 at the time, on its way from Cebu to Manila.
- #24 26.04.79 Boeing 737-2A8
 VT-ECR Indian Airlines (India)
 0(67) Madras (India)
 On its way from Trivandrum to Madras, the aircraft was cleared to descent

from FL270. Shortly afterwards an explosion took place in the forward lavatory, causing a complete instrument and electrical failure. The Boeing had to make a flapless landing at Madras. The aircraft touched down 2500ft past the Runway 25 threshold and overran. The right side of the plane caught fire.

CAUSE: As a result of the explosion, the flaps, reverse thrust and anti-skid systems couldn't be used during the emergency landing.

#25 15.11.79 Boeing 727

N..... American Airlines (USA)
0(78) Chicago; nr. (USA)

Thirty minutes after leaving Chicago, a bomb device hidden in a wooden box in a mail bag detonated. This resulted in pressure fluctuations and smoke in the cabin. A safe landing was made at Washington-Dulles.

FBI thinks the bomb was placed aboard by the 'Unabomber', who was responsible for a number of attacks on universities and airlines since 1978.

#26 09.09.80 Boeing 727

N..... United Air Lines (USA)
0(44) Sacramento (USA)

While passengers were deplaning, a small cardboard box blew up in the cargo hold and injured two cargo handlers.

#27 21.12.80 Sud Aviation SE-210 Caravelle VIR

HK-1810 TAC Colombia (Colombia)
70(70) Guajira (Colombia)

At 14.18hrs the Caravelle took off from Rio Hacha for a flight to Medellin. Five minutes after take-off an explosion occurred and there appeared to be a fire in the right-hand aft portion of the aircraft. The Caravelle went out of control and crashed.

The aircraft was on its first scheduled flight after 17 months of maintenance work.

It's not known for sure whether the explosion was caused by a bomb or not.

#28 31.08.81 Boeing 720-023B

OD-AFR Middle East Airlines - MEA (Lebanon)
0() Beirut IAP (Lebanon)

Shortly after arriving from a flight from Libya, an explosion of approx. 5kgs of dynamite destroyed the aircraft.

#29 13.10.81 Boeing 737-2K2C

PH-TVC Air Malta (Malta)
0(0) Cairo IAP (Egypt)

While offloading luggage a porter and 3 security guards were injured when two parcels exploded about 15mins apart. A third bomb which didn't detonate, was located later.

#30 12.12.81 Boeing 727-025

YN-BXW Aeronica (Nicaragua)
0() Mexico City (Mexico)

When the passengers were ready to embark the plane, a bomb exploded between the rearmost cabin seat on the left aisle and the cabin wall. The blast tore a 3ft hole in the fuselage. The captain, 2 stewardesses and an airport mechanic were injured.

The aircraft was preparing for a flight to San Salvador.

#31 11.08.82 Boeing 747-121

N754PA Pan American World Airways (USA)
1() Hawaii; 140mls (USA)

On a flight from Tokyo one passenger was killed when a bomb, located under the seat cushion, exploded. The explosion also resulted in a hole in the floor and damage to the ceiling and overhead racks. A safe landing was made at Honolulu.

#32 19.08.83 Boeing 727-294

YK-AGA Syrian Arab Airlines (Syria)
0(12) Roma (Italy)

During boarding a glass bottle containing flammable liquid, located under a seat in the passenger area near the right overwing emergency exit, caused a fire. The interior of the plane completely burned out.

#33 23.09.83 Boeing 737-2P6

A40-BK Gulf Air (Oman)
112(112) Mino Jebel Ali (UAE)

After a brief distress message, the aircraft crashed in the desert. Evidence indicated that a bomb had exploded in the baggage compartment. The aircraft was on a flight from Karachi to Abu Dhabi.

#34 18.01.84 Boeing 747

Air France
0(261) Karachi, 70mls (Pakistan)

An in-flight explosion after leaving Karachi blew a hole in the right rear cargo hold and caused a loss of cabin pressure. An emergency descent to 5000ft was made and the aircraft returned to Karachi.

#35 10.03.84 McDonnell Douglas DC- 8-63PF

F-BOLL Union de Transportes Aériens - UTA (France)
0(23) N'Djamena (Tchad)

Twenty minutes after arriving from Brazzaville, a bomb exploded in the central baggage compartment.

#36 23.01.85 Boeing 727-2K3

CP-1276 Lloyd Aéreo Boliviano - LAB (Bolivia)

1(127) Santa Cruz; 30nm (Bolivia)

While descending through FL100 a passenger went into the forward lavatory carrying a dynamite in a briefcase. The dynamite exploded, killing the passenger. The aircraft made a safe landing at Santa Cruz.

#37 09.03.85 Lockheed L-1011 TriStar 500

Royal Jordanian Airlines

0() Dubai IAP (UAE)

On ground at Dubai, after a flight from Karachi, a bomb exploded in a baggage compartment.

#38 23.06.85 Boeing 747-237B

VT-EFO Air India (India)

329(329) Atlantic Ocean ()

The aircraft broke up in flight at FL310 and crashed into the Ocean.
CAUSE: A bomb, placed on board by a Sikh terrorist, caused a powerful explosion.

#39 30.10.85 Boeing 727

American Airlines

0() Dallas-Fort Worth (USA)

An explosion occurred in the forward baggage compartment while baggage was being unloaded.

The device was contained in a vinyl tote bag.

#40 02.04.86 Boeing 727-231

N54340 Trans World Airlines - TWA (USA)

4(121) Kérkira (Corfu); over (Greece)

While descending through FL100 a bomb exploded, causing a 1,40 x 1,60m hole in the fuselage. Four passengers fell off the aircraft. The aircraft landed safely at Athens.

#41 26.10.86 Airbus A.300B4-601

HS-TAE Thai Airways International (Thailand)

0(239) nr Shimizu (Japan)

An explosion at FL330 caused a rapid decompression and the loss of 2 hydraulic systems.

The Airbus made an emergency descent with a max of 2.6g and landed safely.

CAUSE: A passenger attempted to smuggle handgrenade into Japan but it exploded in the aft toilet.

#42 29.11.87 Boeing 707-3B5C

HL-7406 Korean Air (South Korea)
115(115) Andaman Sea; 14°33' N 97°23' E ()

At 00.01h UTC Koream flight 858 departed Abu Dhabi for a flight to Seoul via Bangkok. At 05.01h UTC the last message was received. It appeared that a bomb explosion aboard caused the crash.

Two passengers who had left the plane at Abu Dhabi, left a radio and liquor bottle containing hidden explosives in the overhead rack at row 7.

#43 21.12.88 Boeing 747-121A
N739PA Pan American World Airways (USA)
259(259) + 11 Lockerbie (UK)

The aircraft disintegrated at FL310 after a bomb exploded in the forward cargo hold. Large pieces of debris fell into a residential area of Lockerbie.

#44 19.09.89 McDonnell Douglas DC-10-30
N54629 Union de Transportes Aériens - UTA (France)
171(171) Ténéré desert; 16°54'N 11°59'E (Niger)

Flight UTA 772 (Brazzaville - N'Djamena - Paris CDG) departed N'Djamena at 12.13h. While climbing through FL350, 21mins after take-off, a pentryt bomb exploded near seat 13R. The DC-10 disintegrated and crashed in the desert.

The bomb was probably placed on board at Brazzaville.

The DC-10 had accumulated 60.267 flying hours and 14.777 cycles.

#45 27.11.89 Boeing 727-21
HK-1803 Avianca (Colombia)
107(107) nr Bogota (Colombia)

The aircraft exploded shortly after take-off

#46 18.03.91 Ilyushin 86
SSSR-..... Aeroflot (Russia)
0(360) Sverdlovsk (Russia)

A psychiatric patient threw a petrol bomb, which caused an on-board fire. An emergency landing was made at Sverdlovsk.

The aircraft was on its way from Moscow to Novokuznetsk.

#47 10.12.94 Boeing 747-283B
EI-BWF Philippine Air Lines (Philippines)
1(293) Minami Diato Isl.; nr. (Japan)

On a flight from Manila to Tokyo via Cebu, a bomb exploded in the passenger cabin beneath seat 26K. A successful emergency landing at Okinawa was made at 12.45h.

The muslim group Abu Sayyaf claimed responsibility.

Bombings aboard jet aircraft : statistics

Departure airport ranking:

Karachi (Pakistan) - 4 times
Athens (Greece) - 3 times
Roma (Italy) - 3 times
Chicago (USA) - 3 times
Brazzaville (Congo) - 2 times
Cebu (Philippines) - 2 times

Total casualties:

1626

(including 11 casualties on the ground at Lockerbie and 70 casualties of a Colombian Caravelle of which it's not sure whether a bomb caused the accident or not).

Total aircraft destroyed:

23

Total aircraft destroyed in-flight:

16

Harro Ranter
hranter@inter.NL.net

1. Tenerife, Canary Islands, March 27 1977 - 583 killed
KLM Boeing 747-206B runs into Pan Am Boeing 747-121 on runway
2. Tokyo, Japan, August 12 1985 - 520 killed
JAL Boeing 747SR-46 crashes into mountain, 4 survivors
3. Charkhi Dadri, India, November 12 1996 - 349 victims
Saudi Arabian Airlines Boeing B747-168B collides in mid-air with Kazach Ilyushin Il-76TD
4. Ermenonville, France, March 3 1974 - 346 killed
DC-10 Series 10 of THY Turkish Airlines cargo door bursts open - crashes in a forest
5. Irish Sea, June 23 1985 - 329 killed
Air India Boeing 747-237B, terrorist bomb
6. Riyadh, Saudi Arabia, August 19 1980 - 301 victims
Saudia L-1011-200 Tristar bursts into flames after emergency landing

7. Kinshasa, Zaire, January 8 1996 - 297+ killed
Overloaded African Air Antonov-32 crashes into market place - 4 of 5 crewmembers survive
8. Persian Gulf, July 3 1988 - 290 dead
USS Vincennes downs Iran Air Airbus A300B2-202
9. Chicago, USA, May 25 1979 - 273 dead
American Airlines DC-10 Series 10 crashes due to damaged hydraulics
10. Lockerbie, Scotland, December 21 1988 - 270 killed
Libyan terrorists bomb attack on a Pan Am Boeing 747-121A
11. Sakhalin Island, USSR, September 1 1983 - 269 perished
Soviet Su-15 downs a Korean Air Lines Boeing 747-230B
12. Nagoya, Japan, April 26 1994 - 264 dead
China Airlines Airbus A300B4-622R, 9 survivors
13. Jiddah, Saudi Arabia, July 11 1991 - 261 fatalities
Nationair Canada DC-8 Super 61 leased to Nigeria Airways catches fire after take-off caused by blown tires
14. Ross Island, Antarctica, November 29 1979 - 257 dead
Air New Zealand DC-10 Series 30 flies into polar mountain
15. Gander, Canada, December 12 1985 - 256 fatalities
Arrow Air Inc. DC-8 Super 63PF crashes during take-off
16. Pancur Batu, Indonesia, September 26 1997 - 234 killed
Garuda Indonesia Airways A300B4-220, 222 pax, crashes in bad visibility conditions due to forrest fires
17. New York, USA, July 17 1996 - 230 perished
TWA Boeing 747-131 crashes into ocean near Long Island due to exploding center fuel tank
18. Peggy's Cove, Canada, September 3 1998 - 229
Swissair MD-11 crashes in the Atlantic after fire-problems, no survivors among the 215 passengers

19. Guam, Pacific Ocean, August 6 1997 - 225 fatalities
Korean Airlines Boeing 747 fails to make a correct approach, 29 survive
20. Ban Nong Rong, Thailand, May 26 1991 - 223 killed
Lauda Air Boeing 767-3Z9ER goes down after thrust reverser problems
21. Maharashtra, India, January 1 1978 - 213 killed
Air India B-747-237B explodes in mid-air
22. Taipeh, Taiwan, February 16 1998 - 204 fatalities
China Airlines Airbus A300-622R crashes during retried landing, also killing 15 crew and 7 on the ground
23. Uch Kuduk, Uzbekistan, USSR, July 10 1985 - 200 fatalities
Aeroflot Tupolev 154B-2, goes into flat spin and crashes
24. Maskeliya, Sri Lanka, December 4 1974 - 191 dead
Martinair DC-8 Series 55F hits moutain
25. Puerto Plata, Dominican Republic, February 6 1996 - 189 perished
Alas Nacionales Boeing 757-225 crashes into Atlantic due to wrong air speed indication
26. Immouzer, Morocco, August 3 1975 -188 killed
Alia Royal Jordanian Airlines Boeing 707-321C hits moutain
27. Katunayake, Sri Lanka, November 15 1978 - 184 killed
Icelandair DC-8 Super 63CF ploughes into a coconut plantation, 78 survivors
28. Warsaw, Poland, May 9 1987 - 182 killed
LOT Il-62MK crashes when two engines catch fire at an altitude of 8200 meters
29. Mejorada del Campo, Spain, November 27 1983 - 181 fatalities
Avianca Boeing 747-283B Combi crashes during approach, 11 survivors
30. Ajaccio, Corsica, December 1 1981 - 180 fatalities
Inex Adria Aviopromet Yugoslav DC-9 Super 82 crashes into mountain on approach

31. Zanderij, Surinam, June 7 1989 -177 killed
Crew of SLM DC-8 Super 62 ignores tower instructions, 10 survivors
32. Krasnaya Polyana, USSR, October 13 1972 - 176 dead
Ilyushin-62 crashes into a lake, ILS inoperative
33. Kano, Nigeria, January 22 1973 - 176 fatalities
Alia Royal Jordanian B-707-3D3C crashes during landing due to landing gear damage
34. Zagreb, Yugoslavia, September 10 1976 - 176 dead
Mid-air collision between Inex-Adria DC-9 Series 32 and BA Hsa Trident 3B, ATC language error
35. Dneprodzerzhinsk, USSR, August 11 1979 - 173 killed
Two Aeroflot Tu-134's collide at an altitude of 8000m
36. TÈnÈrÈ Desert, Niger, September 19 1989 - 170 dead
Terrorist bomb aboard a Union de Transportes AÈriens DC-10 Series 30
37. San Andres mountains, Mexico, March 31 1986 - 167 killed
Mexicana Boeing 727-264, tyre burst causes fuel leak
38. Kathmandu, Nepal, September 28 1992 - 167 fatalities
Pakistan International Airlines A300B4-203 crashes on approach
39. Alma-Ata, USSR, July 7 1980 - 163 fatalities
Aeroflot Tu-154B-2 crashes shortly after take-off
40. Lagos, Nigeria, September 27 1992 - 163 fatalities
41. Morioka, Japan, July 30 1971 - 162 dead
All Nippon Airways B-727-281 collides with JASDF F-86F Sabre
42. Havana, Cuba, September 3 1989 - 160 dead
Cubana de Aviacon Il-62M crashes killing all 126 aboard and 34 on ground
43. Xian, China, June 6 1994 - 160 fatalities
China Northwest Tupolev 154M

44. Cali, Columbia, December 20 1995 - 160 killed
Boeing 757-223 of American Airlines hits mountain, 4 survivors
45. Mauritius, Indian Ocean, November 28 1987 - 159 fatalities
South African Airways Boeing 747-244B self-igniting fire-works
46. Tripoli, Lybia, December 22 1992 - 157 fatalities
Jamahiriya Lybian Arab Airlines Boeing Advanced 727-2L5 collides with MiG-23
47. Sch[^]nefeld, GDR, August 14 1972 - 156 killed
Interflug Gesellschaft Il-62 catches fire in rear fuselage
48. At Ta'if, Saudi Arabia, November 26 1979 - 156 victims
Pakistan International Airlines, B-707-340C, fire starts in the aft-cabin, total destruction
49. Detroit, USA, August 16 1987 - 156 perished
Northwest Airlines MD-82, slats not extended on takeoff, crashes on highway
50. Maracaibo, Venezuela, March 16 1969 - 155 perished
VIASA DC-9 Series 32 hits electric power line, crashes in suburb
51. Tenerife, Canary Islands, December 3 1972 - 155 killed
Spantax Covair 990-30A-5 Coronado, loss of control on take-off
52. Isparta, Turkey, September 19 1976 - 155 fatalities
THY Boeing Advanced 727-2F2, wrong airport assumed, hits moutain
53. Kenner, USA, July 9 1982 - 153 killed
Pan Am B-727-235 carrying 145 flies into thunderstorm crashes into suburbs
54. Omsk, USSR, October 15 1984 - ±150 victims
Aeroflot Tu-154 collides with fuel truck on runway
55. Bilbao, Spain, February 19 1985 - 148 dead
Iberia Boeing Advanced 727-256 crashes into TV antenna atop Mt Oiz
56. Tenerife, Canary Islands, April 25 1980 - 146 fatalities
Dan-Air Services B-727-46 crashes into moutain on approach

57. San Diego, USA, September 25 1978 - 144 died
Mid-air collision between Pacific Southwest Airlines B-727-214 and Cessna 172M
58. Palo Alto, Azores, February 8 1989 - 144 dead
Independent Air Inc. Boeing 707-331B hits mountain, communication error with tower
59. Longyearbyen, Spitsbergen, Norway, August 29 1996 -143 killed
Vnukovo Airlines Tu-154M crashes on arrival
60. Liutang, China, November 24 1992 - 141 fatalities
China Southern B-737-3YO hits mountain due to vibration in starboard engine
61. Kahengula, Angola, December 19 1995 - 141 perished
Trans Service Airlift Chartered Lockheed 188C Electra
62. Lagos, Nigeria, November 7 1996 - 141 victims
Nigerian Aviation Development Company Boeing B727 crashes into lagoon
63. Cucuta, Colombia, March 17 1988 - 139 killed
AVIANCA B-727-21, flies into mountain due to pilot error
64. Pacatuba, Brazil, June 8 1982 - 137 victims
Viacao Aerea Sao Paulo Boeing Advanced 727-212, pilot is distracted by lighted city
65. Dallas, USA, August 2 1985 - 137 perished
Delta Airlines Lockheed L-1011-1 Tristar encounters microburst
66. New York, United States of America, December 16 1960 - 134 killed
United Airlines DC-8 Series 11 collides with TWA Lockheed 1049 Super Constellation
67. Tokyo Bay, Japan, February 4 1966 - 133 dead
All Nippon Airways B-727-81 crashes, cause unknown
68. Medellin, Columbia, May 19 1993 - 133 fatalities
Aeronautics Society of Medellin Boeing 727-46 carrying a crew of 7
69. Belarussia, USSR, June 28 1982 - 132 casualties
Aeroflot Yakovlev 42 carrying 124 passengers and a crew of 8

70. Canton, China, October 2 1990 - 132 dead
Hijacked Chinese Boeing Advanced 737-247 first hits an empty B-707-3J6B and then a B-757-21B
71. Teheran, Iran, February 8 1993 - 132 fatalities
Mid-air collision of an Iran Air Tu-154M and a Sukhoi fighter
72. Pittsburgh, USA, September 8 1994 - 132 fatalities
USAir Boeing 737-3B7
73. Funchal, Portugal, November 19 1979 - 131 victims
TAP Boeing Advanced 727-282, overruns runway, plunges of cliff, strikes a bridge, 33 survivors
74. Las Mesitas, Honduras, October 21 1989 - 131 fatalities
TAN Airlines Boeing 727-224 hits moutain on approach, 19 survivors
75. Orly, France, June 3 1962 - 130 killed
Air France B-707-328 crashes on take-off
76. Sverdlovsk, USSR, November 11 1967 - 130 killed
Aeroflot Il-18 crashes due to radar failure
77. Lubango, Angola, November 8 1983 - 130 dead
TAAG-Angola Airlines Boeing Advanced 737-2M2 shot down by guerrillas
78. Gujarat India, October 19 1988 - 130 killed
Indian Airlines B-737-2A8 undershot runway hits trees and high-tension pylon
79. Tokyo, Japan, June 18 1953 - 129 dead
Engine failure on take-off USAF C-124 Globemaster II
80. South Vietnam, December 24 1966 - 129 fatalities
Military chartered Canadair CL-44
81. The Grand Canyon, USA, June 30 1956 - 128 perish
Mid-air collision between UAL DC-7 and TWA Lockheed 1049 Super Constellation

82. Markazi, Iran, January 21 1980 - 128 killed
Iran Air B-727-86 crashes due to ILS malfunction
83. Voronezh, USSR, March 5 1976 - 127 fatalities
Aeroflot Ilyushin 18D, pressurization failure during approach
84. Comoro Islands, November 23 1996 - 127 casualties
Hijacked Ethiopian Airlines B767-260ER runs out of fuel, crashes near shore, 48 survive
85. Nicosia, Cyprus, April 20 1967 - 126 killed
Globe Air Bristol Britannia 313 crashes on landing
86. Damascus, Syria, August 20 1975 - 126 killed
Ceskoslovenske Aerolinie Ilyushin-62 hits sandy hill during approach, 2 survivors
87. Irkutsk, Russia, January 4 1994 - 125 perished
Aeroflot Tupolev 154M goes down due to bad maintenance
88. Mount Fuji, Japan, March 5 1966 - 124 perish
BOAC B-707-436, fatigue cracks in a bolt hole
89. Windhoek, South-West Africa, April 20 1968 - 123 fatalities
South African Airways B-707-344C crashes on take-off, 5 survivors
90. Saulx-les-Chartreux, France, July 11 1973 - 123 killed
Varig Boeing 707-345C, total fire during descent, 11 survivors
91. Arequipa, Peru, February 29 1996 - 123 dead
Faucett B-737-222 crashes burning into mountain
92. Cairo, Egypt, May 20 1965 - 121 killed
Pakistan International Airlines B-720-040B, nose-down condition, 6 survivors
93. Cuenca, Ecuador, July 11 1983 - 119 fatalities
TAME Boeing Advanced 727-2V2, tail section strikes a ridge, crashes into hilly terrain
94. Sainte ThÈrÈse de Blainville, Canada, November 29 1963 - 118 killed
Trans Canadian DC-8 Series 54F, in-flight explosion

95. Heathrow, England, June 18 1972 - 118 killed
British European Airways HS-121 Trident 1C, crew failed to diagnose premature 'droop'
retraction
96. Leningrad, USSR, April 27 1974 - 118 fatalities
Aeroflot Ilyushin 18V has a take-off accident
97. Mont Blanc, Switzerland, January 24 1966 - 117 perished
Air-India B-707-437, bad atmospheric conditions
98. Carini, Sicily, May 5 1972 - 115 fatalities
Alitalia DC-8 Series 43 crashes into mountain
99. New York, USA, June 24 1975 - 115 dead
Eastern Airlines B-727-225 crashes due to windshear, 9 survivors
100. Andaman Sea, November 29 1987 - 115 dead
Korean Air B-707-3B5C, North Korean bomb attack

© EJECT! Aviation Homepage 1998 07/17/1996 c 18:45
LOCATION: East Moriches, NY
CARRIER: Trans World Airlines FLIGHT: 800
AIRCRAFT: B-747-131 REGISTRY: N93119
ABOARD: 230 FATAL: 230 GROUND:
DETAILS: Exploded in-flight at FL 130.

10/04/1992
LOCATION: Amsterdam, Netherlands
CARRIER: EI AI FLIGHT:
AIRCRAFT: B-747-258F REGISTRY: 4X-AXG
ABOARD: 5 FATAL: 5 GROUND: 47
DETAILS: Lost an engine while in flight caused by corroded pins.

12/29/1991
LOCATION: Wanli, Taiwan
CARRIER: Air China FLIGHT:
AIRCRAFT: B747-2R7F REGISTRY: B-198
ABOARD: 5 FATAL: 5 GROUND:
DETAILS: Crashed on takeoff after losing engine due to corroded pins.

11/27/1989 c 07:20
LOCATION: Near Bogota, Columbia

CARRIER: AVIANCA FLIGHT: 203
 AIRCRAFT: B-727-21 REGISTRY: HK-1803
 ABOARD: 107 FATAL: 107 GROUND: 3
 DETAILS: Detonation of an explosive device in the passenger compartment under a seat.

09/19/1989 c 14:00
 LOCATION: Near Bilma Niger
 CARRIER: Union de Transportes Aeriens (France) FLIGHT: 772
 AIRCRAFT: DC-10-30 REGISTRY: N54629
 ABOARD: 170 FATAL: 170 GROUND:
 DETAILS: Detonation of an explosive device in the forward baggage compartment.

02/24/1989
 LOCATION: Honolulu, HA
 CARRIER: United Airlines FLIGHT: 811
 AIRCRAFT: B-747-122 REGISTRY: N4713U
 ABOARD: 356 FATAL: 9 GROUND:
 DETAILS: Improperly latched cargo door. Loss of door in-flight, explosive decompression.
 Nine sucked out of plane.

12/21/1988 c 19:00
 LOCATION: Lockerbie, Scotland
 CARRIER: Pan American World Airways FLIGHT: 103
 AIRCRAFT: B747-121 REGISTRY: N739PA
 ABOARD: 259 FATAL: 259 GROUND: 11
 DETAILS: Detonation of an explosive device in the forward cargo area.

04/28/1988
 LOCATION: Maui, HI
 CARRIER: Aloha Airlines FLIGHT: 243
 AIRCRAFT: B-737-297 REGISTRY: N73711
 ABOARD: 95 FATAL: 1 GROUND:
 DETAILS: Separation of top of fuselage and explosive decompression. Metal fatigue. One
 passenger sucked out.

11/29/1987 c 11:30
 LOCATION: Over Andaman Sea
 CARRIER: Korean Air FLIGHT: 858
 AIRCRAFT: B707-3B5C REGISTRY: HL-7406
 ABOARD: 115 FATAL: 115 GROUND:
 DETAILS: Detonation of an explosive device in the passenger compartment.

11/28/1987 c 04:00
 LOCATION: Over Indian Ocean
 CARRIER: South African Airways FLIGHT: 295
 AIRCRAFT: B-747-244B REGISTRY: ZS-SAS
 ABOARD: 159 FATAL: 159 GROUND:
 DETAILS: Fire in the main cargo area. Hazardous materials in the cargo hold.

04/02/1986
 LOCATION: Near Athens, Greece

CARRIER: Trans World Airlines FLIGHT:
 AIRCRAFT: B-727 REGISTRY:
 ABOARD: FATAL: 4 GROUND:
 DETAILS: Detonation of a explosive device in the passenger compartment causing four passengers to be sucked out.

06/23/1985 c 07:15
 LOCATION: Atlantic Ocean, Near Ireland
 CARRIER: Air India FLIGHT: 182
 AIRCRAFT: B-747-237B REGISTRY: VT-EFO
 ABOARD: 329 FATAL: 329 GROUND:
 DETAILS: Detonation of an explosive device in the forward cargo hold. Aircraft broke up in flight.

09/23/1983 c 15:30
 LOCATION: Near Mina Jebel Ali, UAE
 CARRIER: Gulf Air FLIGHT: 717
 AIRCRAFT: B-737-2P6 REGISTRY: A40-BK
 ABOARD: 112 FATAL: 112 GROUND:
 DETAILS: Detonation of an explosive device in baggage compartment. Crashed during emergency landing

08/11/1982
 LOCATION: Pacific Ocean 40 from Honolulu
 CARRIER: Pan American World Airways FLIGHT:
 AIRCRAFT: B-747 REGISTRY:
 ABOARD: FATAL: 1 GROUND:
 DETAILS: Detonation of an explosive device in the passenger compartment. The aircraft landed safely

06/27/1980 c 21:00
 LOCATION: Tyrrhenian Sea, Ustica, Italy
 CARRIER: Aero Transporti Italiani FLIGHT: 870
 AIRCRAFT: DC-9-15 REGISTRY: I-TIGI
 ABOARD: 81 FATAL: 81 GROUND:
 DETAILS: Possibly struck by missile. Aircraft broke up and crashed.

01/01/1978 c 20:15
 LOCATION: Off Bandra, Maharashtra, India
 CARRIER: Air India FLIGHT: 855
 AIRCRAFT: B-747-237B REGISTRY: VT-EBD
 ABOARD: 213 FATAL: 213 GROUND:
 DETAILS: Went into a steep dive and exploded on impact. Malfunction of altitude director indicator.

11/03/1977
 LOCATION: Belgrade, Yugoslavia
 CARRIER: EI AI FLIGHT:
 AIRCRAFT: B-747 REGISTRY:
 ABOARD: FATAL: 1 GROUND:
 DETAILS: Explosive decompression

10/06/1976 c 13:30

LOCATION: Off Bridgetown, Barbados

CARRIER: Empresa Consolidada Cubana de Aviacion (Cuba) FLIGHT: 455

AIRCRAFT: DC-8-43 REGISTRY: CU-T1201

ABOARD: 73 FATAL: 73 GROUND:

DETAILS: Crashed into Caribbean Sea. Detonation of an explosive device in the aft of the cabin.

01/01/1976 c 05:30

LOCATION: Northeastern Saudi Arabia

CARRIER: Middle East Airlines (Lebanon) FLIGHT: 438

AIRCRAFT: B-720B REGISTRY: OD-AFT

ABOARD: 81 FATAL: 81 GROUND:

DETAILS: Broke-up at FL 370. Detonation of an explosive device the forward cargo compartment.

12/22/1974 c12:30

LOCATION: Maturin, Venezuela

CARRIER: Aerovias Venezolanas SA (Venezuela) FLIGHT: 358

AIRCRAFT: DC-9-14 REGISTRY: YV-CAVM

ABOARD: 77 FATAL: 77 GROUND:

DETAILS: Crashed 5 minutes after takeoff. Unknown cause.

09/15/1974 c 11:00

LOCATION: Phan Rang, Vietnam

CARRIER: Air Vietnam (South Vietnam) FLIGHT: 706

AIRCRAFT: B-727-121C REGISTRY: XV-NJC

ABOARD: 75 FATAL: 75 GROUND:

DETAILS: Hijacked. Detonation of two hand grenades in the passenger compartment.

09/08/1974 c 09:40

LOCATION: Ionian Sea West of Athens, off Kefallinia, Greece

CARRIER: Trans World Airlines FLIGHT: 841

AIRCRAFT: B-707-331B REGISTRY: N8734

ABOARD: 88 FATAL: 88 GROUND:

DETAILS: Went into steep climb then nose-dived into ocean. Detonation of an explosive device in the aft cargo hold

03/03/1974 c 12:40

LOCATION: Bois d' Ermenonville, France

CARRIER: THY (Turkish Air) FLIGHT: 981

AIRCRAFT: DC-10-10 REGISTRY: TC-JAV

ABOARD: 346 FATAL: 346 GROUND:

DETAILS: Crashed shortly after takeoff. Lost improperly latched cargo door. Decompression, damage to controls.

11/03/1973

LOCATION: Over New Mexico

CARRIER: National Airlines FLIGHT:

AIRCRAFT: DC-10 REGISTRY:

ABOARD: 116 FATAL: 1 GROUND:
 DETAILS: Overspeeding of starboard engine, engine disintegrated, pieces struck fuselage,
 broke window, passenger sucked out.

07/22/1973 22:06
 LOCATION: Off Papeete, Tahiti
 CARRIER: Pan American World Airways FLIGHT: 816
 AIRCRAFT: 707-321B REGISTRY: N417PA
 ABOARD: 78 FATAL: 78 GROUND:
 DETAILS: Crashed 30 seconds after takeoff into the ocean.

05/18/1973
 LOCATION: Southern Siberia, USSR
 CARRIER: Aeroflot FLIGHT:
 AIRCRAFT: Tupolev Tu-104A REGISTRY:
 ABOARD: 81 FATAL: 81 GROUND:
 DETAILS: Broke up at FL 300. Detonation of a bomb in the cabin being carried by a
 passenger.

06/15/1972 c 14:00
 LOCATION: Near Pleiku, Vietnam
 CARRIER: Cathay Pacific Airways (Hong Kong) FLIGHT: 700Z
 AIRCRAFT: Convair 880M REGISTRY: VR-HFZ
 ABOARD: 81 FATAL: 81 GROUND:
 DETAILS: Crashed while en route. Detonation of an explosive device in the passenger cabin.

01/26/1972
 LOCATION: Near Hermsdorf, Czechoslovakia
 CARRIER: JAT FLIGHT:
 AIRCRAFT: DC-9-32 REGISTRY: YU-AHT
 ABOARD: 28 FATAL: 27 GROUND:
 DETAILS: Detonation of bomb in forward cargo hold. Crew member fell 15,000 feet in the
 tail section and survived.

02/21/1970
 LOCATION: Germany
 CARRIER: Swissair FLIGHT:
 AIRCRAFT: Convair CV-990-30A-6 REGISTRY: HBICD
 ABOARD: 47 FATAL: 47 GROUND:
 DETAILS: Detonation of an explosive device in the rear of the plane shortly after takeoff.

10/12/1967 c 07:25
 LOCATION: Off south-western Turkey
 CARRIER: British European Airways FLIGHT: 284
 AIRCRAFT: de Havilland Comet 4B REGISTRY: G-ARCO
 ABOARD: 66 FATAL: 66 GROUND:
 DETAILS: Broke up at FL290. Detonation of an explosive device in the passenger cabin.

12/08/1963 20:59
 LOCATION: Elkton, MD
 CARRIER: Pan American World Airways FLIGHT: 214

AIRCRAFT: B-707-121 REGISTRY: N709PA
ABOARD: 81 FATAL: 81 GROUND:
DETAILS: Exploded and crashed while in holding pattern. Lightning induced ignition of fuel tank vapors.

07/28/1963 c 01:50
LOCATION: Off Bandra, Maharashtra, India
CARRIER: United Arab Airlines (Egypt) FLIGHT: 869
AIRCRAFT: de Havilland Comet 4C REGISTRY: SU-ALD
ABOARD: 63 FATAL: 63 GROUND:
DETAILS: Crashed while preparing to land.

05/22/1962 c 21:15
LOCATION: Near Unionville, MO
CARRIER: Contentional Airlines FLIGHT: 11
AIRCRAFT: B-707-124 REGISTRY: N70775
ABOARD: 45 FATAL: 45 GROUND:
DETAILS: Crashed while en route. Detonation of a dynamite bomb in the right rear lavatory.

Unusual Accidents

Captain allowed his children to manipulate the controls.

03/23/1994 00:57
LOCATION: Near Mezhduretshensk, Russia
CARRIER: Russian International Airways FLIGHT: 593
AIRCRAFT: Airbus A310-304
REGISTRY: F-OGQS S/N: 596
ABOARD: 75 FATAL: 75 GROUND:
DETAILS: The aircraft crashed after the captain allowed his child to manipulate the controls of the plane. The pilot's 11 year old daughter and 16 year old son were taking turns in the pilot's seat, flying the plane. While the boy was flying, he put the airliner in a bank of 90 degrees and the nose dropped sharply. Someone pulled back on the yoke to obtain level flight but the plane stalled. Amazingly, rather than the co-pilot in the right hand seat taking over the controls, the captain began to coach his son in recovery techniques. After several stalls and rapid pull-ups the plane went into a spiral descent. In the end the co-pilot initiated a 4.8g pull-up and nearly regained a stable flightpath but the aircraft struck the ground killing all aboard.

Captain almost sucked out of plane

06/10/1990 c 08:20
LOCATION: Oxfordshire, England

CARRIER: British Airways FLIGHT: 5309
 AIRCRAFT: BAC One-Eleven
 REGISTRY: S/N:
 ABOARD: 85 FATAL: 0 GROUND:
 DETAILS: On a flight from Birmingham, England to Malaga, Spain, at FL 230, a large section of windshield fell away from the aircraft. The decompression pulled the captain out from under his seatbelt. Despite trying to hold onto the yoke, the captain was sucked out into the opening. A steward in the cockpit was able to grab hold of his legs. Another steward was able to strap himself into the vacant seat and aid in holding onto the captain's legs. The copilot wearing full restraints made an emergency landing at Southampton. The captain remained half way out of the aircraft for 15 minutes and suffered only frostbite and some fractures. Improper bolts used to replace the windshield two days earlier.

Ran out of fuel while in holding pattern

01/25/1990 21:34
 LOCATION: Cove Neck, New York
 CARRIER: AVIANCA (Colombia) FLIGHT: 052
 AIRCRAFT: Boeing B-707-321B
 REGISTRY: HK 2016 S/N: 19276
 ABOARD: 158 FATAL: 73 GROUND:
 DETAILS: The aircraft was put in a series of extended holding patterns as it approached New York. The crew informed ATC they were running out of fuel but did not declare an emergency and were cleared to land. After a missed approach and during a go-around, the plane ran out of fuel and crashed in a wooded area. The captain speaking very little English and communicating through the first officer at no time declared an emergency. The first officer used the term "we need priority" several times, rather than declaring an emergency. The ATC did not realize the peril of the aircraft. Failure of the crew to properly communicate the emergency situation to the ATC.

Crew preoccupied with listening to a World Cup Soccer match

09/03/1989 c 20:45
 LOCATION: Near Sao Jose do Xingu, Brazil
 CARRIER: VARIG (Brazil) FLIGHT: 254
 AIRCRAFT: Boeing B-737-241
 REGISTRY: PP-VMK S/N: 21006
 ABOARD: 54 FATAL: 13 GROUND:
 DETAILS: The aircraft ran out of fuel due to a navigation error and crashed into the jungle. The crew, preoccupied with listening to a World Cup championship match, flew in the wrong direction. It is

alleged that the pilot led the survivors two days through the jungle to rescue and the first words out of his mouth were "who won".

Nine passengers sucked out of plane and lost at sea

02/24/1989 02:09
LOCATION: Honolulu, Hawaii
CARRIER: United Air Lines FLIGHT: 811
AIRCRAFT: Boeing B-747-122
REGISTRY: N4713U S/N:
ABOARD: 356 FATAL: 9 GROUND:
DETAILS: After leaving Honolulu, on a flight from Los Angeles to Sydney, Australia, the loss of an improperly latched cargo door resulted in explosive decompression and loss of power in the No. 3 and 4 engines. Nine passengers were sucked out of the plane and lost at sea. The plane landed safely.

Both pilots shot by fired airline employee

12/07/1987 16:16
LOCATION: San Luis Obispo, California
CARRIER: Pacific Southwest Airlines FLIGHT: 1771
AIRCRAFT: British Aerospace BAe-146-200
REGISTRY: N350PS S/N: E-2027
ABOARD: 43 FATAL: 43 GROUND:
DETAILS: A fired USAir employee, David Burke, after leaving a goodbye message to friends, shot both pilots. The aircraft went into a steep dive and crashed.

Plane crashed after pilot ignored Ground Proximity Warning System

02/19/1985 09:27
LOCATION: Mt. Oiz, near Durango, Vizcaya, Spain
CARRIER: Iberia Airlines (Spain) FLIGHT: 610
AIRCRAFT: Boeing B-727-256
REGISTRY: EC-DDU S/N: 21777
ABOARD: 148 FATAL: 148 GROUND:
DETAILS: The aircraft crashed into an antenna on Mt. Oiz. Incorrect interpretation of Ground Proximity Warning System (GPWS). The captain was heard shouting "shut up" at the GPWS as it announced "pull up". Overconfidence in altitude alert system. Incorrect interpretation of its warnings.

All four engines failed after flying through volcanic ash

06/24/1982 20:44

LOCATION: Mount Galunggung, Indonesia

CARRIER: British Airways FLIGHT: 009

AIRCRAFT: Boeing B-747

REGISTRY: G-BDXH S/N:

ABOARD: 257 FATAL: 0 GROUND:

DETAILS: The aircraft flew into a plume from a volcanic eruption at 37,000 feet during the night. All engines failed and the windshield lost transparency because of pitting. The first engine was restarted at 12,000 feet, followed by the other three and the plane landed safely at Jakarta.

Aircraft crashed after crew struggled with mentally ill pilot

02/09/1982

LOCATION: Tokyo, Japan

CARRIER: Japan Air Lines FLIGHT:

AIRCRAFT: Douglas DC-8-61

REGISTRY: JA-8061 S/N: 45889

ABOARD: 174 FATAL: 24 GROUND:

DETAILS: The aircraft flew into shallow water after a struggle with a mentally ill pilot. It appears the captain, known to have mental problems, put an engine into reverse while the co-pilot and flight engineer battled to restrain him.

Captain experimented with autothrottle system

11/03/1973 c 16:40

LOCATION: Near Albuquerque, New Mexico

CARRIER: National Airlines FLIGHT: 27

AIRCRAFT: Douglas DC-10-10

REGISTRY: N60NA S/N:

ABOARD: 128 FATAL: 1 GROUND:

DETAILS: Overspeeding of the starboard engine caused the engine to disintegrate. Pieces struck the fuselage, breaking a window, causing rapid explosive decompression and a passenger was sucked out of the plane. The plane landed safely. The captain and flight engineer experimenting with the autothrottle system to see its response to various other instrument settings caused overspeeding of the engine.

Twenty-nine survivors rescued after 2 months in the Andes mountains

10/13/1972

LOCATION: Near San Fernando, Chile

CARRIER: TAMU FLIGHT:

AIRCRAFT: Fairchild-Hiller FH-227D/LCD

REGISTRY: T-571 S/N: 572

ABOARD: 45 FATAL: 29 GROUND:

DETAILS: The flight crashed into Andes mountains. The survivors were not found until 12/22/72. Survivors resorted to cannibalism to stay alive. The book and movie "Alive" is based on this accident.

Crew member fell 33,000 feet and survived

01/26/1972 c 17:00

LOCATION: Near Hermsdorf, Czechoslovakia

CARRIER: JAT Yugoslav Airlines FLIGHT: 364

AIRCRAFT: Douglas DC-9-32

REGISTRY: YU-AHT S/N: 47482

ABOARD: 28 FATAL: 27 GROUND:

DETAILS: The plane crashed after the detonation of bomb in the forward cargo hold. A stewardess fell 33,000 feet in the tail section and although breaking both legs and being paralyzed from the waist down, survived. The bomb was believed to be placed on the plane by a Croatian extremist group.

Co-pilot accidentally deployed spoilers 60 feet off the ground

07/05/1970 08:09

LOCATION: Toronto, Canada

CARRIER: Air Canada FLIGHT: 621

AIRCRAFT: Douglas DC-8-63

REGISTRY: CF-TIW S/N: 46114

ABOARD: 109 FATAL: 109 GROUND:

DETAILS: While landing and approximately 60 feet above the runway, the spoilers were inadvertently deployed causing the aircraft to fall and lose the No. 4 engine. The crew then decided to go-around. The aircraft exploded while attempting the go-around. Inadvertent deployment of spoilers while the aircraft was still in the air by the first officer. Faulty design by allowing the spoiler handle to perform two different unrelated tasks.

Captain suffered heart attack

04/22/1966 20:30

LOCATION: Near Ardmore, Oklahoma

CARRIER: American Flyers Airline FLIGHT:

AIRCRAFT: Lockheed 188C Electra
REGISTRY: N183H S/N: 1136
ABOARD: 98 FATAL: 83 GROUND:
DETAILS: The aircraft crashed into foothills during landing attempt at Ardmore Municipal Airport . Incapacitation of captain with a heart attack during final stages of approach.

Pilot decided to give passengers a view of the mountain

03/05/1966 c 14:15
LOCATION: Near Gotemba City, Mt. Fuji, Japan
CARRIER: British Overseas Airways FLIGHT: 911
AIRCRAFT: Boeing B-707-436
REGISTRY: G-APFE S/N: 17706
ABOARD: 124 FATAL: 124 GROUND:
DETAILS: The aircraft crashed into Mt. Fuji after encountering severe turbulence when the pilot decided to give the passengers a view of the mountain. The aircraft encountered severe clear air turbulence and started to come apart in the air before crashing.

Aircraft crashes after collision with a whistling swan

11/23/1962
LOCATION: Ellicot, Maryland
CARRIER: United Air Lines FLIGHT:
AIRCRAFT: Vickers Viscount 745D
REGISTRY: N7430 S/N: 128
ABOARD: 18 FATAL: 18 GROUND:
DETAILS: The aircraft struck a flock of Whistling Swans at night, at 6,000 ft. One, estimated to be 13 pounds, struck the leading edge of the tail stabilizer, weakening the structure and causing it to detach. The aircraft lost control and crashed.

Son placed bomb aboard aircraft to collect insurance on his mother

11/01/1955 c 19:00
LOCATION: Longmont, Colorado
CARRIER: United Air Lines FLIGHT: 629
AIRCRAFT: Douglas DC-6B
REGISTRY: N37559 S/N: 43538
ABOARD: 44 FATAL: 44 GROUND:
DETAILS: The aircraft crashed 11 minutes after taking off from Denver on a flight to Seattle. Detonation of a bomb in the No. 4 cargo hold, placed by John Graham in his mother's luggage in order to collect \$37,500 in insurance. A delayed flight caused the

bomb to detonate over flat land rather than the mountains as planned. He was executed for the crime.

Husband placed a bomb aboard aircraft to collect insurance on his wife

09/09/1949 10:45

LOCATION: Sault-aux-Cochons, PQ, Canada

CARRIER: Canadian Pacific Airlines FLIGHT:

AIRCRAFT: Douglas DC-3

REGISTRY: CF-CUA S/N: 4518

ABOARD: 23 FATAL: 23 GROUND:

DETAILS: The aircraft disintegrated in flight 40 miles outside of Quebec. Detonation of a dynamite bomb in the forward baggage compartment. Planted by Albert Guay, a jeweler, in a plot to kill his wife, a passenger on the plane. Guay, who assembled the bomb, had his mistress Marguerite Pitre air express the bomb on the aircraft. Ms. Pitre brother, a clockmaker, helped make the timing mechanism. The insurance policy was for 10,000 dollars. All three were hanged for the crime.

Falulty design caused aviation fuel to be sucked into heating vent

10/24/1947

LOCATION: Bryce Canyon, Utah

CARRIER: United Air Lines FLIGHT:

AIRCRAFT: Douglas DC-6

REGISTRY: NC37510 S/N: 42875

ABOARD: 52 FATAL: 52 GROUND:

DETAILS: Fire was reported on board the aircraft before it crashed. An almost identical accident with the same cause occurred on 11/11/47. The flight crew transferred fuel either intentionally or inadvertently from the No. 4 alternate tanks to the No. 3 alternate tanks and failed to stop the transfer process in time to avoid overflowing the No. 3 alternate tank. Gasoline flowed through the No. 3 alternate vent line, out the vent, and was carried back by the slip stream, entering the cabin heater combustion air intake scoop. When the cabin heater came on, an explosion and fire occurred. Design flaw in the aircraft.

Captain intentionally engaged the gust lock in flight

10/08/1947

LOCATION: El Paso, Texas

CARRIER: American Airlines FLIGHT: 311

AIRCRAFT: Douglas DC-4

REGISTRY: NC90432 S/N:

ABOARD: 56 FATAL: 0 GROUND:

DETAILS: The aircraft went into steep dive and pulled out 350 feet from the ground. As an experiment, a captain riding in the jump seat engaged the gust lock in flight. The command pilot rolled the elevator with no response as the jump seat captain disengaged the gust lock causing the aircraft to go into a steep dive, execute part of an outside roll and become inverted. Neither the command nor jump seat captain had seat belts on and accidentally feathered No. 1, 2 and 4 engines. The co-pilot managed to unfeather the props and pull out of the dive.

U.S. Army Air Corps plane crashed into Empire State Building

07/28/1945 9:49

LOCATION: New York, New York

CARRIER: Military FLIGHT:

AIRCRAFT: USAAC B-25 Bomber

REGISTRY: 0577 S/N:

ABOARD: 3 FATAL: 3 GROUND: 11

DETAILS: A U.S. Army Air Force plane crashed into the 79th floor of the Empire State Building in heavy fog. Lt. Col. William Franklin Smith Jr., the pilot, became disoriented while trying to land at Newark Airport. Lt. Smith was told he had a 3 hour wait to land at Newark. Impatient to get his plane on the ground, he falsely declared he had official business at La Guardia Airport with the intention of diverting to Newark as soon as he was cleared. The 12 ton plane smashed a 20 ft. hole in the building. Fuel from the ruptured gas tanks poured out and set two floors ablaze killing 10 people. One engine exited the south side of the building and plunged into a penthouse below.

Air India Flight 182

Report on the accident to Boeing 747-237B VT-EFO, Air India Flight 182,
off Cork, Ireland on 23 June 1985
by John Barry Smith,
Independent Aircraft Accident Investigator

Appendix I Questions

Source: John Barry Smith

Questions:

There are many questions raised by the realization that four large commercial airliners were not attacked by terrorists detonating bombs but by a common mechanical problem of faulty wires which allow cargo doors to rupture open when they shouldn't. Listed below are some of the informal questions and partial answers that the wiring/cargo door/explosive decompression explanation creates regarding the four flights of Air India Flight 182, Pan Am Flight 103, United Airlines Flight 811, and Trans World Airlines Flight 800 and all aircraft in general.

A. How and why does forward cargo door open in flight?

United Airlines Flight 811 door open cause was electrical short to door motor to unlatch position which overrode safety locking sectors and failed switch and door unlatched and opened. Pan Am Flight 103 and United Airlines Flight 811 had total forward cargo door openings while Air India Flight 182 and Trans World Airlines Flight 800 had rupture at aft midspan latch with bottom eight latches holding tight. Door openings were probably a result of aging aircraft, out of rig door, chafed aging faulty Poly-X wiring, weakened Section 41 area, design weakness of no locking sectors for midspan latches, AAR 92/02, page 12, and only one latch per eight feet of vertical door. Air India Flight 182, Pan Am Flight 103, and Trans World Airlines Flight 800 had similar circumstances.

B. How does open door in flight cause nose to come off for Air India Flight 182, Pan Am Flight 103, and Trans World Airlines Flight 800?

Cargo door opens and huge ten by thirty foot hole appears in nose, structural members of door and frame are missing, floor beams are fractured, bent, and broken, aircraft direction is askew, flight control surfaces affected, engines damaged, and 300 knots, more than the fastest hurricane or force five tornado on earth, hits damaged area and tears nose off within three to five seconds.

C. Why did nose of United Airlines Flight 811 stay on?

Nose of United Airlines Flight 811 may have stayed on because the pilot said he had just come off autopilot and did not fight plane as it gyrated, or plane was younger than others, or the time from door opening to tearing off was 1.5 seconds and allowed the pressurization to be relieved somewhat and six less feet of width of hole was torn off.

D. Air India Flight 182 and Pan Am Flight 103 not a bomb?

Yes, not a bomb for Air India Flight 182 and Pan Am Flight 103 as initial event. Evidence refutes bomb explanation and is in government accident reports which careful analysis will reveal and documented on www.corazon.com. Those accident investigators did not have the benefit of hindsight, the internet, or several subsequent similar accidents to compare and draw different conclusions.

E. Trans World Airlines Flight 800 not center tank as initial event?

Center tank exploded yes, but after door ruptured/opened, hole appeared in nose, nose torn off in wind, fuselage falling with disintegrating fuel tanks and ignited by fodded and on fire engine number 3 or 4 at 7500 feet thereby explaining the Chairman's question, "Why so few bodies burned?" The answer is they were not there to be burned. The nose came off with the passengers inside cabin and descended to ocean alone.

F. Is explosive decompression enough to tear nose and forward part of aircraft off?

Explosive decompression is enough to rupture a pressurized hull at weak spot, one latch for eight feet of door, in a weak area, Section 41, but not enough to tear nose off. The ultimate destructive force is the 300 knots of slipstream, more powerful than any wind on earth. If cargo door popped in balloon, the large hole would appear but the nose would stay on. In a tornado, nose comes off within three to five seconds.

G. When forward cargo door opens does it always result in deaths?

No, with United Airlines preflight in 1991 the aft door opened electrically inadvertently and nothing happened because it was on the ground and no pressure differential. So no damage. Then Pan Am Flight 125 in 1987 had forward door open partially and plane could not pressurize adequately and turned around and landed, so no damage with slight pressure differential except expense of fuel and risk to life. Then 811 happened with smaller hole and 1.5 second delay in opening and nine dead with larger pressure differential. Then 103, 800, and 182 had explosive decompression up high with maximum differential and door ruptured and shattered and took skin to the left and right and above with it exposing huge hole and forward part of aircraft came off and all died. When the forward cargo door ruptures or fully opens or partially opens, different consequences occur from minor to severe depending on pressure differential which depends on altitude and speed at which door ruptures/opens.

H. Is there a conspiracy to keep cargo door explanation quiet?

There is no conspiracy, no plot, no coverup by agencies involved with the cargo door explanation:

1. No conspiracy of Sikh terrorists named Singh to put a bomb on Air India Flight 182; the door ruptured in flight.

2. No conspiracy of Libyan terrorists or whoever to put a bomb on Pan Am Flight 103; the door ruptured in flight.

3. No conspiracy to detonate a bomb on United Airlines Flight 811 as the passengers thought, as the crew thought and told the tower who told the Coast Guard and crash crews on the ground as they prepared for a wounded 747 coming in after a bomb blast; the door ruptured in flight.

4. No conspiracy to put a bomb on Trans World Airlines Flight 800,

5. No conspiracy of terrorists to shoot a missile,

6. No coverup by US Navy to hide accidental shootdown,

7. No coverup by Boeing, NTSB, FAA, or TWA who are hiding the knowledge the door ruptured in flight.

I. Why the huge hole on starboard side in cargo door area while port side smooth?

That's where the forward cargo door is located on all the aircraft, forward of the wing on the right side. The rectangular shattered zone around the forward cargo door is apparent on all the wreckage reconstruction photographs and drawings. The unilateral damage on TWA Flight 800 refutes the center tank explosion as the initial event.

J. Are passengers at risk right now?

Yes, all passengers currently flying in early model Boeing 747s with Poly X wiring are at risk of the faulty wiring shorting on the door unlatch motor causing the ruptured opening of the midspan latches of the cargo door leading to explosive decompression and fatalities. The fault has unofficially occurred in 1985, 1987, 1988, 1989, 1991, and 1996.

K. What is the sudden loud sound on the CVR on all four aircraft at the initial event time of the inflight breakup?

The sound is the rush of air molecules to the outside to equalize the high pressure air in the cabin with the low pressure air outside at altitude. Explosive decompression is a very loud event.

L. Why the almost immediate power cut to the recorders?

The main equipment compartment (MEC) is immediately adjacent and in front of the forward cargo compartment. The MEC has the wiring power to the recorders and the explosion of decompression nearby cuts off power.

M. Why the right side inflight airframe damage?

The starboard (right) side is where the forward cargo door opens in flight and material from inside the compartment and cabin above are ejected into the slipstream. Engine number three and the right horizontal stabilizer are close to and aft of the forward cargo compartment. The objects are ingested into the nearby engine number three, strike the leading edge of the right wing, and continue aft and strike the right horizontal stabilizer. The port side is relatively unscathed from inflight debris.

N. Why the shattered area around the forward cargo door?

When the explosion of decompression occurs, the door is flung open if all the latches unlock and shattered if the bottom eight latches hold but rupture at the midspan latches. In any case the top part of the door opens outward and upward and away taking much fuselage skin above the door with it.

O. Why the streak for Trans World Airlines Flight 800?

The streak is the reflection of the evening sun of shiny metal skin from the forward cargo door area coming off in flight during the explosive decompression and seen by ground observers in darkness to the east as the objects quickly decelerate from 300 knots in a horizontal direction to straight down from 13700 feet.

P. What is the ignition source for the center fuel tank explosion of Trans World Airlines Flight 800?

The ignition source for the center fuel tank explosion is the on fire engine number three which ingested foreign objects from the forward cargo compartment after the ruptured opening of the forward cargo door. The falling and disintegrating fuselage and fuel tanks were ignited by the fiery exhaust and caused the explosion well after the initial event.

Q. Why to do the authorities think Pan Am 103 was a bomb explosion?

There was a relatively mild, directed discharge of a shotgun type weapon in the forward cargo compartment after the explosive decompression. This discharge put a small shatter zone of 20 inches into the skin on the port side of the compartment. The authorities call this event the initial event of a bomb explosion. A Boeing 747 can tolerate a 20 inch hole in its fuselage and in fact has been designed to withstand such a hole of that size and larger. United Airlines Flight 811 showed that a Boeing 747 can safely withstand a ten foot by twenty foot hole in the fuselage and land safely. Bombs are not mild, are spherical, would make a bomb sound on the CVR, and leave much other evidence than a small hole.

R. Why do the authorities think Air India Flight 182 was a bomb explosion?

Air India Flight 182 had a catastrophic inflight breakup that looked like a bomb had gone off inside it. An explosive decompression mimics a bomb explosion. There was evidence of an explosion. At the time there was no other reasonable explanation for such an explosive decompression for a Boeing 747

except for a bomb or to leave the cause unstated. The finding of a bomb explosion for Air India Flight 182 was based on two assumptions, later refuted, by the Indians: an explosive decompression could abruptly turn off the electrical supply to the recorders and the floor panels separated upward from an exploding force from below.

S. How can the experts and the public be so wrong?

Experts and laypersons below:

1. police
2. aircraft accident investigators
3. media
4. government
5. manufacturer
6. attorneys, plaintiffs, defendants, and judges
7. airlines
8. flightcrews
9. passengers.

This is a political and human nature question; the best I can do to explain it is as follows: Experts are often wrong; they are human. In the case of the wiring/cargo door/explosive decompression for four Boeing 747 accidents, the experts were all partially right and partially wrong, some more than others. The good ones try to find their errors, correct them and continue on; however, it is understandable that the not so good experts and laypersons are reluctant to investigate alternative probable causes for fatal aircraft accidents if that path leads to unpleasant truths:

For the law enforcement authorities to have their budgets cut and staff reduced instead of increased for more terrorist activities,

For accident investigators who have previously made conclusions about causes that are now refuted and whose credibility would now be in jeopardy and threaten their reputations,

For the media to have a boring mechanical story that has happened before and was supposed to have been fixed instead of an exciting spy conspiracy story,

For the government who has oversight of all to find out it overlooked and allowed noncompliance of regulations to occur,

For the manufacturer to discover most of the thousands of airplanes it constructed have severe design problems of outward opening non plug cargo doors and faulty wiring installed.

For attorneys, plaintiffs, defendants, and judges who have caused the transfer of hundreds of millions of dollars in lawsuits to discover it was done on factual errors,

For the airlines to find out they may have not kept their airframes maintained properly,

For the flightcrews who do not want to believe their aircraft can come apart at any second and there is nothing they can do about it,

For the passengers who want to be persuaded there is no danger in flying and insist on being reassured that any problems have been fixed, their ticket prices are low, and they have their baggage with them.

All parties are acting in their perceived best interest and believing in wishful

thinking. They are not objective. In this particular case, when Boeing 747s are breaking apart in flight, there is an understandable perceived best interest by all parties to believe they are not responsible for the accidents and the fatalities. By having the blame shifted to outside forces such as terrorists, most parties are absolved of guilt. The parties, law enforcement and security, responsible for allowing the 'bomb' to be put aboard are rewarded with higher staffs and budgets. The only losers with the 'bomb' explanation are the ones accused of putting it there.

The electrical problem in airliners is difficult to detect because the symptoms are treated instead of the cause. Faulty wiring and switches do more than cause cargo doors to open in flight, they cause yaw dampers to swing back and forth, they cause autopilots to disconnect or act strange, and they often cause fires. When cargo doors ruptured open in flight over a period of eleven years in four airlines in four airports in three countries, investigation jurisdictions were spread out over distance and time. Each agency looked at the sole tree and did not see the forest of four trees.

There are built in protection beliefs when a Boeing 747 crashes. The manufacturer contributes to the welfare and salaries to tens of thousands of employees and indeed, the whole northwest of the United States derives much support from Boeing. If the company were to be put in jeopardy because of manufacturing errors and be the subject of lawsuits, literally millions of citizens would be concerned. All parties including the government, the media, the investigating agencies, and the legal system do not want the company to be in danger and instinctively, although not conspiratorially, act together to protect that company. If any sort of plausible explanation that exonerates the company exists, that explanation will be eagerly sought and agreed with. That sudden agreement explains why the 'bomb' explanation for all four aircraft was discussed within hours of the discovery of the accident and immediately accepted as a working hypothesis. In every report the 'bomb' explanation is the one most quickly sought to be confirmed by the authorities. Incredible lengths were taken in time and money to confirm the 'bomb' explosion.

An explosion by explosive decompression caused by an inadvertently opened forward cargo door inflight mimics a 'bomb' explosion in many ways. Passengers get hit by flying debris, metal is petaled outwards, recorders pick up a loud noise, wings and tails get struck by pieces of skin, engines suck in pieces of metal, and the aircraft can disintegrate and catch on fire as it falls. Tangible evidence of a bomb is hard to find as the bomb explodes and distributes the timer, fuze, and container far and wide. It looks at first glance as if a bomb had gone off.

It is understandable how all concerned parties are eager to accept the plausible and absolving 'bomb' explanation and very, very reluctant to investigate the implicating wiring/cargo door/explosive decompression explanation for the four Boeing 747 accidents that suffered breakups in flight.

It is also understandable that a person motivated by actually being in a sudden, night, fiery, fatal, jet airplane crash and surviving, although the pilot was killed, takes great effort to prevent it from happening to others. Because that person is also being completely independent of all the other parties he can objectively evaluate the separate accidents to see the pattern and thus the common probable cause for all. That fatal accident was in 1967 and that person is the author of this report.

It is only when the evidence becomes overwhelming, incontrovertible, and irrefutable that an alternative explanation to a bomb is even considered seriously and when that new explanation reveals a clear and present hazard to the flying public, then the parties will reluctantly reexamine the evidence to conclude that it was not the lesser evil of 'bomb' but the greater evil of a

mechanical problem, a design problem, an oversight problem, that was supposed to have been fixed, but wasn't, and it could happen again.

T. A layperson's explanation for the destruction of Air India Flight 182 relies on basic science and common sense and might go like this:

Why do airplanes fly?

They fly because of lift which exceeds the drag. Common sense tells us that cutting anything such as butter with a knife causes friction. Friction also slows things down when an object moves through the air and creates heat. Friction is drag.

Lift is created when the air flowing over the top of the wing takes a longer distance than the wind flowing over the bottom of the wing. This causes a pressure differential between the top and bottom of the wing. The wing is sucked upwards into the lower pressure air on top of the wing.

The wing must be moving through the air. This can be done in many ways but the usual way is for an engine to make the wing move forward by expelling gases to the rear. This powerful thrusting overcomes the friction of the drag and moves the wing through the air which creates the lift and the airplane flies.

Why do balloons rupture?

Balloons rupture when the compressed higher pressure inside air breaks through the balloon material and to suddenly equalize the pressure to the uncompressed lower pressure outside air. It happens so fast it's called an explosion. The rupture cause can occur from within or from the outside of the balloon. If the balloon material is just stretched too far, the rupture cause is on the surface. The outside air pressure is less at the balloon goes higher making the inside air pressure greater and greater. That is why a full balloon that climbs and climbs will always pop if the material is made to withstand the normal pressures on the ground.

Regardless of the cause of the rupture, the material of the balloon is shredded, torn, and frayed from the outward force. If the balloon is placed under deep water then the reverse is true and the balloon will implode and the material will be shredded, torn, and frayed from an inward force. In this regard, a submarine is opposite from an airplane. The higher an airplane goes, the higher the pressure inside; the lower a submarine goes, the higher the pressure outside. An airplane can explode while a submarine can implode.

What makes the loud pop sound?

The pop is the noise of the suddenly rushing outward air molecules rubbing against the other slower moving air molecules. Heat and noise is created.

What evidence is there of the balloon pop in air?

A sudden loud sound.

Torn, shredded, and frayed material.

Any inside material of the balloon moving to the outside.

What is lightning?

Lightning is the equalizing of a electrical potential from one charged area to a differently charged area. It is similar to a balloon pop except the movement is with electrons instead of air molecules. Lightning causes fires by the intense heat created by this equalizing of electron pressure differential.

Wiring conducts this discharge of electrons in directions to make things like motors move or stop moving. When the wiring is not insulated the electrons in the bare wire will seek out a different way to flow to equalize the different energy potential created by the generators. and as a result, fires may start or motors may turn on when they are not supposed to.

Compressed air in a balloon and a full battery is similar in that they both have energy stored up that seeks to discharge if given a chance.

Why does a hand move backward when it is stuck out the window and turned flat against the wind?

Air has weight. It may be invisible but it is real. When your hand is thin to the wind, the resistance of your hand moving through the air molecules is less but when you turn your hand flat against the wind, the extra area of your wide hand gives a greater resistance to the wind and the weight of the wind force is increased to push your hand back. If the wind force is very powerful it can push your hand back so hard it can break it. The highest wind on earth exists in Force Five Tornadoes with wind speed up to 250 miles per hour. These winds tear roofs off houses, pick up trucks and spin them around, and toss cows for long distances.

Why did Air India Flight 182 crash?

For Air India Flight 182, the huge airplane was able to fly because of its wings which gave lift as the plane moved through the air powered by the jet engines which created thrust which overcame the friction of the drag of the airframe on the air molecules.

As the plane flew higher, the air inside become compressed relative to the outside air. The inside air was actually less compressed than the air on the ground, but relative to the outside very low pressure air at altitude, the inside air was highly compressed thus creating a large pressure differential. It was like a balloon being expanded.

The balloon of the fuselage of Air India Flight 182 got bigger and bigger. It actually expanded from the inside out as the air molecules inside tried to get outside to the less dense air to equalize the pressure differential. The air molecules inside pressed against every inch of the fuselage at the rivets, the windows, the doors, the hinges, the latches, and the skin itself.

Usually Air India Flight 182 would later descend and the process would be reversed and the pressure differential would be reduced until landing when the outside and inside pressure would be equal and the balloon of the fuselage would shrink back to normal. This continual blowing up and letting out the air in the balloon of the fuselage put wear and tear on all the fitting, rivets, windows, hinges, latches, and doors in the fuselage frame.

The time in June, Air India Flight 182 was flying normally very high up with the pressure differential at its maximum, the balloon was at its most expanded with the inside air molecules pressing the hardest on the inside of the fuselage which included the cockpit, the passenger cabin, the lavatories, and the cargo compartments.

Suddenly, lightning struck in a small way when the electrons of electricity which were normally blocked on their way to a motor found another way to get there because the blocking insulation cracked and exposed the bare wire which touched another discharge path. The lightning flowed to a motor which turned on and did what it was designed to do when it received electricity, turn some wheels called cams which encircled some pins in a device called a latch. In this case the cams turned in the direction to allow the latch of a forward cargo door to unlock. As the latch became just so slightly unlocked, the huge internal compressed air pressure burst the entire cargo door open at the weakest point, the midspan latches that held a long eight foot stretch of sliced fuselage together and had no safety locks to prevent what was accidentally happening.

The balloon of Air India Flight 182 popped. A sudden loud sound was produced and heard by everyone on board as the compressed air rushed out of the balloon of the fuselage and forward cargo compartment into the outside air in front of the engines on the right side of the airplane. The rupture area of the cargo door became shattered, torn, and frayed from the outward force of the air molecules. The pop of the balloon was so violent it disrupted all the electricity in a nearby equipment compartment and turned off the power to the data recorders. Material from inside the cabin and cargo compartment was ejected outward into engines and against the right wing and rear stabilizers.

The explosion of the pop of the fuselage is called an explosive decompression. The force is so great it curls, pits, craters, bends, tears metal into fragments and affects the actual atom makeup of the metal. The hole the explosive decompression caused when the large door was ruptured and tore outward, upward, and away was about twenty feet wide and thirty feet tall.

If Air India Flight 182 had not been moving the damage may have remained as it was, a big hole in the right side of the nose with a lot of stuff from the cabin and cargo compartment ejected and missing. However, there was 300 knots, about 330 miles per hour, of wind force on the nose of the airplane. The nose shuddered because the sides, the bottom, and top of the fuselage which had strong beams to hold it together were all bent, twisted, and broken.

The enormous wind force of the weight of the fast moving air molecules on the weakened forward part of Air India Flight 182 tore it off. The jagged blunt end of the torn off nose was too much drag for the engines to overcome. The airplane slowed down. The airplane could not fly because there was not enough lift from the wings.

The aircraft broke in two and fell to the sea, coming apart in many pieces as it disintegrated from the unusual forces applied from all directions.

The passengers inside Air India Flight 182 who were now outside falling would die because the human body can not withstand the force of striking very dense water molecules at a high speed.

To sum up: The surface of the inflated fuselage popped when the lightning of the electricity caused a motor to turn on which allowed a hole to appear in the forward cargo door and allowed the compressed air molecules to escape outside to the less compressed air molecules. The escape was so sudden as to shatter and tear the surface of the inflated fuselage at the forward cargo door. The aircraft came apart when the extremely fast moving air molecules pressed so hard against the weakened forward part as to break it in two. The passengers died because they struck the water too fast for the water to make a hole for them.

The technical terms for all is the probable cause of this accident was the sudden opening of the forward lower lobe cargo door in flight and the subsequent explosive decompression at the

midspan latches. The door opening was attributed to faulty wiring in the door control system which permitted electrical actuation of the door latches toward the unlatched position after initial door closure. The fatal injuries were the result of the explosive nature of the decompression.

U. Why have I pursued this issue of wiring/cargo door/explosive decompression events for over a decade?

The best answer I can give to that is that my life was literally within two seconds of ending but was saved by the unselfish action of my pilot who in a time of stress with a disabled aircraft took the time to tell me to 'eject' which I did unquestionably and lived by the two seconds I had while he died by the two seconds he did not have. Because I survived one, I believe I am repaying a moral debt to prevent others from dying in a sudden night fiery fatal jet airplane crash.

John Barry Smith

www.corazon.com

barry@corazon.com

Independent Aircraft Accident Investigator

Commercial pilot, instrument rated, former FAA Part 135 certificate holder.

US Navy reconnaissance bombardier navigator, RA-5C 650 hours.

US Navy patrol crewman, P2V-5FS 2000 hours.

Air Intelligence Officer, US Navy

Retired US Army Major MSC

Owner Mooney M-20C, 1000 hours.

Survivor of sudden night fiery fatal jet plane crash in RA-5C

Air India Flight 182

Report on the accident to Boeing 747-237B VT-EFO, Air India Flight 182,
off Cork, Ireland on 23 June 1985

by John Barry Smith,
Independent Aircraft Accident Investigator

Appendix J Bruntingthorpe



A dramatic test proves that simple improvements can checkmate bomb-wielding terrorists.

BY JIM WILSON

In less than a minute, bombs will shower England's Bruntingthorpe Airfield with the jagged remains of a Boeing 747 jumbo jet.

"We cannot tell you their exact size and location," says Richard Wright, a spokesman for the Civil Aviation Authority (CAA), which is sponsoring one of the most dramatic experiments in aviation history. They are about to blow up a retired Air France 747. If the experiment plays out as expected, the CAA will have solid proof that simple improvements in baggage container and cargo bay design can minimize the damage of terrorist bombs, like the one that downed Pan Am Flight 103 over Lockerbie, Scotland, in December 1988.

Wright's colleague, Rory Martin, suggests I pay especially close attention to the rear of the doomed plane. "We concentrated on the cargo bay," he explains. "We want to know how the explosions work, how structures fail." To this end, one of the four bombs has been placed inside a standard baggage container, close to an unprotected section of fuselage.

Taking Martin's advice, I aim my binoculars at a spot between the tail and the wing as I listen to the final countdown. Three, two, one . . . Four explosions detonate simultaneously. Inside the aft cargo bay, the pressure wave from one of the blasts has blown through a standard baggage container as if it were just wrapping paper. Unimpeded, these rapidly expanding, high-temperature gases hammer into the fuselage.

To make the experiment more realistic, the interior of the plane was pressurized. Creating just

the right amount of pressure proved to be one of the day's most difficult challenges, and it caused several holds in the countdown. During one of these delays, Chris Peel, a top British structures and materials expert, told me why getting the pressurization right was so important to the outcome of the experiment. "If the aircraft is unpressurized, small cracks will produce minor damage. Catastrophic damage occurs when the pressure difference amplifies the damage, causing the cracks to run," he says.

These amplifying effects soon become apparent. The explosion creates a jagged tear that races forward to the wing, makes a 90° turn and then splits the skin along a line of rivets around the fuselage. The tail section slumps down on the runway. A cloud of fire-extinguishing carbon dioxide gas is released to smother any secondary fires that may have erupted.

After this gas has dispersed, I am allowed a closeup look at the damage. "The standard container was virtually transparent to the explosion," says Peel. A container hardened with a material similar to that used in bulletproof vests and placed near the front of the forward cargo bay (see diagram on opposite page) appears to have fully contained the force of the bomb planted inside.

A second standard 5 x 5 x 5-ft. container also has been demolished, but there is little visible evidence of this outside of the plane. A 15-ft. "bulletproof" panel placed against the fuselage as a sort of shock absorber apparently has performed as advertised. There is likewise no evidence of damage to the fuselage next to a standard baggage container that has been modified by the addition of an 8-in. foam liner.

It will be late fall before the Defence Evaluation and Research Agency, which conducted the experiment for the CAA, issues its final report. But a cursory inspection shows that technology for blunting terror's threat is at hand. "If you put all the changes together," suggests Martin, "they make a good system."

By Lauren Terrazano
Staff Writer

A CENTER FUEL tank blown up by TWA Flight 800 investigators shows damage patterns unlike anything found on the fuel tank of the downed plane, according to early test results -- a development that could finally rule out the possibility that any explosive charge destroyed the plane, sources said.

Since last spring, officials had said they were close to eliminating the bomb and missile theories that had long dominated speculation about the crash's cause. But FBI investigators have been reluctant to be definitive, saying they wanted to re-analyze the wreckage and await the results of more tests.

The test results, from several detonations of a Boeing 747 tank in Bruntingthorpe, England, last month, brought investigators one step closer to dropping the idea of a small, "shaped charge" placed on or near the Flight 800 tank -- the only possibility left of a bomb, because of the lack of other evidence.

"Very small amounts of explosives left very distinctive marks, unlike anything we've seen on the plane," said one investigative source, speaking of the recent tests. "Even the small amounts [of explosives] left distinctive signatures on the structures, so if a small bomb had gone off, it clearly would leave a signature."

Five other theories of ignition remain, including a dud missile or other object piercing the plane's skin and four mechanical scenarios: a static charge within the tank, a faulty scavenge pump, corroded fuel probes and damaged wiring in the right wing.

Investigators have determined the blast originated in the nearly empty 12,890-gallon tank, igniting fuel air vapors in an explosion that tore the plane apart, killing all 230 people aboard. The actual ignition source remains a mystery.

The National Transportation Safety Board has directed hundreds of tests in laboratories around the

world to study potential factors in the explosion.

In October, investigators plan to blow up portions of a center fuel tank in Denver in conjunction with work being done on fuel volatility with the California Institute of Technology. Investigators hope to determine the direction in which flame travels through the tank's different compartments. The testing could help investigators confirm the exact point of ignition within the tank.

Full-scale explosions will follow "within six months" said NTSB spokesman Peter Goelz, adding that results of the Denver tests would not likely be made available before the public hearings planned on the crash in December. "So little is known about the flammability of Jet A fuel that we need to continue and expand our tests," Goelz said.

The NTSB said the results of the Bruntingthorpe tests are still being analyzed and would not be released until the hearing.

In those tests, investigators set off series of small explosions at various points on the tank, trying to determine impacts that could be compared to TWA Flight 800's reconstructed fuel tank. A final explosion included filling the tank with propane to see how it broke apart.

The board also measured the data from the explosions on a cockpit voice recorder to compare to the recording from TWA Flight 800. The data are still being analyzed, but investigators said they weren't hopeful about the comparisons because the test plane used in Bruntingthorpe wasn't pressurized like Flight 800 was, and it would therefore emit a different sound signature.

A parallel criminal investigation of the crash is continuing, and FBI Assistant Director James Kallstrom told victims' families July 19 that the inquiry could wrap up within 60 to 90 days.

The agency said yesterday it would not comment on the Bruntingthorpe tests. "Because the investigation is ongoing, we're not discussing any test results that may have been completed," said FBI spokesman Joseph Valiquette.

May 17, 1997

BRUNTINGTHORPE, England (Reuter) --

Scientists Saturday blew up an old jumbo jet in their quest for ways to make planes safer from terrorist attack.

The giant jet was almost split in two by the blasts, which left the tail section lying crumpled on the ground.

The test, sponsored by Britain's Civil Aviation Authority (CAA) and the U.S. Federal Aviation Administration (FAA), was designed to find new ways of making aircraft more bomb-resistant.

Four bombs were exploded inside the pressurized cargo hold of a Boeing 747 in the former U.S. Air Force Strategic Air Command base at Bruntingthorpe, Leicester, about 100 miles north of London.

In 1988, 270 people were killed when a bomb destroyed a Pan Am 747 which crashed to the earth in Lockerbie, Scotland. In 1989, another 171 perished when a bomb brought down a French UTA DC-10 airliner over Niger.

The experiment, part of a five-year \$5 million research program to improve aircraft structures, was carried out by Britain's Defense Evaluation Research Agency (DERA), a wing of the Ministry of Defense.

Two explosions were designed to test two new types of baggage containers and a third tested a body-armor type of protective material in the cargo hold.

A fourth demonstrated the impact of bombs against unprotected structures, CAA spokesman Richard Wright said.