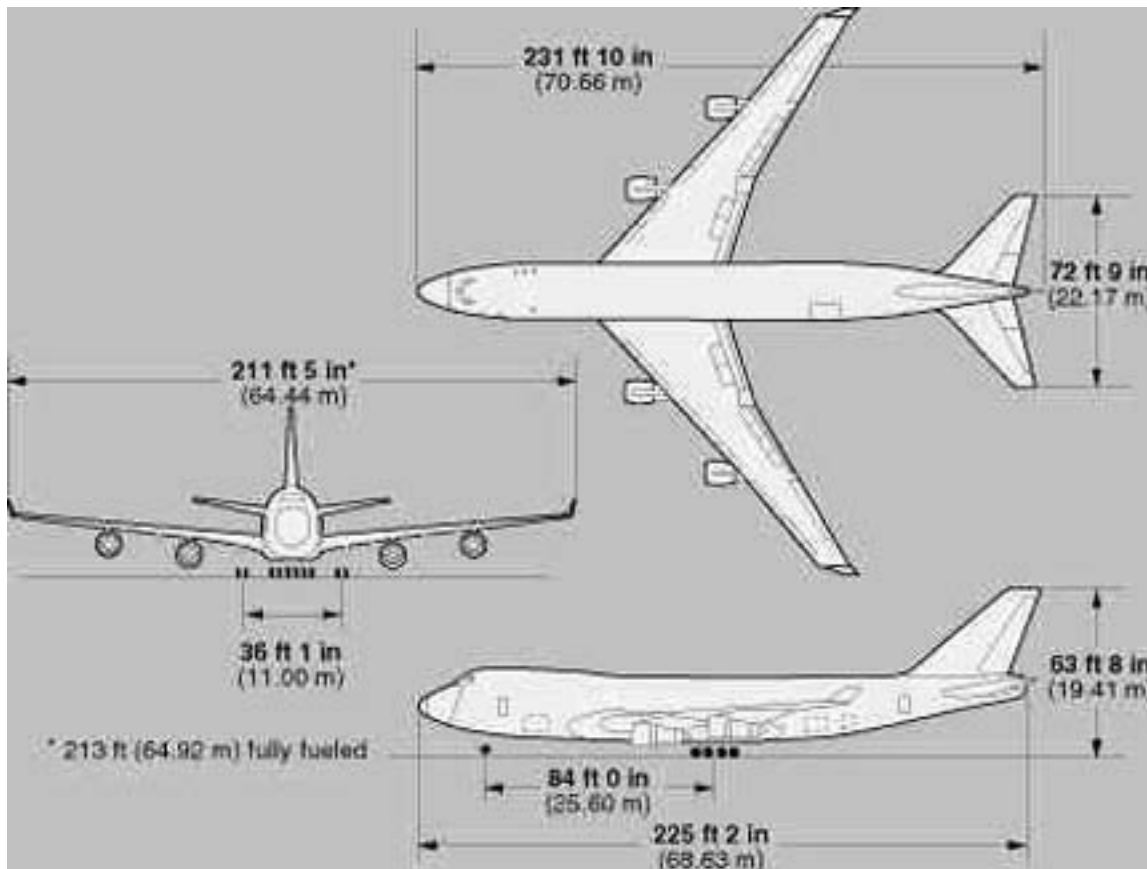


Shorted wiring/forward cargo door rupture/explosive decompression/inflight breakup explanation described in pictures, text, and drawings for United Airlines Flight 811, Pan Am Flight 103, Air India Flight 182, and Trans World Airlines Flight 800.

John Barry Smith 22 March 2002



Caption for above drawing: Layout of Boeing 747 dimensions.



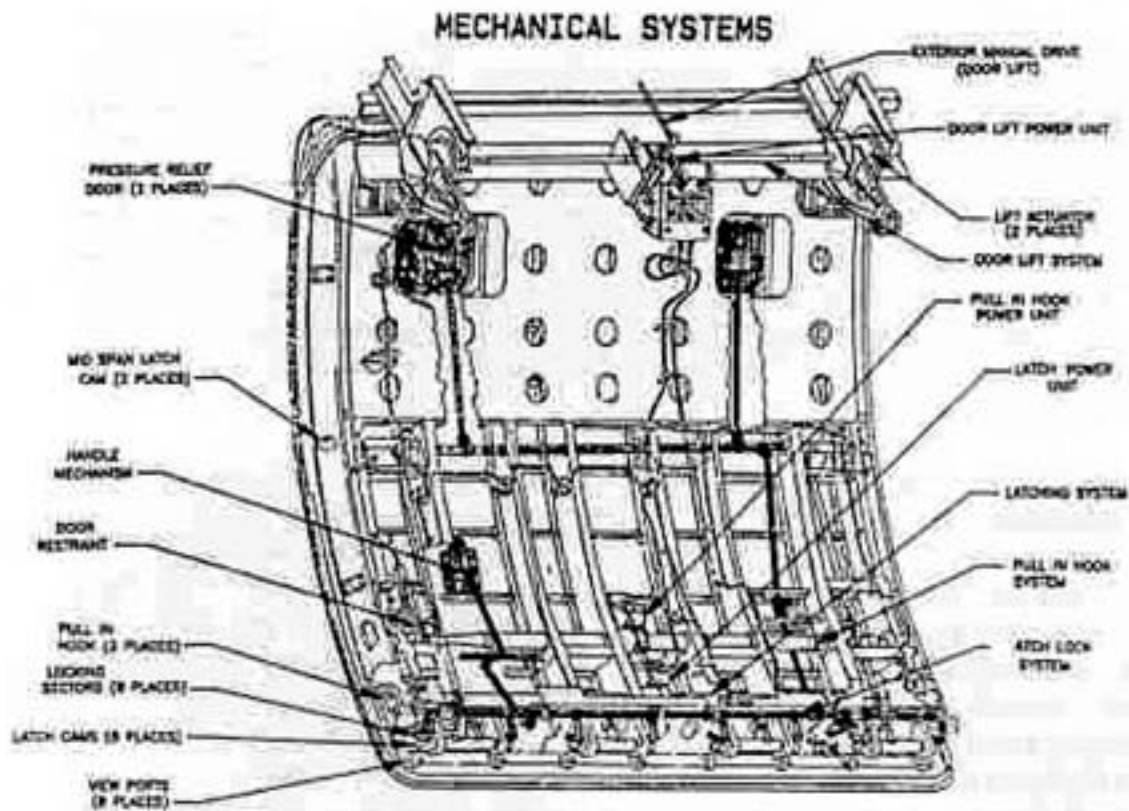
Caption for above photograph:  
Boeing 747 on ground loading cargo through opening outward nonplug forward cargo door. The tiny dot of the one midspan latch on the leading edge of the door can be seen.



Caption for above photograph:  
Closeup of Boeing 747 closed forward cargo door showing manual locking handle, upper hinge, over pressure relief doors, engine number two, passenger windows above door, and R2 door.



Caption for above photograph: Closeup of open forward cargo door showing open manual locking handle, several of the bottom eight latches, forward leading edge midspan latch, and the aft leading edge midspan latch pin.



Caption for above drawing and below description of operation of cargo door: Drawing of Boeing 747 cargo door 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.

Electrical power for operation of the cargo door switches and actuators is supplied from the ground handling bus, which is powered by either external power or the APU. See figure 17 for a diagram of the cargo door electrical circuitry. The engine generators cannot provide power to the ground handling bus. APU generator electrical power to the ground handling bus is interrupted when an engine generator is brought on line after engine start. The APU generator "field" switch can be reengaged by the flightcrew, if necessary on the ground, to power the ground handling bus. The air/ground safety relay automatically disconnects the APU generator from the ground handling bus, if it is energized, when the airplane becomes airborne and the air/ground relay senses that the airplane is off the ground.

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.

The cargo doors on the B-747 have a master latch lock handle installed on the exterior of the door.

The handle is opened and closed manually. The master latch lock handle simultaneously controls the operation of the latch lock sectors, which act as locks for the latch cams, and the two pressure relief doors located on the door. Figure 5 depicts a lock sector and latch cam in an unlocked and locked condition.

Figure 4.--Boeing 747 lower lobe forward cargo door.

Figure 5.--Cargo door latch cam and lock sector in unlocked and locked positions.

The door has three electrical actuators for opening/closing and latching of the door. One actuator (main actuator) moves the door from the fully open position to the near closed position, and vice versa. A second actuator (pull-in hook actuator) moves the pull-in hooks closed or open, and the third actuator (latch actuator) rotates the latch cams from the unlatched position to the latched position, and vice versa. The latch actuator has an internal clutch, which slips to limit the torque output of the actuator.

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.

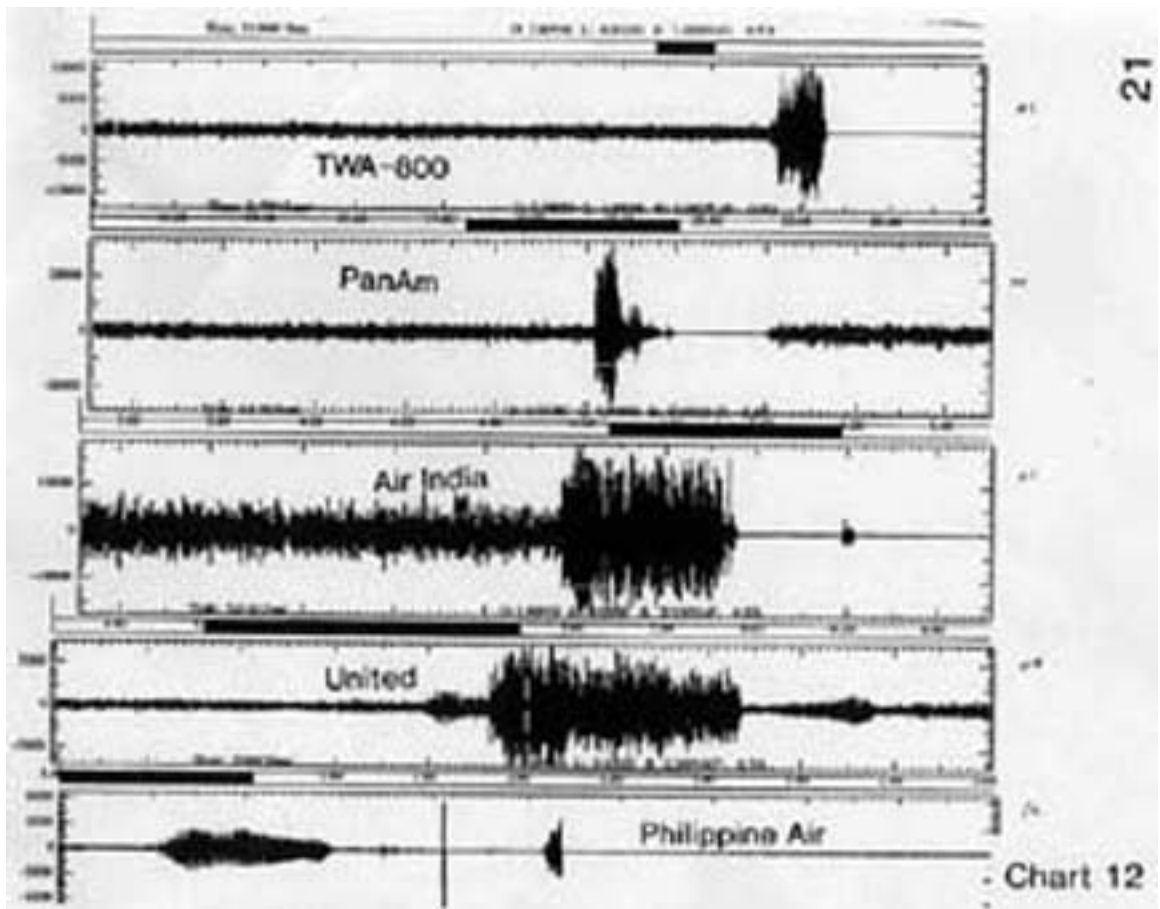
The final securing operation is the movement of lock sectors across the latch cams. These are manually moved in place across the open mouth of each of the eight lower cams through mechanical linkages to the master latch lock handle. The position of the lock sectors is indicated indirectly by noting visually 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 B-747 cargo door has eight (8) view ports located beneath the latch cams for direct viewing of the position of the cams by means of alignment stripes. Procedures for using these view ports for verifying the position of the cams were not in place or required by Boeing, the FAA, or UAL (see 1.17.5 for additional information).

Closing the door manually is accomplished through the same sequence of actions without electrical power. The door actuator mechanisms are manually driven to a closed and latched position by the use of a one-half inch socket driver. The door can also be opened manually with the use of the socket driver. There are separate socket drives for the door raising/lowering mechanism, the pull-in hooks, and the latches.



Caption for above photograph: United Airlines Boeing 747 in colors of 1989 with normally closed forward cargo door.



Caption for above Chart: Chart 12 from Public Docket for Trans World Airlines Flight 800 comparing the sudden loud sounds from Trans World Airlines Flight 800, Pan Am Flight 103, Air India Flight 182, United Airlines Flight 811 and a Boeing 737.



Caption for above drawing: Sensational artist's impression on cover of June 1989 Popular Mechanics showing United Airlines Flight 811 as it descends to land after inadvertent opening of forward cargo door in flight.



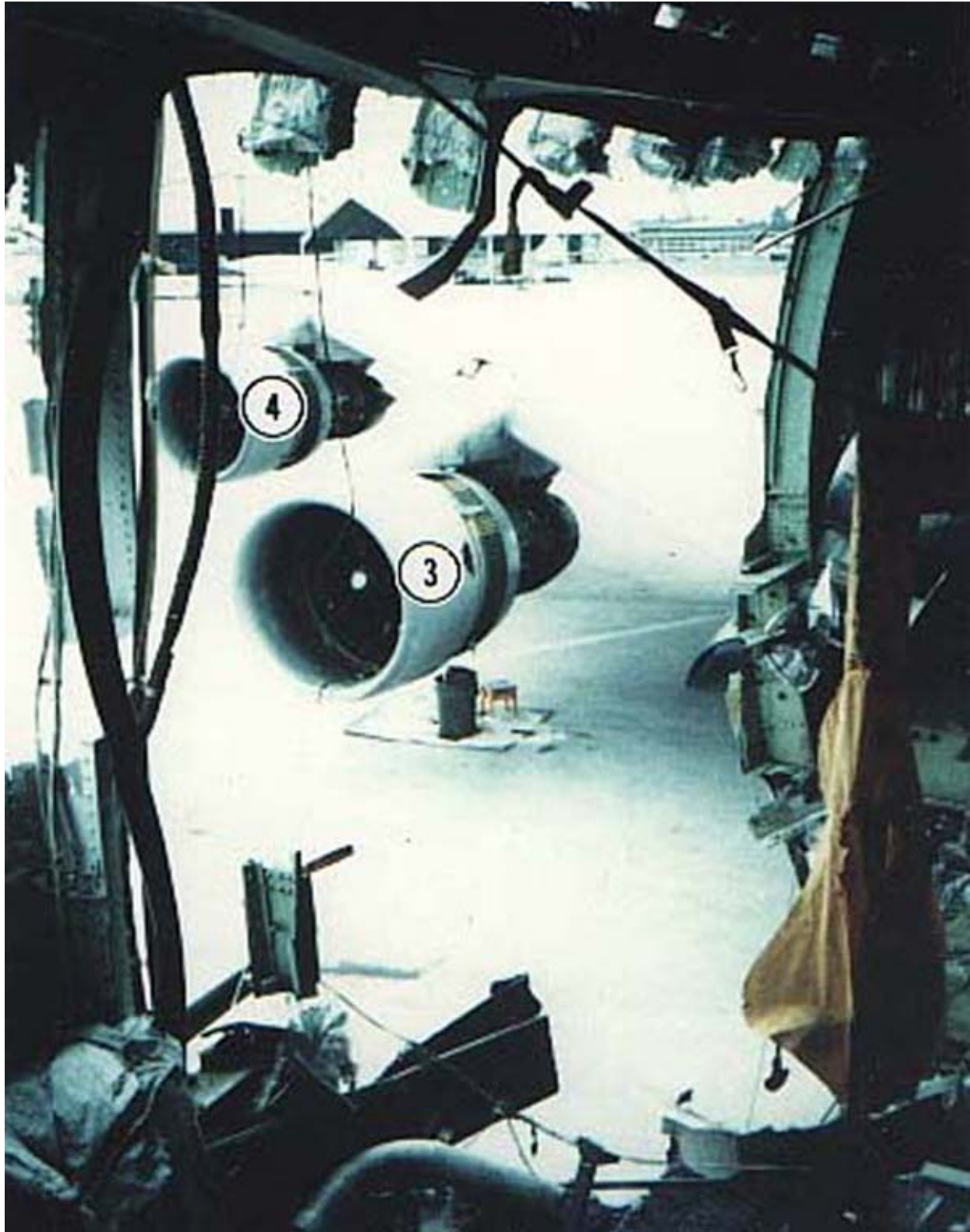
Caption for above photograph: Photo of hole in United Airlines Flight 811 made by inadvertent opening of forward cargo door in flight.



Caption for above photograph: Photo of hole in United Airlines Flight 811 made by inadvertent opening of forward cargo door in flight.



Caption for above photograph: Photo from NTSB AAR 92/02 of hole in United Airlines Flight 811 made by inadvertent opening of forward cargo door in flight.



Caption for above photograph: Photo from inside United Airlines Flight 811 showing the hole caused by by inadvertent opening of forward cargo door in flight revealing engine numbers three and four which received the ejected foreign objects and caused the fire and internal engine damage.

## Sea surrenders Flight 811 culprit



Navy photo by Omar Hasan

The bottom half of the cargo door from United Flight 811 is examined on board a Navy contract support ship after it was retrieved from a depth of nearly three miles. The crew of the mini-sub Sea Cliff hopes to recover the top half this weekend. See story on Page A3.

Caption for above photograph: Photo of newspaper article and photograph showing the lower half of retrieved forward cargo door, loose wiring, the longitudinal split at midspan latches, and the peeled away skin from the aft midspan latch.



Caption for above photograph: Photo from NTSB AAR 92/02 for United Airlines Flight 811 showing both halves of the retrieved door, the longitudinal split at midspan latches, and the peeled away skin from the aft midspan latch.



Caption for above photograph: Photo from NTSB AAR 92/02 for United Airlines Flight 811 showing bottom half of the retrieved door, the longitudinal split at midspan latches, and the peeled away skin from the aft midspan latch.

United Airlines Flight 811:

"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. NTSB Accident Report 92-02 Page 25

United Airlines Flight 811:

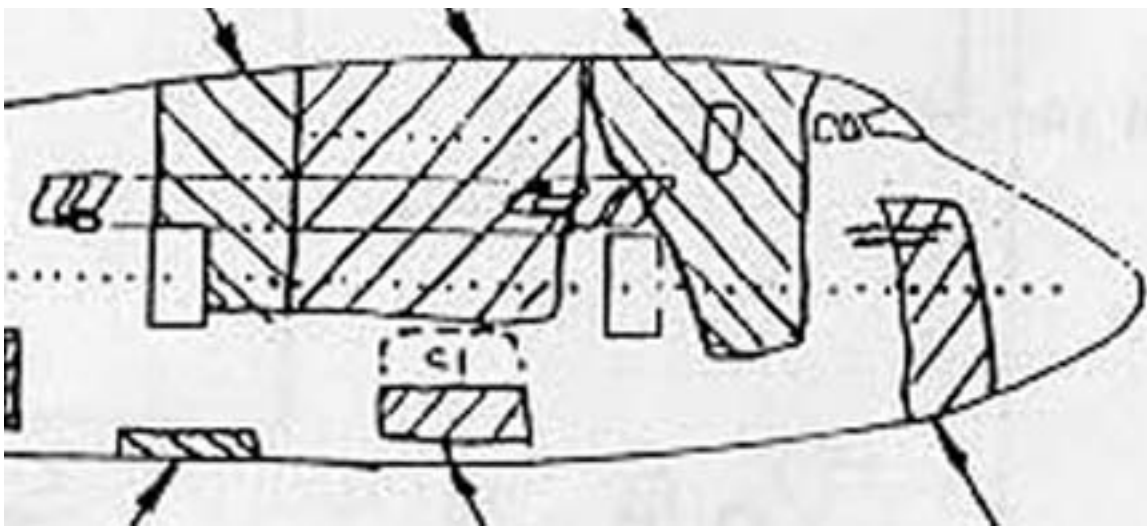
"However, the decompression event caused a data loss of approximately 2 1/2 seconds. When the data resumed being recorded, all values appeared valid with the exception of the pitch and roll parameters. Lateral acceleration showed a sharp increase immediately following the decompression. Vertical acceleration showed a sharp, rapid change just after the decompression and a slight increase as the airplane began its descent." NTSB AAR 92/02. page 25

Regarding United Airlines Flight 811 from NTSB AAR 92/02 to explain the above evidence:

'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. Contributing to the cause of the accident was a deficiency in the design of the cargo door locking mechanisms, which made them susceptible to deformation, allowing the door to become unlatched after being properly latched and locked.'



Caption for above photograph: Photograph of Air India Boeing 747.



Caption for above drawing: Reconstruction drawing from the Kirpal Report and the CASB report on Air India Flight 182 showing the longitudinal split of the forward cargo door and the vertical tearing of the skin above the door.

From the Kirpal report:

"2.11.4.6 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."

"After lunch with them I [Mr. Campbell] asked " in light of what we now know on 811 do you still think that Air India was a bomb ?"

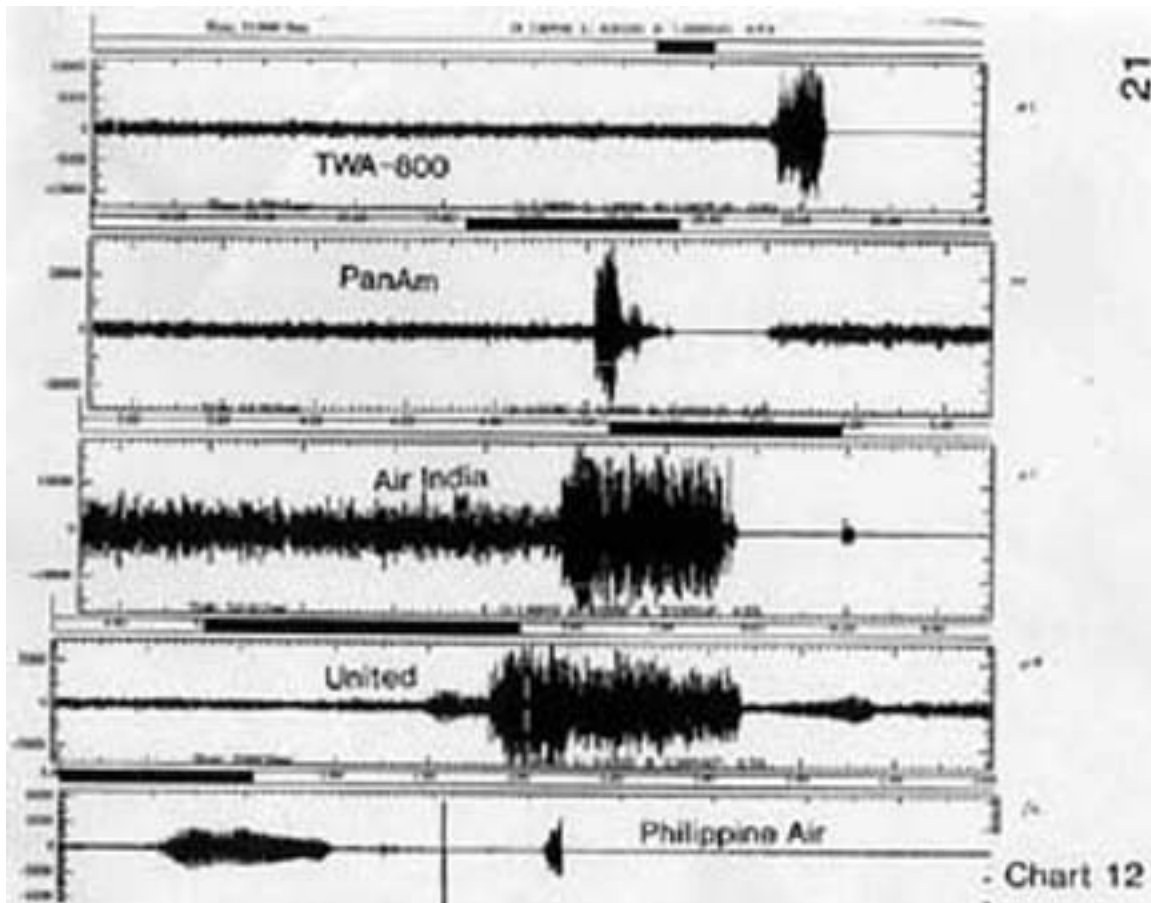
The reply was that we [NTSB] never thought that Air India was a bomb in fact the video shows a cargo door exactly the same as 811. I [Mr. Campbell] wrote to both Air India and the Canadian Safety Board with my findings on 811 but did not even have the courtesy of a reply ."

Caption for above text: Quote from correspondence of Mr. and Mrs Campbell discussing comments from NTSB officials matching United Airlines Flight 811 forward cargo door to Air India Flight 182 forward cargo door.

B737, and a gun shot on the flight deck of a B737 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.

Caption for above text:

Excerpt from the Kirpal report and CASB report on Air India Flight 182 giving an explanation for the sudden loud sound which matches an explosive decompression open cargo door event on a DC-10, a widebody passenger airliner.



Air India Flight 182:

"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

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

#### 4.0 CONCLUSIONS

The Canadian Aviation Safety Board respectfully submits as follows:

##### 4.1 Cause-Related Findings

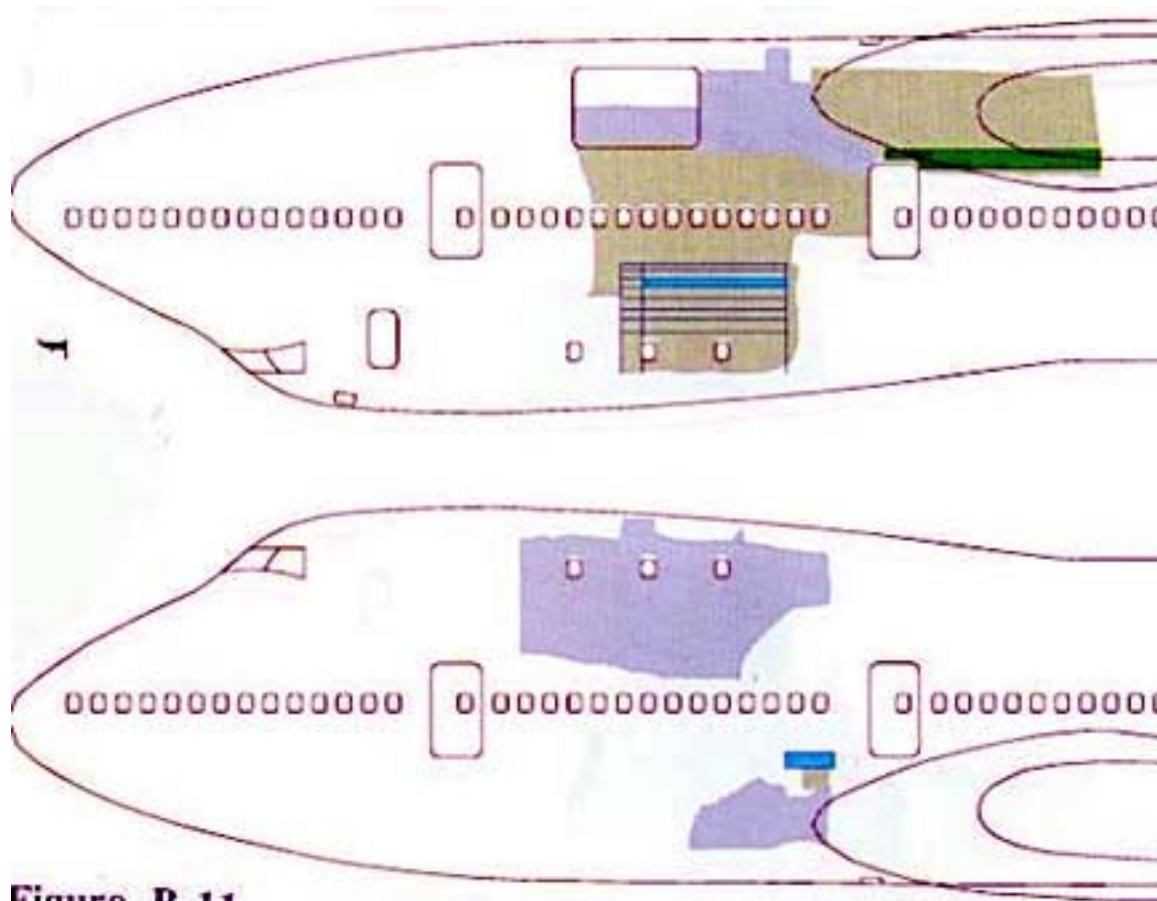
1. At 0714 GMT, 23 June 1985, and without warning, Air India Flight 182 was subjected to a sudden event at an altitude of 31,000 feet resulting in its crash into the sea and the death of all on board.
2. The forward and aft cargo compartments ruptured before water impact.
3. The section aft of the wings 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.



Caption for above photograph: Pan Am 747 showing colors of 1988 and open forward cargo door.



Caption for above photograph: Staged bombing of a Boeing 747 at Bruntingthorpe UK showing the massive damage which occurs when a real bomb goes on in a Boeing 747.



**Figure B-11**

Caption for above photograph: Figure B11 from AAIB 2/90 for Pan Am Flight 103 showing initial event time fuselage destruction with small 'bomb' hole rectangle and huge rectangular destruction around forward cargo door.



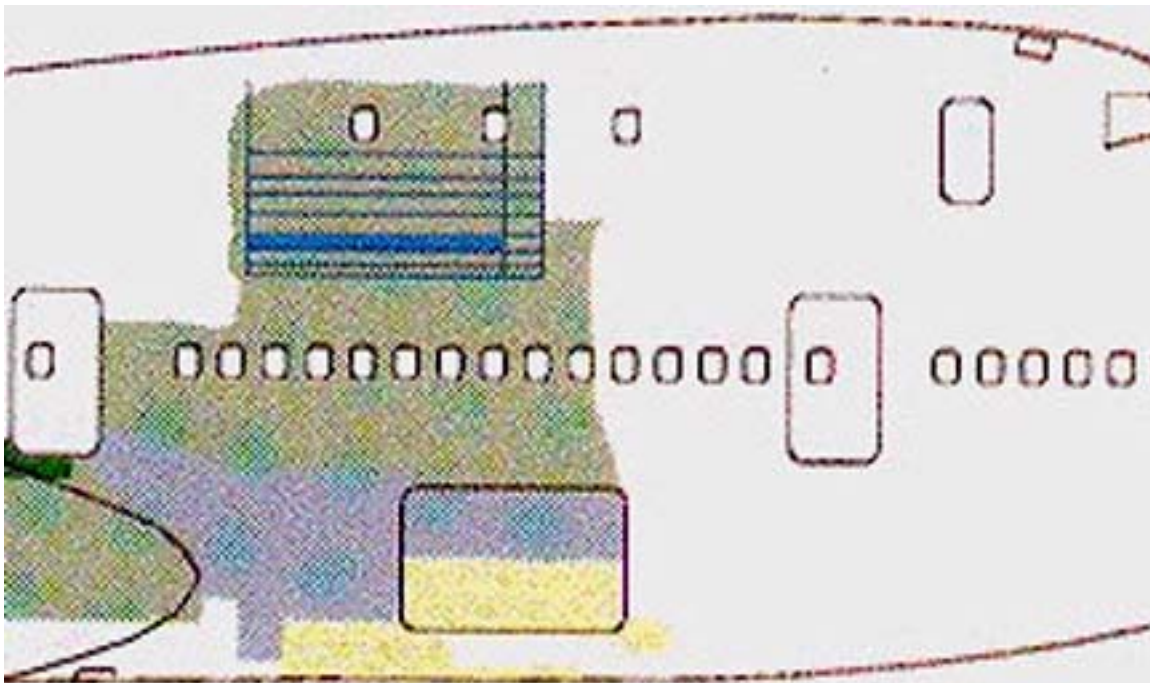
Caption for above photograph: Port side of Pan Am Flight 103 forward of the wing showing the small 'bomb' hole and relatively smooth and intact fuselage skin around it.



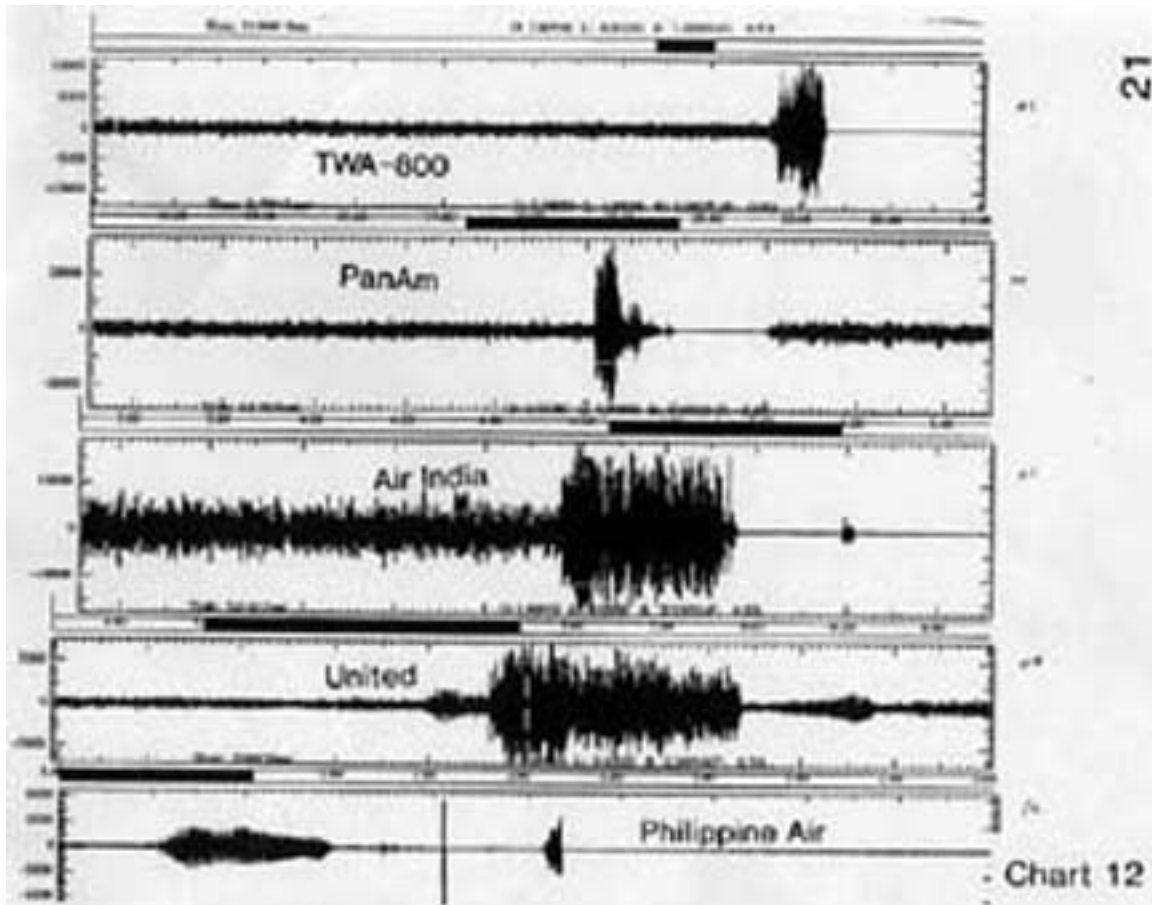
Caption for above photograph: Photograph from AAIB showing Pan Am Flight 103 forward cargo door area revealing the vertical torn skin above door, peeled back skin from the aft midspan latch, generally shattered area, and mostly missing lower half of door which includes the manual locking handle and the eight bottom latches.



Caption for above photograph: Closeup of the peeled back skin from the aft midspan latch of the forward cargo door of Pan Am Flight 103.



Caption for above drawing: Reconstruction drawing from the AAIB 2/90 report on Pan Am Flight 103 showing the large area of torn off skin around the forward cargo door, the longitudinal split of the door, and the vertical tearing of the skin above the door.



#### Pan Am Flight 103:

"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

#### Pan Am Flight 103:

"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 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'



Caption for above photograph: Photograph of Trans World Airlines Boeing 747 in 1996 colors.



Caption for above photograph: Photograph of the port side of Trans World Airlines Flight 800 showing the relative undamaged skin forward of the wing.

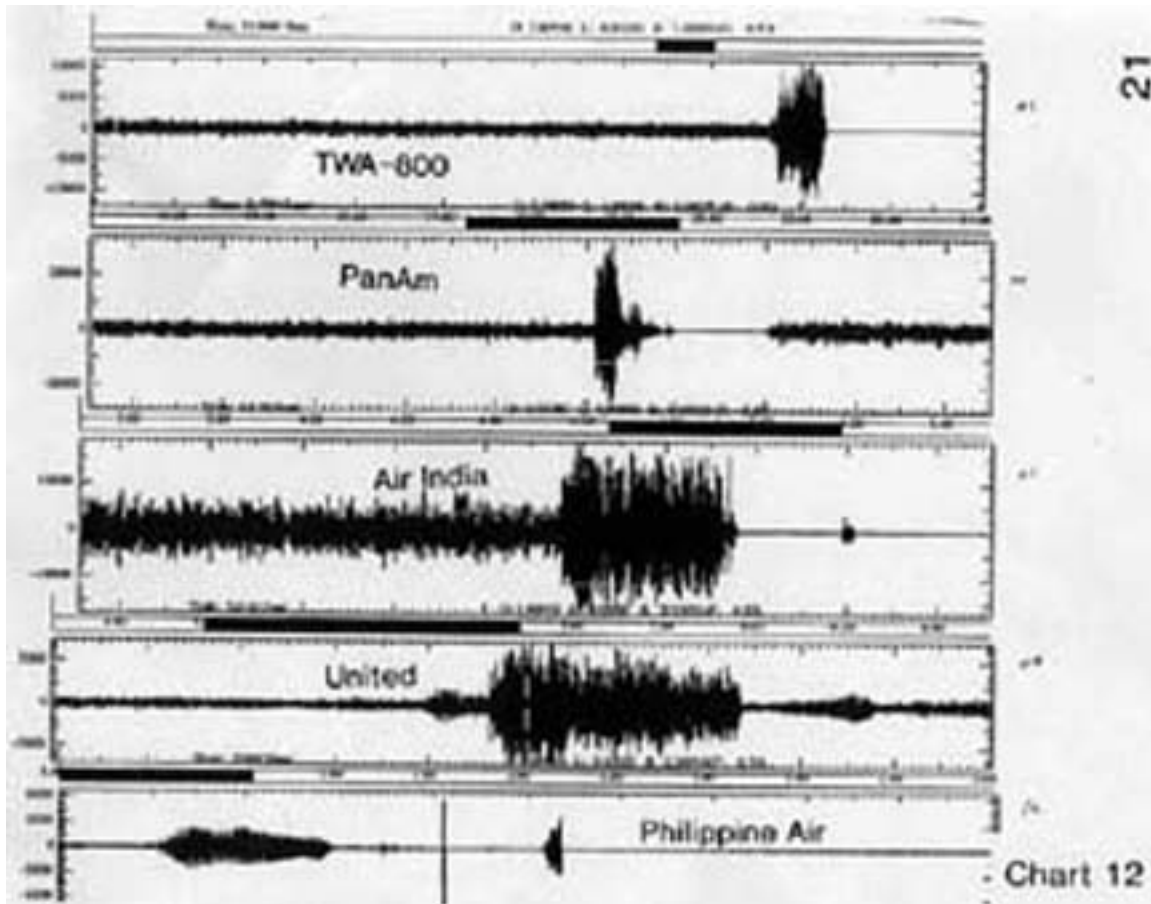


Caption for above photograph: Shattered starboard side around forward cargo door of Trans World Airlines Flight 800 revealing outwardly and petaled shaped skin around aft midspan latch.



Caption for above photograph: Photograph showing outwardly and petaled shaped skin around forward midspan latch.

3. Docket Number SA-516, 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."



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. The accident airplane's last recorded radar transponder return occurred at 2031:12, and a review of the FDR data indicated that the FDR lost power at 2031:12. '

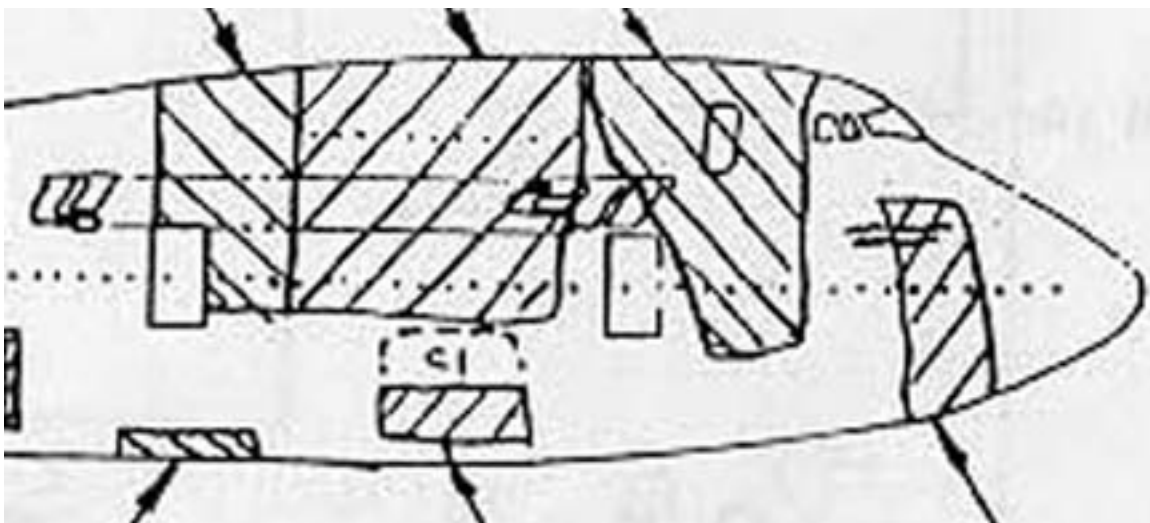
Caption for above text: From NTSB AAR 00/03 for Trans World Airlines Flight 800.

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.

Four aircraft and four forward cargo door areas:



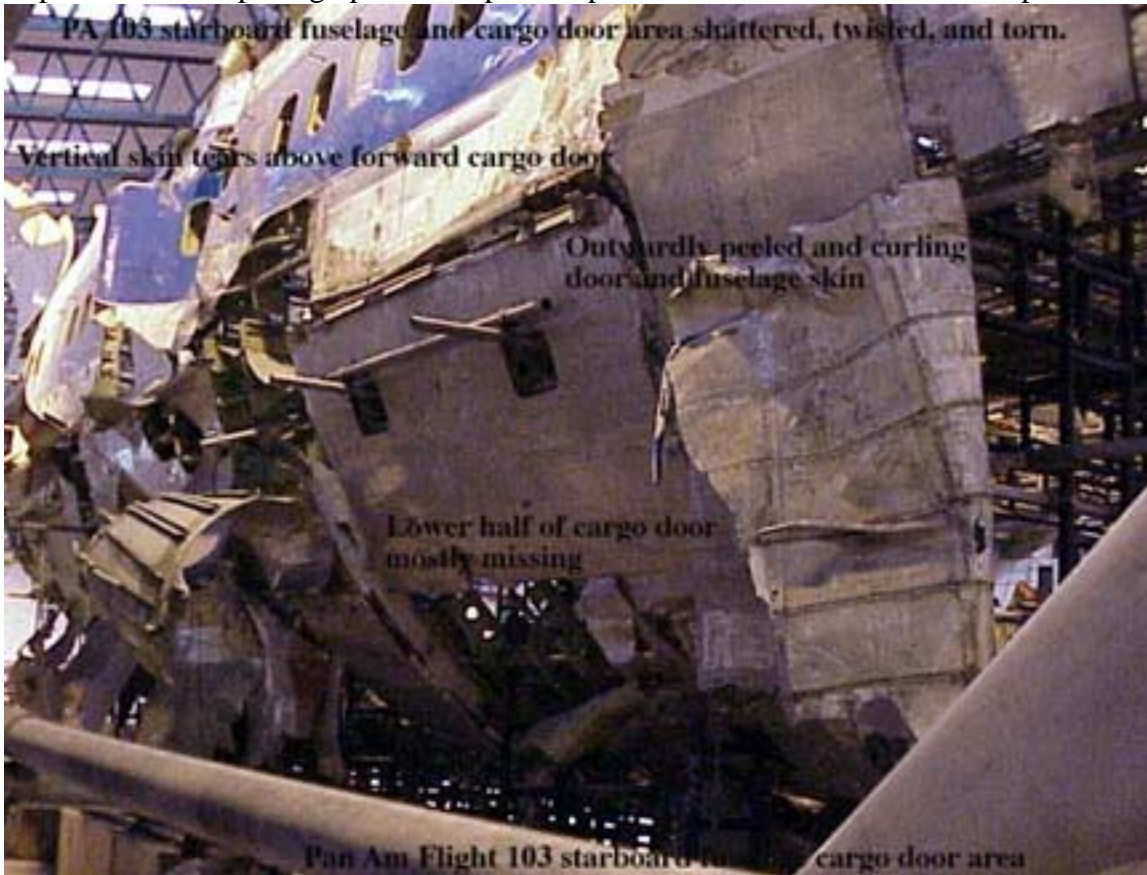
Caption for above photograph: Photo from NTSB AAR 92/02 for United Airlines Flight 811 showing bottom half of the retrieved door, the longitudinal split at midspan latches, and the peeled away skin from the aft midspan latch.



Caption for above drawing:  
Reconstruction drawing from the Kirpal Report and the CASB report on Air India Flight 182 showing the longitudinal split of the forward cargo door and the vertical tearing of the skin above the door.



Caption for above photograph: Closeup of the peeled back skin from the aft midspan latch PA 103



Caption for above photograph: Photograph from AAIB showing Pan Am Flight 103 forward cargo door area revealing the vertical torn skin above door, peeled back skin from the aft midspan latch, generally shattered area, and mostly missing lower half of door which includes the manual locking handle and the eight bottom latches.



Caption for above photograph: Shattered starboard side around forward cargo door of Trans World Airlines Flight 800 revealing outwardly and petaled shaped skin around aft midspan latch.