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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

MAIN WRECKAGE FLIGHT PATH STUDY
(22 pages)

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Washington, DC

November 21, 1997

MAIN WRECKAGE FLIGHT PATH STUDY

By Dennis Crider

A. ACCIDENT: DCA-96-MA-070

Location:	East Moriches, New York
Date:	July 17, 1996
Time:	2031 Eastern Daylight Time
Airplane:	Boeing 747-131, N93119

B. GROUP IDENTIFICATION

No group was formed for this activity.

C. SUMMARY

On July 17, 1996, at 2031 EDT, a Boeing 747-131, N93119, crashed into the Atlantic Ocean, about 8 miles south of East Moriches, New York, after taking off from John F. Kennedy International Airport (JFK). The airplane was being operated on an instrument flight rules (IFR) flight plan under the provisions of Title 14, Code of Federal Regulation (CFR), Part 121, on a regularly scheduled flight to Charles De Gaulle International Airport (CDG), Paris, France, as Trans World Airlines (TWA) Flight 800. The airplane was destroyed by explosion, fire, and impact forces with the ocean. All 230 people aboard were killed.

D. DETAILS OF THE INVESTIGATION

SCOPE

The Trajectory Study covered the flight path of the wreckage items that separated from the main wreckage in the early portion of the breakup sequence up to the separation of the forward fuselage. This report covers the flight path of the main wreckage after separation of the forward fuselage.

EFFECT OF NOSE SEPARATION

The separation of the forward fuselage will result in large changes to the aerodynamic and mass property characteristics of the aircraft. The center of gravity will shift aft, the weight will go down, and the aircraft moments of inertia will be reduced. The mass properties as estimated by Boeing are summarized in the following table.

Parameter	Before Nose Separation	After Nose Separation
Gross Weight (lbs.)	574000	494606
C.G. %MAC	21.1	57.8
Iyy slug-ft^2	27790000.0	15780000.0
Ixx slug-ft^2	19110000.0	18970000.0

One aerodynamic effect of the loss of the forward fuselage is the loss of the aerodynamic loads on the forward fuselage itself. A second aerodynamic effect will be due to the replacement of the smooth forward fuselage with a blunt open front. This will result in a direct increase in drag but will also effect the flow around the inboard wing. The changes in the longitudinal aerodynamic coefficients (lift, drag and pitching moment) due to the separation of the forward fuselage were estimated by Boeing and are presented in figures 1, 2, and 3. Flight control positions are assumed to remain at their pre nose-off positions.

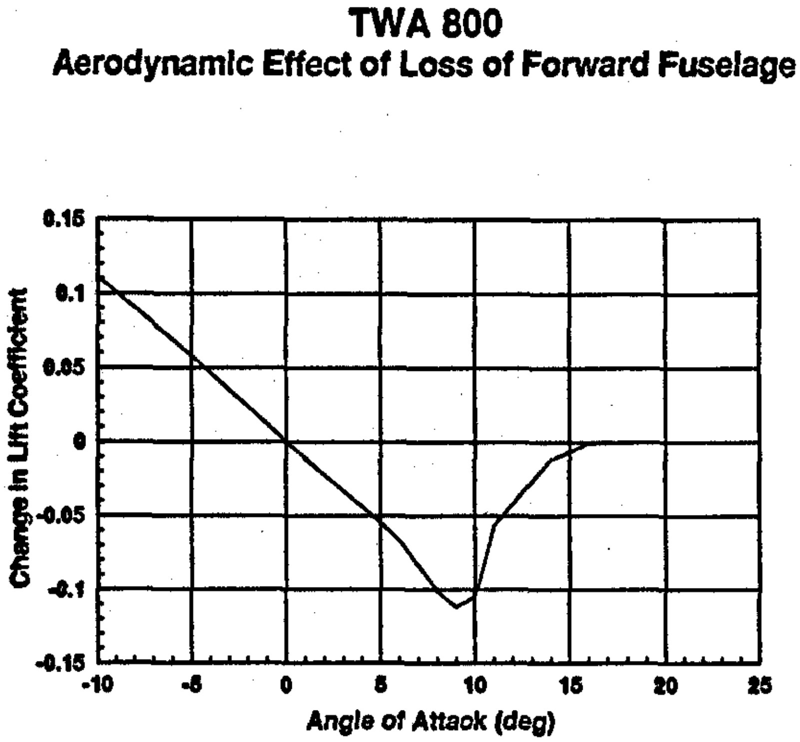
TWA 800
Aerodynamic Effect of Loss of Forward Fuselage
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
Change in Lift Coefficient
-10
-5
0
5
10
15
20
25
Angle of Attack (deg)

Figure 1

3

TWA 800
Aerodynamic Effect of Loss of Forward Fuselage

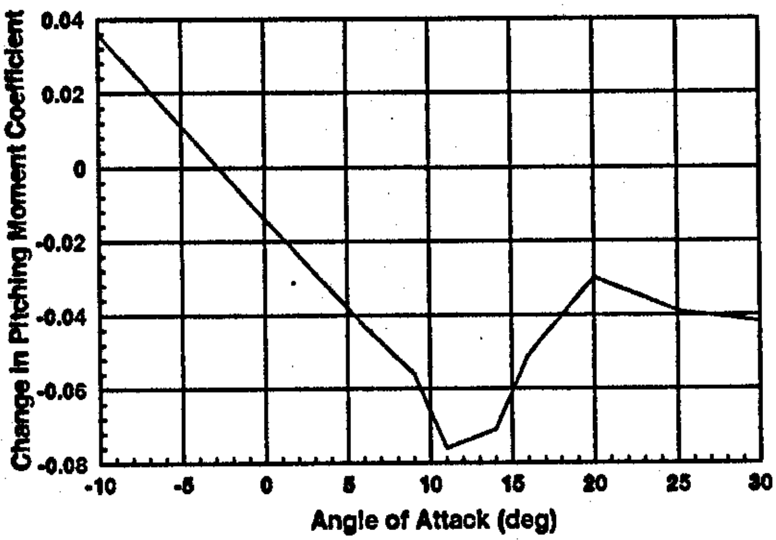

Figure 2

4

TWA 800
Aerodynamic Effect of Loss of Forward Fuselage

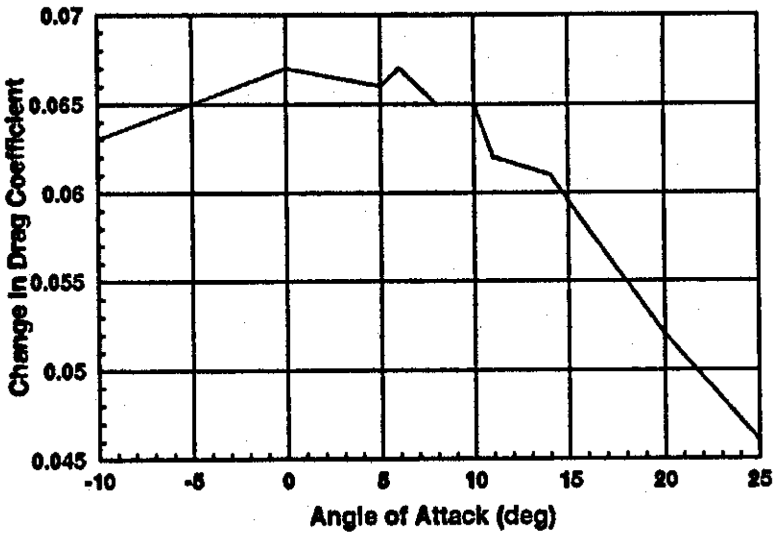

Figure 3

LONGITUDINAL SIMULATION

A longitudinal motion only simulation of the main wreckage was performed initially using the Safety Board's simulation code. Thrust, mass and longitudinal aerodynamic characteristics for a 747-100 were coded into the user model routines within the simulation. After a fixed simulation time, the aerodynamic model switched from the basic 747-100 aerodynamic data tables to the forward fuselage off data tables. At the same time the mass properties switched to their forward fuselage off values.

The aircraft was trimmed to the last FDR recorded altitude, airspeed and climb angle (indirectly through pitch angle) and then flown forward without control input. Running a power off, a power full and a trim power case investigated the effect of engine power. At 8:31:16 seconds (748 sec elapsed time), the simulation switched to the forward fuselage off data tables and mass properties. The resulting longitudinal only simulation flight is presented in figures 4 through 9. As can be seen, the effect of power is small.

TWA 800
Main Wreckage Simulation
Longitudinal Motion Only

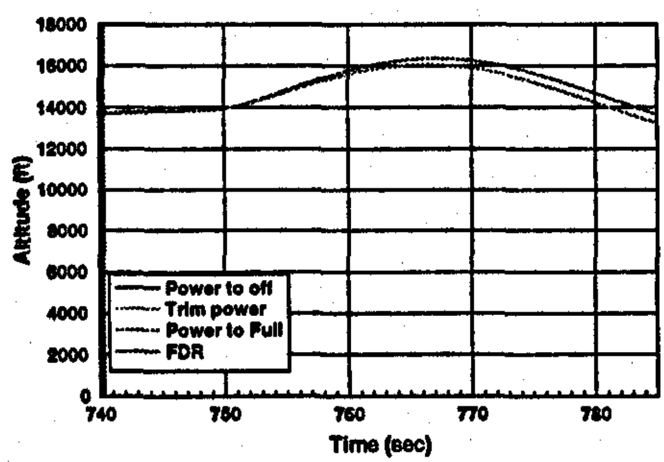

Figure 4

6

TWA 800
Main Wreckage Simulation
Longitudinal Motion Only

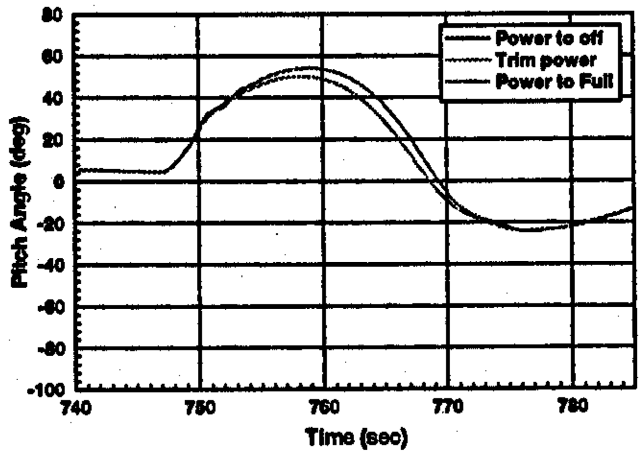

Figure 5

TWA 800
Main Wreckage Simulation
Longitudinal Motion Only

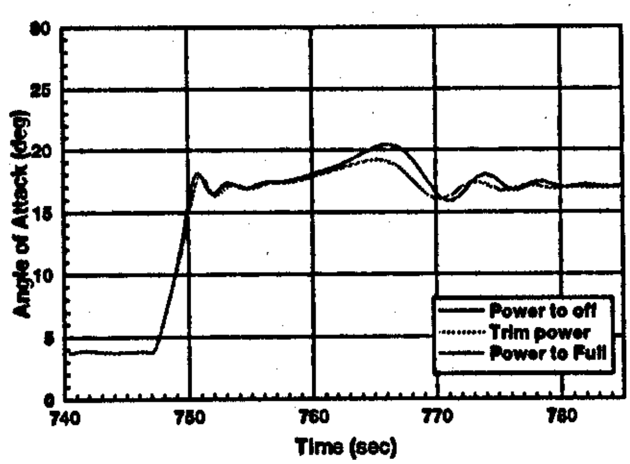

Figure 6

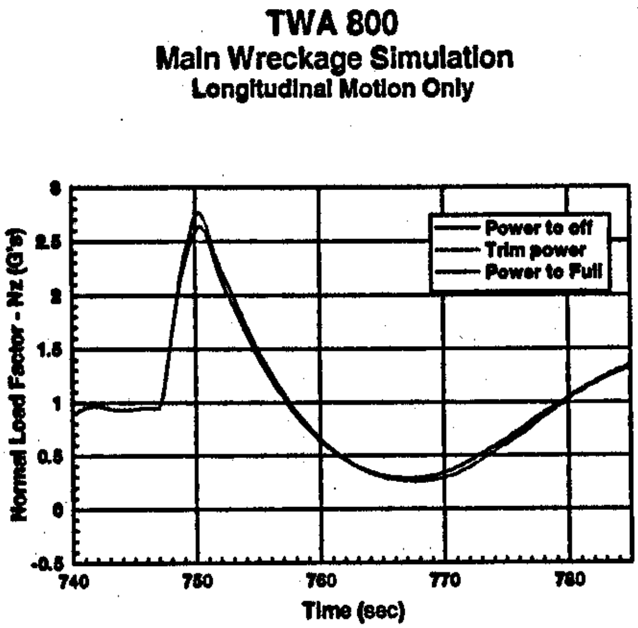

Figure 7

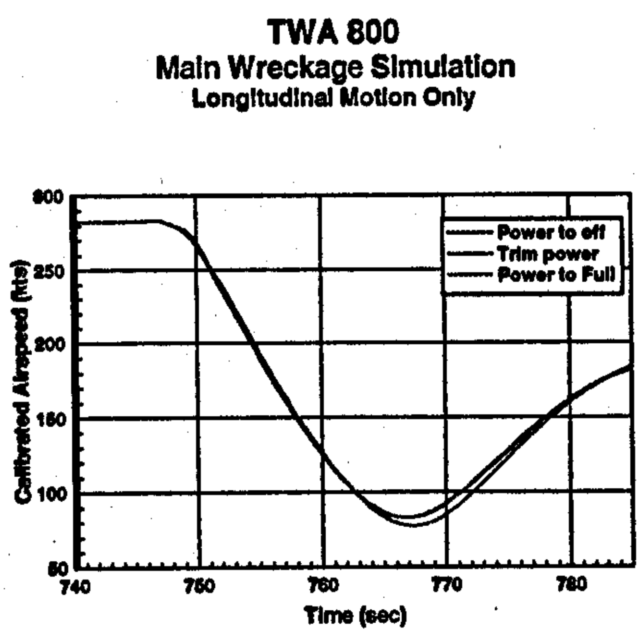

Figure 8

(8)

TWA 800
Main Wreckage Simulation
Longitudinal Motion Only

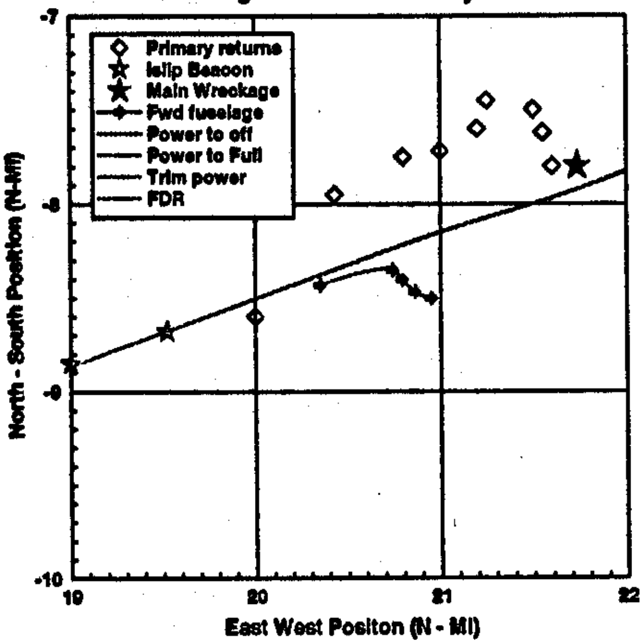

Figure 9

GROUND TRACK SIMULATION

The longitudinal only simulation clearly shows the pitch up and exchange speed for altitude response of the aircraft to the loss of the forward fuselage. However, as can be seen in figure 9, the radar data indicates that the aircraft turned North of the pre-event course line. The radar hits and recovery location of the main wreckage provide constraints which were used to add lateral motion to the simulation.

The longitudinal response of the aircraft also shows an increase in angle of attack into the stall region. The lateral/directional aerodynamics of the nose-off main body at stall angle of attack is difficult (if not impossible) to model reliably. An alternative approach was thus taken. Banking the aircraft to tilt the lift vector controlled ground track. Airspeed was controlled (to reach the radar points at the proper time) by incrementing pitching moment. A pitching moment increment was also applied to transition from the intact aircraft to the nose off aircraft data (to mirror the downward folding nose before separation).

The recovery position of wing tip components (the right wing tip itself was found floating in the water) and left wing requires that they be carried most of the way to the green zone by the crippled aircraft. The CIA witness statement analysis indicated that a fireball (thought to be associated with the separation of the left wing and resulting liberation of fuel) occurred 42 seconds after the center wing tank explosion. Therefore, at that time, the flying aircraft is replaced with a ballistic trajectory for the final seconds of "flight." The CIA witness analysis further indicated that water impact occurred 49 seconds after the initial explosion. The CIA witness analysis further indicated that there was an event near the apogee of the climb. This point was picked as the point to fail the engines. Since the effect of power has been determined to be small, this assumption should not significantly affect the results.

The radar primaries indicate a turn North followed by a turn to the South towards the main wreckage recovery site. Since there are areas of uncertainty about all radar points and an absence of altitude information, there are multiple solutions, which can fit the available data. Two approaches were explored.

1. A roll to the left followed by a right roll.
2. A left roll.

Both approaches used the following timeline of events.

CLOCK TIME	ELAPSED TIME	EVENT
8:31:12	743.77	Initial Event
8:31:13.4	747.0	Nose departure
8:31:51.4	785.0	Wing tip failure immediately followed bv left wing failure

At the time of the wing failure, the simulation of the main wreckage turns pure ballistic (drag only).

Dennis Crider

Dennis Crider
Aerospace Engineer Performance

Left bank then right roll

The results from the simulation iterations using the left bank followed by a right roll approach are given in figures 10 to 20.

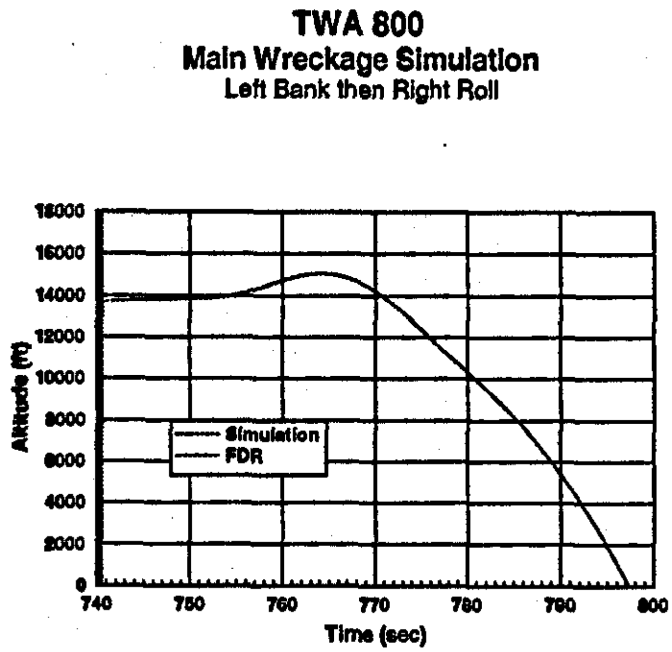

Figure 10

11

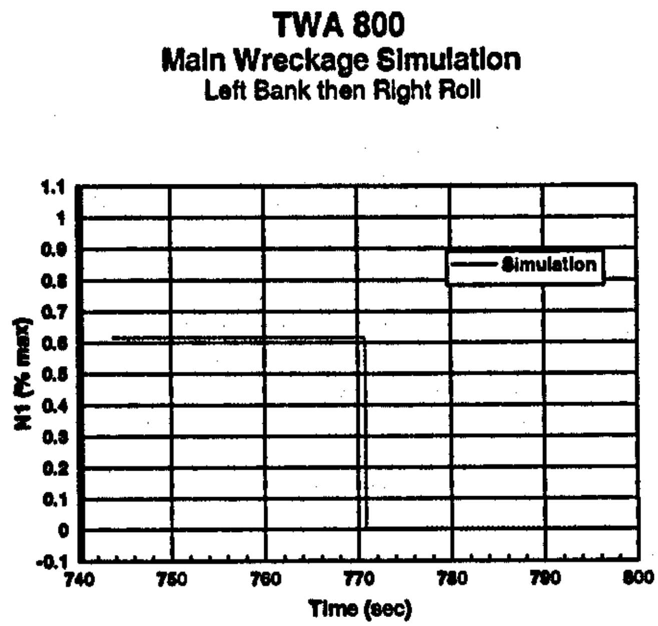

Figure 11

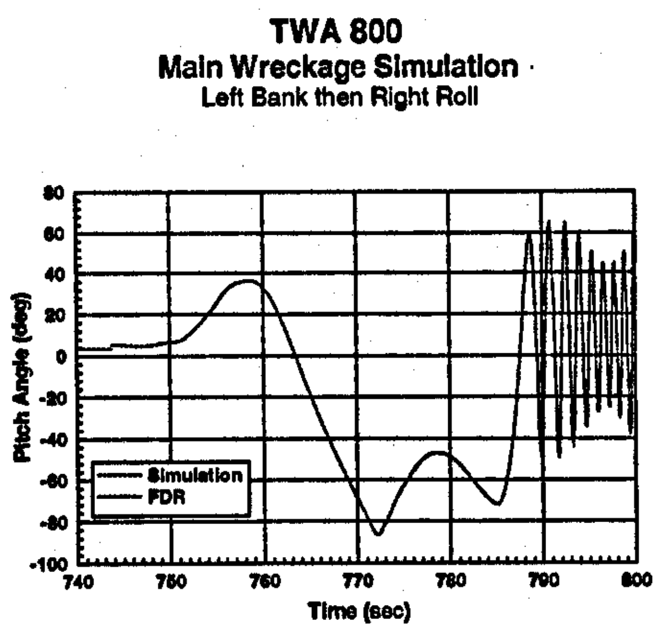

Figure 12

TWA 800
Main Wreckage Simulation
Left Bank then Right Roll

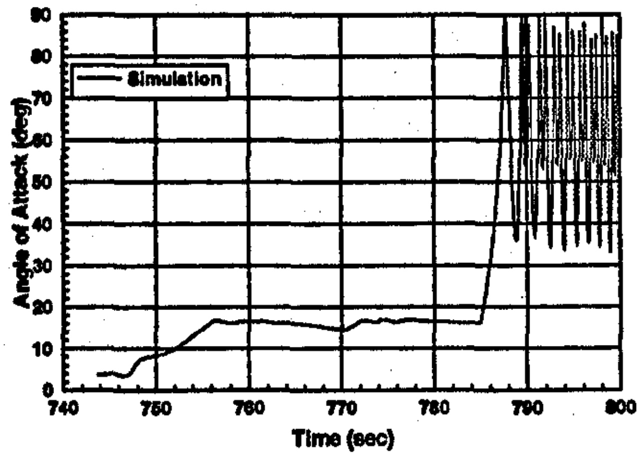

Figure 13

TWA 800
Main Wreckage Simulation
Left Bank then Right Roll

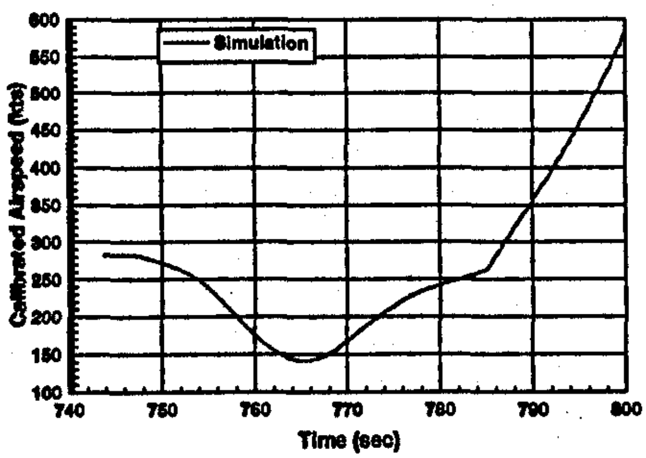

Figure 14

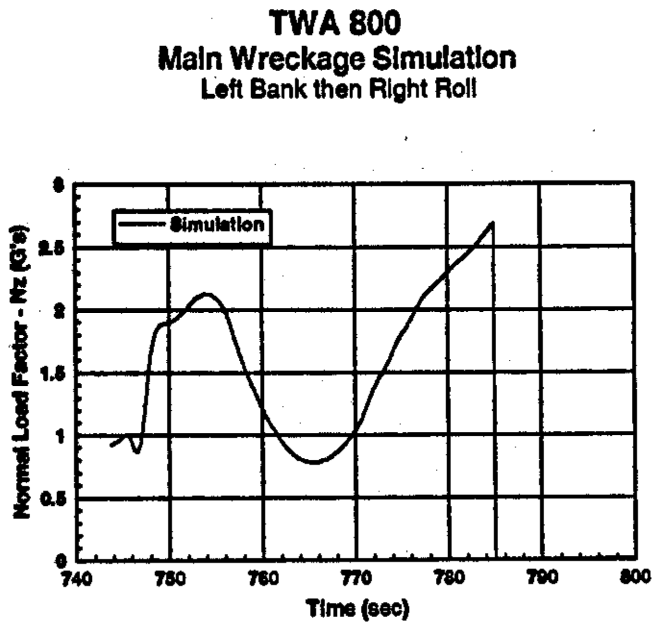

Figure 15

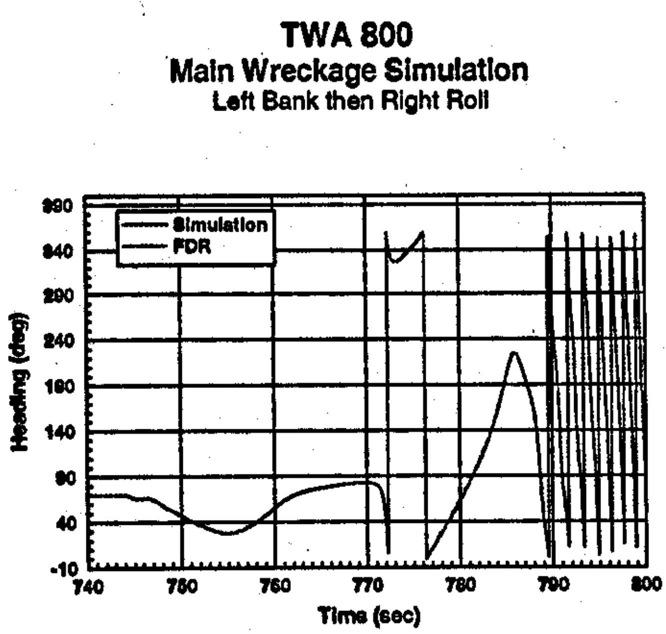

Figure 16

TWA 800
Main Wreckage Simulation
Left Bank then Right Roll

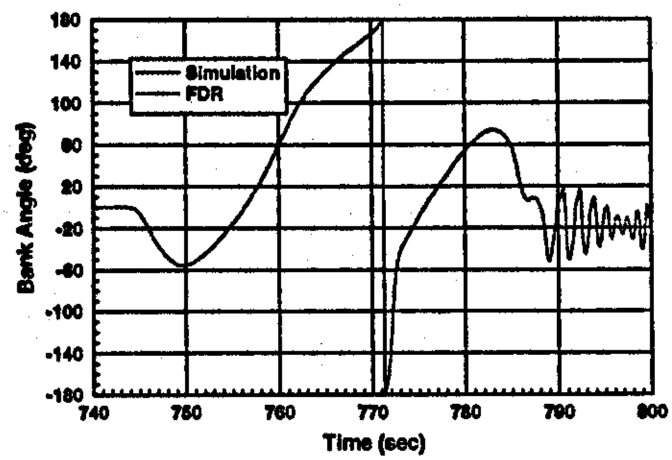

Figure 17

TWA 800
Main Wreckage Simulation
Left Bank then Right Roll

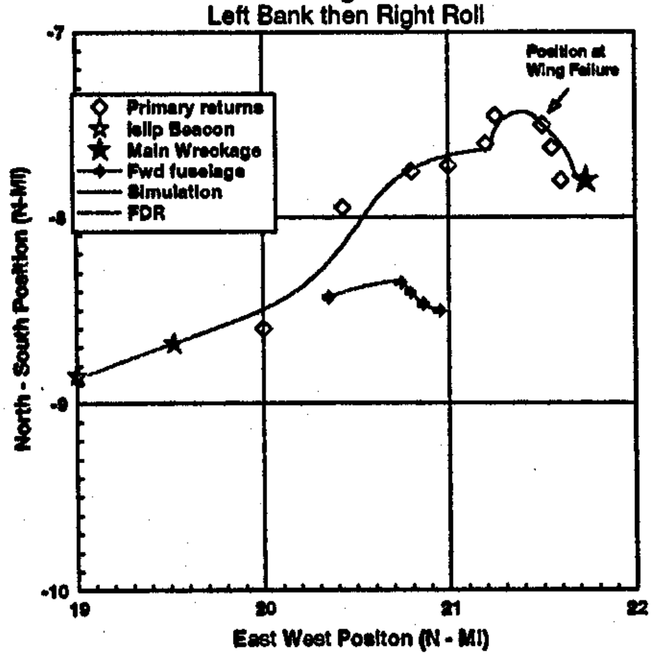

Figure 18

TWA 800
Main Wreckage Simulation
Left Bank then Right Roll

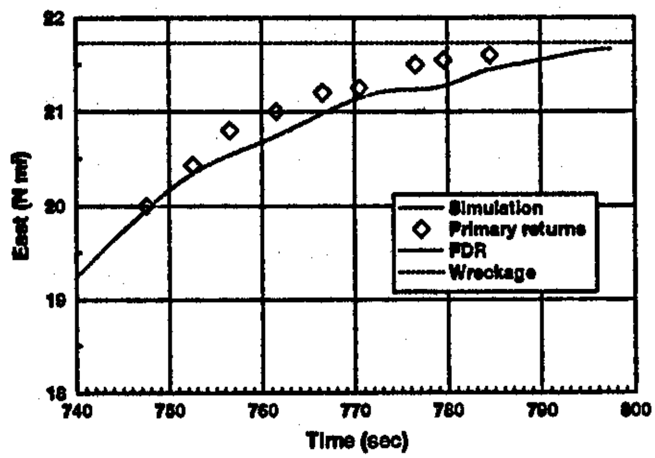

Figure 19

TWA 800
Main Wreckage Simulation
Left Bank then Right Roll

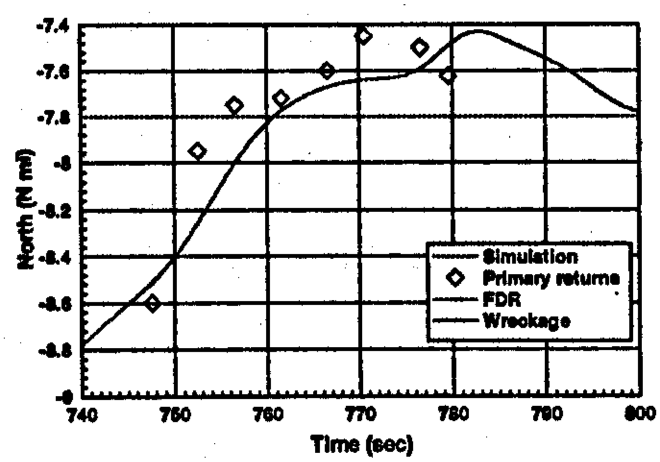

Figure 20

Left roll approach

The results from the simulation iterations using the left roll approach are given in figures 21 to

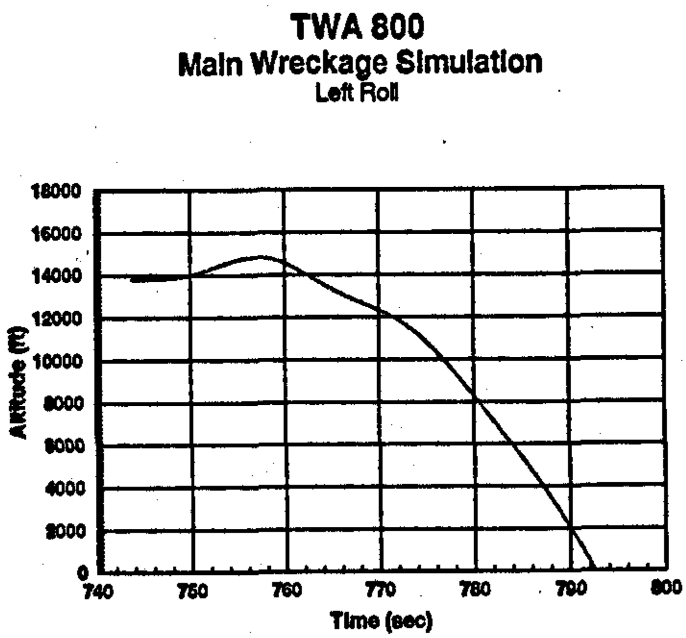

Figure 21

17

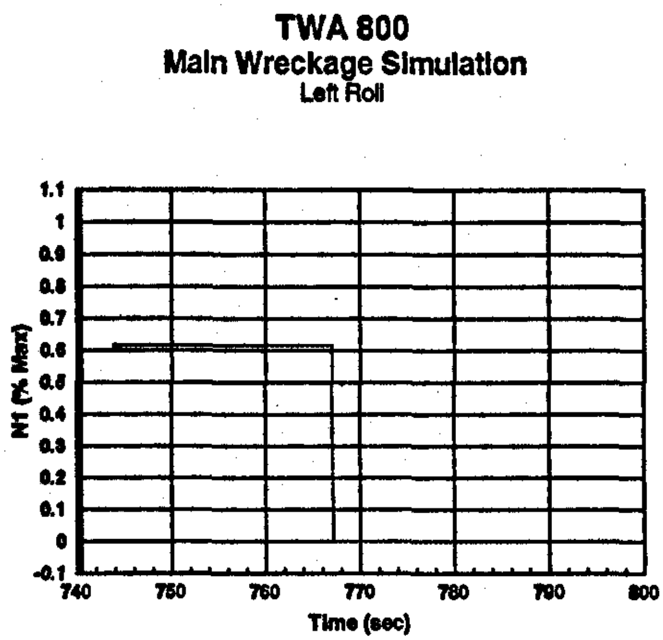

Figure 22

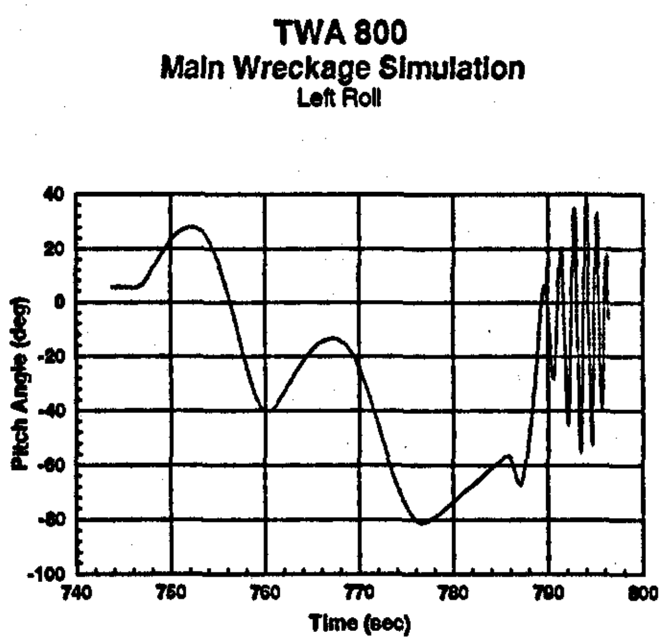

Figure 23

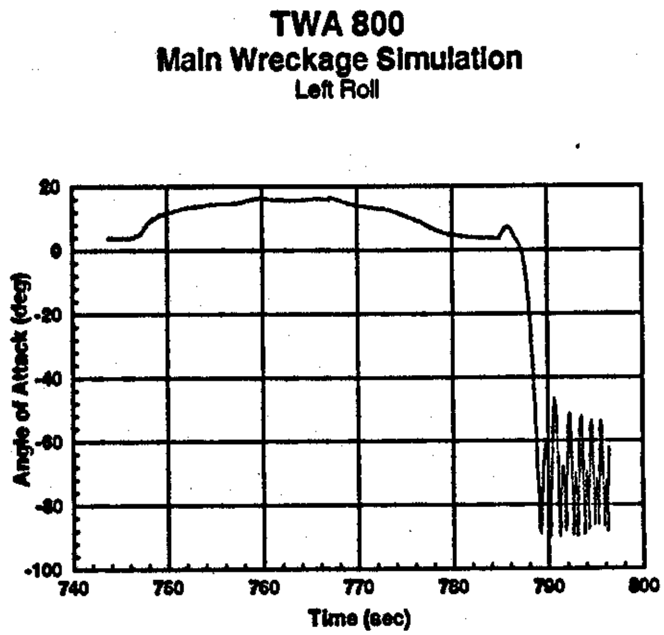

Figure 24

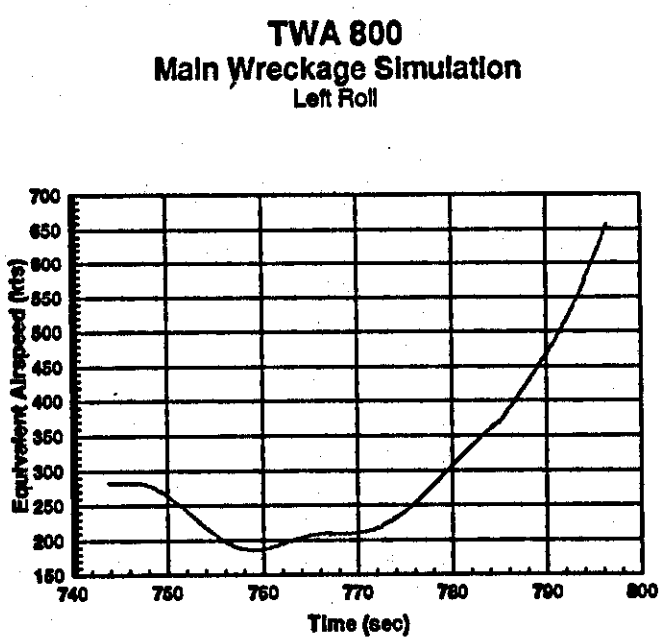

Figure 25

TWA 800
Main Wreckage Simulation
Left Roll

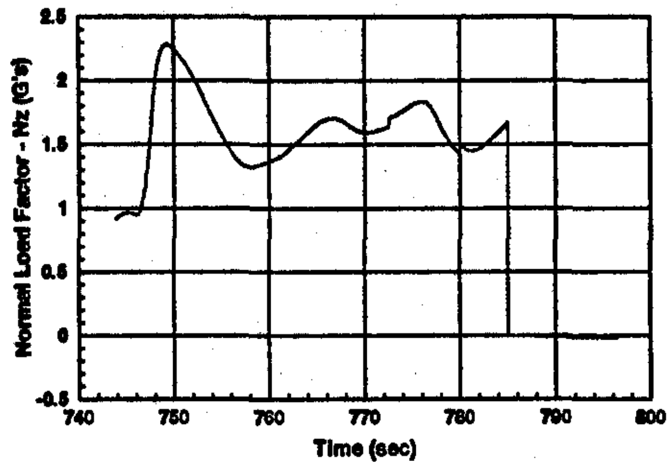

Figure 26

TWA 800
Main Wreckage Simulation
Left Roll

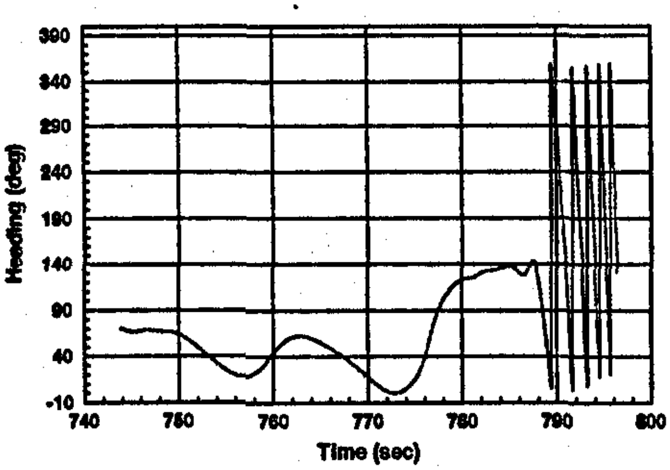

Figure 27

TWA 800
Main Wreckage Simulation
Left Roll

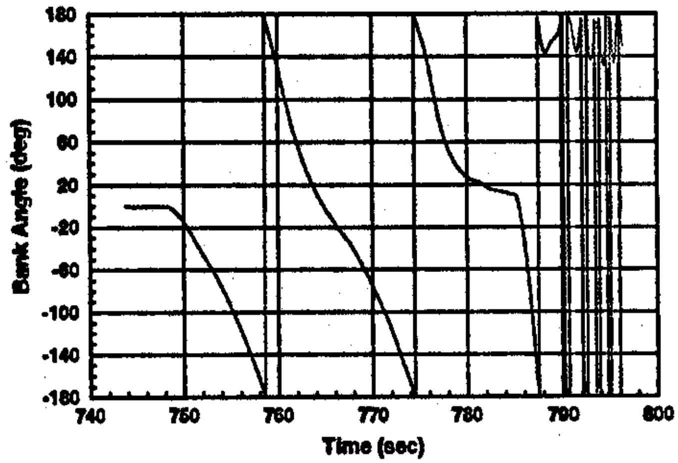

Figure 28

TWA 800
Main Wreckage Simulation
Left Roll

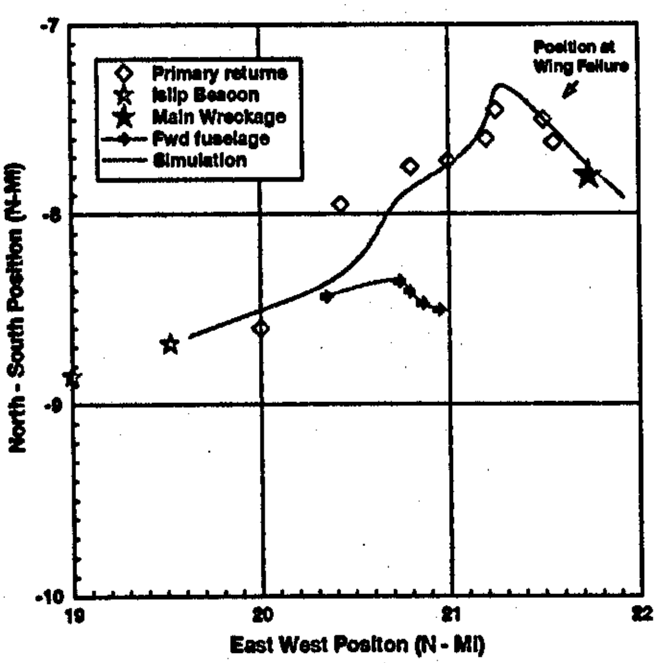

Figure 29

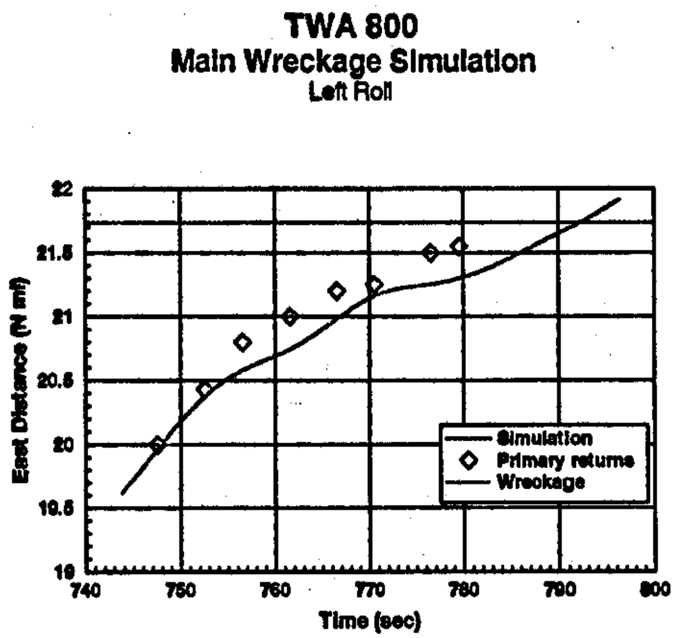

Figure 30

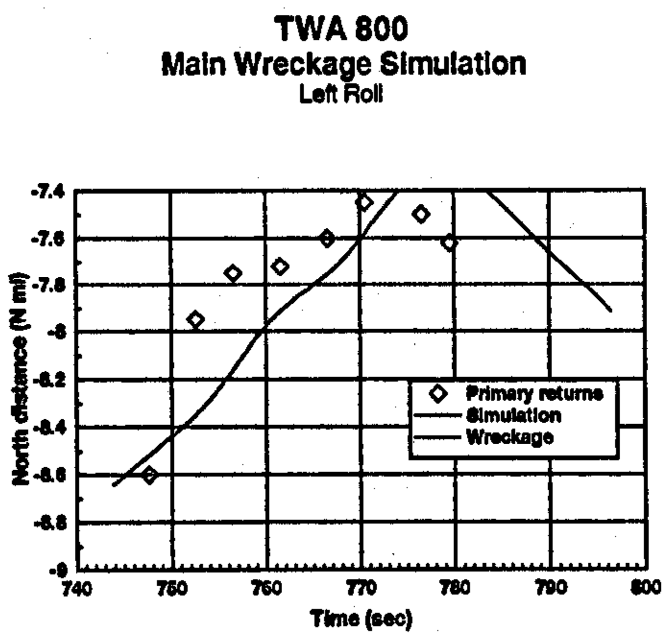

Figure 31