

BEFORE THE  
NATIONAL TRANSPORTATION SAFETY BOARD  
Washington, D.C.

- - - - -x  
In the matter of the investigation :  
of the accident involving :  
Trans World Airlines, Inc. :  
Flight 800, B-747-131, N93119, :  
8 miles south East Moriches, :  
New York on July 17, 1996 :  
- - - - -X

Baltimore Convention Center  
Halls A and B  
One West Pratt Street  
Baltimore, Maryland 21201-2499

Monday, December 8, 1997

The above-entitled matter came on for hearing  
pursuant to notice, at 9:00 a.m.

**APPEARANCES :**

Board of Inquiry:

Honorable Jim Hall Chairman	Member NTSB
Dr. Bernard Loeb	Director, Office of Aviation Safety
Dr. Vernon Ellingstad	Director, Office of Research and Engineering
Mr. Barry Sweedler	Director, Office of Safety Recommendations and Accomplishments
Mr. Dan Campbell	General Counsel

Technical Panel:

Thomas Haueter	Chief, Major Investigations Division
Al Dickinson	Investigator-in-Charge, Operations

Also Present:

Debra Eckrote  
Norman Wiemeyer  
Malcolm Brenner  
James Wildey  
John Clark  
Frank Hilldrup  
David Mayer  
But Simon  
Henry Hughes  
George Anderson  
Doug Wiegman  
Mitchell Garber  
Merritt Birky  
Dan Bower  
Dennis Crider  
Robert Swaim  
Charles Pereira  
Deepak Joshi  
Larry Jackson

Parties:

Lyle K. Streeter	Air Safety Investigator, Department of Transportation, FAA
Captain Jerome Rekart	Chief Accident Investigator, Air Line Pilots Association
Captain Robert Young	Director of Flight Operations Safety, Trans World Airlines
J. Dennie Rodrigues	Senior Air Safety Investigator, Boeing Commercial Airplane Group
Fred Liddell	Chief Investigator, International Association of Machinists and Aerospace Workers
Hal Thomas	Technical Engineer, Honeywell
Raymond Boushie	President, Hydro-Aire

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**EXH I B I T S**

<b>EXHIBIT NUMBER</b>	<b>DESCRIPTION</b>
17(a)	Mr. Jackson's report on the airplane reconstruction
18(a)	Sequencing report
18(b)	Sequencing report
15(C)	Report on eliminated factors
18(c)	Report on nose landing gear doors, etc.
15(b)	High/low velocity testing by Boeing

<b>Closing Statements:</b>	<b>Page</b>
None.	

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**PRO C E E D I N G S**

(Time Noted: 8:55)

CHAIRMAN HALL: Good morning. I would like to bring to order the National Transportation Safety Board public hearing into the accident involving TWA Flight 800 near East Moriches, Long Island.

On July 17th, 1996 a Boeing 747-131 operated by Trans World Airlines as Flight 800 to Paris exploded and crashed into the Atlantic Ocean about fourteen minutes after take-off from New York's John F. Kennedy International Airport. All 230 persons aboard lost their lives. While the shock of this event has slowly abated, the horror has not.

The National Transportation Safety Board launched the largest investigation in its history. Indeed, it is the largest investigation of a transportation accident in our nation's history. The Federal Bureau of Investigation began a parallel investigation to determine if the tragedy was a criminal act.

As you all know, the FBI has recently suspended its criminal investigation of the crash, and we are here in furtherance of the NTSB'S search not only for the cause of this accident, but even more importantly, for ways to make sure a tragedy such as

1 TWA 800 never occurs again.

2 It is difficult to put into words the  
3 enormity of this investigation. Besides the hundreds  
4 of employees from the NTSB and FBI who have worked on  
5 this every day for the last seventeen months, staffing  
6 and logistical resources from the Federal Aviation  
7 Administration, the United States Coast Guard, United  
8 States Navy, the Federal Emergency Management Agency,  
9 the CIA, Suffolk and Nassau Counties, the City of New  
10 York and the State of New York, as well as volunteers  
11 from the American Red Cross, selflessly devoted days,  
12 weeks and months to this investigation and to the  
13 public safety responsibilities associated with it.

14 Many of us are now familiar with the scope of  
15 the search and recovery effort that resulted in the  
16 identification and return of all 230 victims to their  
17 loved ones -- an unprecedented accomplishment -- and  
18 the salvaging of more than 95 percent of the aircraft  
19 from 120 feet under the ocean.

20 In the nine months of the recovery effort,  
21 there were 677 surface-supplied dives and 3,667 scuba  
22 dives, resulting in 1,773 hours of bottom time for the  
23 divers . That is the equivalent of 74 twenty-four hour  
24 days, and I hope all of you all can think with me and  
25 visualize the brave men and women who made those dives

1 under those conditions to recover the loved ones and  
2 the wreckage. We all owe them a debt of gratitude.

3 In addition, there were 376 remotely operated  
4 vehicle dives. Thirteen thousand trawl lines covering  
5 forty square miles gathered 20,000 underwater items.  
6 That is how we were able to recover from the bottom of  
7 the Atlantic Ocean pieces as small as a quarter.

8 That massive underwater activity permitted us  
9 to build the largest aircraft reconstruction in the  
10 history of civil aviation. Fully ninety-four feet of  
11 the 747's fuselage was rebuilt, including the center  
12 wing tank, the heaviest structural part of that  
13 airplane.

14 The reconstruction, absent the supporting  
15 structure, weighs about 60,000 pounds and consists of  
16 almost 900 pieces, not counting the center wing tank,  
17 which itself consists of over 700 pieces.

18 The reconstruction and detailed lab work  
19 enabled out investigators to determine the sequence of  
20 events from the initial fuel explosion to the ultimate  
21 destruction of Flight 800. You will hear a detailed  
22 report on those findings today.

23 While this effort was going on, the Safety  
24 Board participated in or conducted flight tests,  
25 explosion tests and laboratory examinations from

1 airfields in England to California, and labs in  
2 Tennessee, New Mexico, California, Colorado, Ohio and  
3 Washington State. You will learn the results of all of  
4 those studies during this hearing.

5 This investigation also includes the most  
6 extensive radar data study in the Board's history,  
7 including the review of several hundred thousand radar  
8 returns from nine locations in five states.

9 As you may know, the mystery of Flight 800  
10 has generated intense public interest. Among the more  
11 than 1,300 letters that my office alone has received on  
12 this accident are more than 500 letters from members of  
13 the public, from university professors to aviation  
14 enthusiasts to people who just think they have a good  
15 idea and wanted to help solve the mystery. I have  
16 directed that every letter be answered and all ideas  
17 explored.

18 The binders containing those letters are  
19 located behind me this morning. They include  
20 suggestions such as a smoker lit a cigarette in the  
21 lavatory and ignited fuel vapors; a mobile phone  
22 ignited gases in the air; if the crash was caused by  
23 weather events like a cyclone, lightning or wind shear;  
24 by bird strikes; by an exploding tire; by a cargo door  
25 opening; by a laser beam; by a bullet from a high-

1 powered rifle; by a malfunctioning fuel pump or vent;  
2 by contaminated fuel; by mechanical problems like bad  
3 rivet holes or failures in the cabin pressurization  
4 system; by metal fatigue; or even that the plane was  
5 just too heavy to stay in the air.

6           Some of these theories are just not possible.  
7 But, of those that were, I can assure you that we had  
8 already examined most of them, and we made sure we  
9 looked into all the rest. These letters were, for the  
10 most part, from people like you and me, well-meaning  
11 American citizens trying to help us get to the bottom  
12 of this tragedy, and I would like to tell them that I  
13 appreciate their willingness to write, their  
14 willingness to help and their interest in helping us  
15 solve the tragedy of TWA 800.

16           So far, the National Transportation Safety  
17 Board has obligated \$30 million of the taxpayers'  
18 dollars, not including the salaries and benefits for  
19 Safety Board personnel or any other federal employees  
20 involved in this event.

21           All of this in an effort to reach the two  
22 goals of this investigation -- learning the ignition  
23 source that sparked the fuel tank explosion, and I  
24 believe even more importantly finding the best means of  
25 reducing the likelihood of explosive fuel/air vapors

1 from accumulating in airliner fuel tanks. Because, in  
2 the final analysis, had the vapors in TWA Flight 800's  
3 fuel tank not been explosive, this accident would not  
4 have occurred, no matter what the ignition source.

5 During this week-long hearing, you will hear  
6 testimony on our efforts to find the ignition source.  
7 You will hear about the work designed to determine  
8 whether two possible external ignition sources could  
9 have been involved -- a small explosive charge or a  
10 high-speed particle such as a fragment from a missile,  
11 space junk or even a meteorite.

12 You will also hear about four mechanical  
13 possibilities involving the center tank scavenge pump,  
14 static electricity, the fuel quantity indicating  
15 system, and/or the fuel tank electrical conduits.

16 It should be noted that whatever caused the  
17 crash of Flight 800, the explosion of a center wing  
18 tank in any aircraft is an extremely rare event. While  
19 our entire civil aviation fleet is extremely safe, the  
20 Boeing 747 in particular has registered an admirable  
21 safety record.

22 There are currently about 970 747's  
23 worldwide. In the almost thirty years that the 747's  
24 have been operating, the fleet has accumulated more  
25 than 52 million flight hours and 12 million flights.

1           Almost a year ago the Safety Board issued  
2           recommendations aimed at minimizing the possibility of  
3           having explosive vapors in airliner fuel tanks. As you  
4           know, the FAA last week replied to our recommendations.  
5           Although under our procedures the entire Board must  
6           respond to the FAA statement, I think I can say that  
7           while I am disappointed that the FAA continues to  
8           reject short-term operational solutions, I believe the  
9           recent letter sets a new tone and places the FAA with  
10          those of us who believe that the elimination of  
11          explosive vapors is at least as important as designing  
12          out ignition sources. Those issues, of course, will be  
13          explored fully this week, as well.

14          Since this accident, the industry and the FAA  
15          have moved on several fronts to address concerns raised  
16          during the investigation. The FAA convened a two-day  
17          conference on fuel flammability, a subject that was not  
18          as well understood as previously thought.

19          The FAA proposed an airworthiness directive  
20          last month that would require the installation of  
21          components to suppress electrical shorting in aircraft  
22          wiring that is connected to the fuel tanks. This would  
23          also involve inspections of the fuel quantity  
24          indicating systems for purposes of avoiding electrical  
25          arcing.

1           A separate airworthiness directive requires  
2 the immediate inspection of scavenge pump wiring on  
3 some older 747's. As we all know, the scavenge pump  
4 from Flight 800 has not been recovered.

5           Boeing Commercial Aircraft Corporation has  
6 recommended that Boeing 747 operators check all wiring  
7 to fuel tanks during the next major inspection, and has  
8 said it intends to replace a fuel probe on some older  
9 model 747's that it says has exhibited faulty wiring on  
10 some models.

11           All of these actions are welcome, and they  
12 show a commitment on the part of the industry and the  
13 FAA to reduce as many potential ignition sources as  
14 possible. This has always been the design philosophy  
15 adopted by the FAA and industry, and laudable as it is,  
16 it is a goal that is extremely difficult to attain,  
17 indeed, if it is possible at all.

18           We continue to believe that the FAA and the  
19 aviation industry do well to try to eliminate every  
20 possible ignition source, but they should also endeavor  
21 to eliminate explosive vapors in fuel tanks, a more  
22 attainable goal that would prevent another accident  
23 like TWA 800.

24           The industry has been attempting to eliminate  
25 ignition sources for many decades, with great success.

1 But, as TWA 800 shows, they have not been completely  
2 successful. I, for one, don't see how every ignition  
3 source can be eliminated. As I said, I am hopeful  
4 after reading the FAA's letter to us last week that we  
5 are now moving in the same direction.

6 In our thirty-year history, the Safety Board  
7 has conducted more than 120 public hearings on major  
8 aviation accident investigations. This is the 121st.  
9 Previous hearings include the 1979 DC-10 crash in  
10 Chicago, which was the deadliest aviation accident in  
11 American history; the 1987 MD-80 accident in Detroit,  
12 which until Flight 800 was the second deadliest  
13 aviation accident in history; and the 1994 Boeing 737  
14 accident near Pittsburgh which actually had a two-  
15 session hearing.

16 This week's hearing, as with those, is being  
17 held for the purpose of supplementing the facts,  
18 conditions and circumstances discovered during the on-  
19 scene investigation. This process will assist the  
20 Safety Board in determining the probable cause and in  
21 making recommendations to prevent future -- similar  
22 accidents in the future.

23 Public hearings such as this are an exercise  
24 in accountability, accountability on the part of the  
25 Safety Board that is paid by public dollars, that it is

1 conducting a thorough and fair investigation;  
2 accountability on the part of the Federal Aviation  
3 Administration that it is adequately regulating the  
4 industry; accountability on the part of the airline  
5 that it is operating safely; accountability on the part  
6 of the manufacturers as to the design and performance  
7 of their products; and accountability on the part of  
8 the work force, the pilots, the machinists and flight  
9 attendants, that they are performing up to the  
10 standards of professionalism expected of them.

11 These proceedings tend to become highly  
12 technical affairs, but they are essential in seeking to  
13 reassure the public that everything is being done to  
14 ensure the safety of the airline industry, to be sure  
15 that they can -- that they and their loved ones can get  
16 on an airplane and safely arrive at their destination.

17 This hearing is not being held to determine  
18 the rights or liabilities of private parties, and any  
19 matters dealing with such rights and liabilities will  
20 be excluded from these proceedings.

21 Over the course of this hearing we will hear  
22 reports from some of the Safety Board's investigators  
23 and receive sworn testimony from experts on safety  
24 issues arising from the accident. Specifically, we  
25 will concentrate on the following issues:

- 1           1.     Examination of cockpit voice recorder, flight
- 2                     data recorder and radar data and sequencing;
- 3           2.     Fuel tank design philosophy and certification
- 4                     standards;
- 5           3.     Flammability of Jet-A-fuel;
- 6           4.     Ignition sources;
- 7           5.     Potential flammability reduction
- 8                     techniques/procedures; and
- 9           6.     Aging Aircraft

10                    We expect to hear from about 40 witnesses  
11 over the next five days, many of them in panels  
12 discussing one of the issues I have just mentioned.

13                    At this point, please permit me to introduce  
14 the other members of the Board of Inquiry who are at  
15 the head table here with me. There to my right are Dr.  
16 Bernard Loeb, Director of the Office of Aviation  
17 Safety, Dr. Vernon Ellingstad, Director of the Office  
18 of Research and Engineering; and Mr. Barry Sweedler,  
19 Director of the Office of Safety Recommendations and  
20 Accomplishments. Mr. Dan Campbell, the Safety Board's  
21 General Counsel, is also at this table.

22                    The Board of Inquiry will be assisted by a  
23 Technical Panel made up of National Transportation  
24 Safety Board Investigators. These persons are -- and  
25 they are seated to my right, your left -- Mr. Tom

1 Haueter, Chief of the Major Aviation Accident Division;  
2 Al Dickinson, Investigator-in-Charge of this accident;  
3 and the following group chairmen:

4 Debra Eckrote, Norm Weimeyer, Malcolm  
5 Brenner, Jim Wildey, John Clark, Frank Hilldrup, David  
6 Mayer, Burt Simon, Henry Hughes, George Anderson, Doug  
7 Wiegman, Mitch Garber, Merritt Birky, Dan Bower, Dennis  
8 Crider, Bob Swaim, Charlie Peraira, Deepak Joshi and  
9 Larry Jackson.

10 Obviously, all of them are not at the table  
11 at the moment, but they will be the individuals you  
12 will see through the course of the five-day hearing.

13 I would also like to acknowledge the presence  
14 of my fellow Board members this morning. You are all  
15 familiar with our Vice Chairman, Robert Francis, who  
16 was the Board member on scene for this accident. Also  
17 here are members John Hammerschmidt, John Goglia and  
18 George Black. I appreciate them joining us.

19 In addition, seated behind me is my Special  
20 Assistant, Deb Smith, who will be assisting me during  
21 the proceedings.

22 Neither I nor any Safety Board personnel will  
23 attempt during this hearing to analyze the testimony  
24 received, nor will we at any time attempt to determine  
25 the probable cause of this accident. Such analysis and

1 cause determination will be made by the full five-  
2 member Safety Board after consideration of all the  
3 evidence gathered during our investigation.

4 The report on the aircraft accident involving  
5 Flight 800 reflecting the Safety Board's analysis and  
6 probable cause determinations will be considered for  
7 adoption by the full Board at a later public meeting.

8 We have a number of Safety Board employees  
9 here to assist those of you attending this meeting.  
10 You will recognize them by the salmon colored  
11 credentials they wear around their neck. Please  
12 contact them for any administrative concerns you may  
13 have. We are paid by your public funds, and we are  
14 glad to be here and assist you in any way we can.

15 I am very pleased to see the large number of  
16 news media here to cover this meeting. In fact, due to  
17 the interest this investigation has generated, we have  
18 issued more than 500 press credentials, which means  
19 there are about forty percent more media  
20 representatives here than there are employees of the  
21 entire National Transportation Safety Board.

22 But, this is a public proceeding, and most of  
23 the 250 million Americans will rely on the media to  
24 learn what transpires here. I am going to ask the  
25 media, however, not to conduct any interviews here in

1       this auditorium. This is for the business of the  
2       public hearing. All interviews should be conducted  
3       outside this room.

4               Also, there are meeting rooms upstairs for  
5       NTSB staff and family members, and the family members  
6       of those who perished on TWA Flight 800. News media  
7       representatives are not authorized access to these  
8       rooms .

9               The Safety Board's Rules provide for the  
10       designation of parties to a public hearing. In  
11       accordance with these rules, those persons, government  
12       agencies, companies and associations whose  
13       participation in the hearing is deemed necessary to the  
14       public interest and whose special knowledge will  
15       contribute to the development of pertinent evidence are  
16       designated as parties.

17               The parties assisting the Safety Board in  
18       this particular hearing have been designated in  
19       accordance with these Rules. As I call the name of  
20       each party, will each -- will its designated  
21       spokesperson please give his or her name, title and  
22       affiliation for the record, and briefly introduce the  
23       people who are at the table with you.

24               The Department of Transportation, Federal  
25       Aviation Administration?

1                   MR. STREETER: Good morning, Mr. Chairman. I  
2 am Lyle Streeter, the Assistant Manager of the FAA's  
3 Accident Investigation Division out of FAA  
4 Headquarters .

5                   I have with me Mark Thomasage (sic) from our  
6 General Counsel's Office; Bud Dormer, the Manager of  
7 the Accident Investigation Division; Joe Manno (sic) ,  
8 the FAA Coordinator on this accident; and three people  
9 back here from our various radar facilities that will  
10 be involved in assisting us with the early  
11 presentations today, and we will have other technical  
12 assistants up here at various times during the hearing.

13                  CHAIRMAN HALL: Mr. Streeter, welcome. We  
14 appreciate the FAA's participation in this hearing.

15                  The Airline Pilots Association?

16                  CAPTAIN REKART: Good morning, Mr. Hall. I  
17 am Captain Jerry Rekart. I am the Chief Accident  
18 Investigator for the Airline Pilots Association and  
19 also the ALP Coordinator for this accident.

20                  At the table with me today, Mr. Michael Huhn  
21 and Mr. Chris Baum who are Staff Engineers at the  
22 Airline Pilots Association; Captain Joe Cronig who is  
23 Chairman of the ALP MEC; Mr. Vincent Cocca and Mr.  
24 Steven Green who are Investigators along with -- in the  
25 ALP Investigation.

1                   CHAIRMAN HALL: Thank you, Captain, and we  
2 welcome the Airline Pilots Association's participation  
3 in this hearing.

4                   Trans World Airlines, Inc.?

5                   CAPTAIN YOUNG: Good morning, Mr. Chairman.  
6 My name is Robert Young. I am the Captain Robert  
7 Young, the Director of Flight Operations Safety for  
8 Trans World Airlines.

9                   I would like to introduce the members at my  
10 table. I have Mr. Dan Rephlo, who is the Manager of  
11 Fleet Engineering for Boeing Aircraft; Ms. Margaret  
12 Giugliano, the Assistant General Counsel for TWA; Mr.  
13 James Reilly, the Director of Air Traffic Control for  
14 TWA; Mr. Randall R. Craft, who is the Counsel for TWA;  
15 and Mr. William Brown, Counsel for TWA.

16                  CHAIRMAN HALL: Thank you, Captain Young.  
17 Welcome, and we appreciate TWA's participation in this  
18 hearing.

19                  The Boeing Commercial Airplane Group?

20                  MR. RODRIGUES: Good morning, Mr. Chairman.  
21 I am Dennis Rodrigues, Senior Air Safety Investigator  
22 for the Boeing Commercial Airplane Group. With me I  
23 have Mr. Charlie Higgins, Vice President of Airplane  
24 Safety and Performance. I have Mr. Steve Bell, an  
25 attorney.

1                   Also, Mr. Ivor Thomas, Chief Engineer of  
2                   Propulsion Safety and Fuel; Mr. Rich Breuhaus, Chief  
3                   Project Engineer for the Fuel System Safety Program;  
4                   Mr. Jack Winchester, Senior Manager of Structures; and  
5                   Mr. Steve Hatch, 747 Chief Project Engineer.

6                   CHAIRMAN HALL: Welcome, Mr. Rodrigues. We  
7                   appreciate the Boeing Commercial Airplane Group's  
8                   participation in this hearing.

9                   The International Association of Machinists  
10                  and Aerospace Workers?

11                  MR. LIDDELL: Good morning, Mr. Chairman. My  
12                  name is Fred Liddell. I am IM's Chief Investigator for  
13                  this accident. With me at the table is Mr. Al Calhoun,  
14                  General Chairman; Mr. Gary Graham, Flight Attendants --

15                  CHAIRMAN HALL: If you would pull that mike  
16                  just a little closer. Thanks .

17                  MR. LIDDELL: Mr. Gary Graham, Flight  
18                  Attendant Investigator; Mr. Rocky Miller, Flight  
19                  Attendant Investigator; Ms. Sherry Miller-Cooper,  
20                  Flight Attendant General Chairman; Mr. Ron Giachetti,  
21                  Machinist Investigator.

22                  CHAIRMAN HALL: Thank you very much. We  
23                  appreciate the International Association of Machinist  
24                  and Aerospace Workers' participation in this hearing.  
25                  Honeywell, Inc.?

1                   MR. THOMAS: Good morning, Mr. Chairman. My  
2 name is Hal Thomas. I am Technical Engineering, and I  
3 lead Honeywell's Air Safety Team.

4                   With me I have Keith Ross, Office of General  
5 Counsel; Robert Gille, Technical Engineering; John  
6 Leshowski, Office of General Counsel; Neal Speranzo,  
7 Technical Engineering; and Melissa Young, Honeywell  
8 Corporate Offices.

9                   CHAIRMAN HALL: Crane Company/Hydro-Aire?

10                  MR. BOUSHIE: Good morning, Mr. Chairman. My  
11 name is Ray Boushie. I am the President of Hydro-Aire  
12 Division of Crane Company. With me this morning is  
13 Stan Bluhm who is our Director of Mechanical  
14 Engineering; Stewart Johnson who is our Director of  
15 Strategic Planning; Mr. Paul Russ who is Vice President  
16 of Engineering of our Lear/Romac (sic) Division; Mr.  
17 Dane Jaques and Mr. Mark Dombroff, Counsel.

18                  CHAIRMAN HALL: Thank you. We greatly  
19 appreciate Honeywell and Crane Company/Hydro-Aire's  
20 participation in this hearing.

21                  On December 1st the Board of Inquiry held a  
22 pre-hearing conference in Washington, DC. It was  
23 attended by the Board's Technical Panel and  
24 representatives of the parties to this hearing who have  
25 just been introduced to you.

1           During that conference, the areas of inquiry  
2           and the scope of issues to be explored at the hearing  
3           were defined, and the selection of witnesses to testify  
4           on those issues were finalized. Copies of the witness  
5           list are available at various locations around the  
6           building, and available to the public through the  
7           Internet.

8           The Safety Board is a public agency engaged  
9           in the public's business and supported by public funds.  
10          The work it does in the business of aviation safety is  
11          open for public review, and our investigation is an  
12          open book.

13          Yesterday, the Safety Board opened the docket  
14          of this investigation and placed 4,000 pages of  
15          documentation into the public record. A substantial  
16          portion of this, representing those exhibits to be used  
17          at this hearing, is available free of charge to the  
18          public through our home page on the Internet. The  
19          docket can be accessed by entering "www.nts.gov," and  
20          hitting the button indicating the TWA Flight 800  
21          hearing section.

22          There, you will not only find the exhibits,  
23          but the witness list, biographical information on all  
24          of here on the Board of Inquiry and the Technical Panel  
25          and other general information concerning the hearing.

1                   Paper copies of the docket may be obtained  
2                   for purchase by contacting Kinko Corporate Document  
3                   Services, 300 North Charles Street here in Baltimore.  
4                   They can be called at "(410) 625-5862." Paper copies  
5                   may also be ordered for purchase through our Public  
6                   Inquiries Section in Washington at "(202) 314-6551."  
7                   Both of those numbers are available at our Internet  
8                   site.

9                   The witnesses testifying at this hearing have  
10                  been selected because of their ability to provide the  
11                  best available information on the issues to be  
12                  addressed. The Board's Investigator-in-Charge will  
13                  summarize certain facts about the accident and the  
14                  investigative activities that have taken place since  
15                  then, and then we will call our first witness.

16                  The witnesses will be questioned first by the  
17                  Board's Technical Panel, then by the designated  
18                  spokesperson for each party, and finally by the Board  
19                  of Inquiry.

20                  As Chairman of the Board of Inquiry, I will  
21                  be responsible for the conduct of this hearing. I will  
22                  make all rulings on the admissibility of evidence, and  
23                  all rulings will be final.

24                  Anyone wishing to purchase a transcript of  
25                  this hearing, including the parties to this

1 investigation, should contact the Court Reporter  
2 directly.

3 I would like to acknowledge other officials  
4 who are here observing this meeting. From the French  
5 Bureau Enquetes-Accidents, Mr. Didier Bonnel, Mr.  
6 Didier Delaitre, Mr. Jean-Francois Berthier and Mr.  
7 Dan-Cohen Nir.

8 From the European Joint Aviation Authorities,  
9 Mr. Dominique Cortizo, Mr. Ken Fontaine, Mr. Remy Jouty  
10 and Mr. Edmond Boullay.

11 From the Embassy of France, Mr. Jean-Michel  
12 Bour.

13 From the British Air Accidents Investigations  
14 Branch, Mr. Jerry Barnett, Mr. Tony Cable, Mr. Pete  
15 Claiden and Mr. Rex Parkinson.

16 From our neighbors to the north, the Canadian  
17 Safety Board, its Chairman, Benoit Bouchard and his  
18 entire Board; Ms. Wendy Tadros, Maurice Harquil and  
19 Charles Simpson, the Board members, and they are joined  
20 by their Executive Director, Ken Johnson.

21 Also observing the proceedings today are  
22 representatives of the United States Senate and the  
23 United States House of Representative staffs. From the  
24 Senate Commerce Committee, Mr. Sam Whitehorn; from the  
25 Senate Commerce Committee, Ms. Anne Hodges; from the

1 House Aviation Committee, Mr. Dave Schaffer (sic); from  
2 the House Aviation Committee, Ms. Donna McLean.

3 In addition, Mr. Paul Marccone from  
4 Congressman Traficant's office, and Mr. Diana Weir --  
5 Ms. Diana Weir from Congressman Forbes' Chief of Staff.  
6 I would like to welcome all of our observers. We  
7 appreciate your attendance and your interest in these  
8 proceedings .

9 Finally, I would like to say a word to the  
10 family members of the victims who are here with us  
11 today, or those who are watching the proceedings on C-  
12 Span.

13 While all of us have felt enormous sympathy  
14 for your grief for many months, none of us can claim to  
15 know what you have gone through since the night of July  
16 17th, 1996. We can, however, make sure that we  
17 dedicate all possible resources to finding out what  
18 happened that night and doing what we can to assure it  
19 doesn't happen again.

20 My heart and thoughts are with you during  
21 this hearing. I hope that you will see that it is a  
22 major step toward the goal of finding out exactly what  
23 happened, and ensuring that a tragedy like this never  
24 happens again.

25 With all exhibits having been entered into

1 the docket, and I will ask Mr. Al Dickinson, the  
2 Investigator-in-Charge of this investigation to present  
3 his opening statement. Mr. Dickinson?

4 MR. DICKINSON: Thank you, Mr. Chairman.  
5 Good morning, and good morning ladies and gentlemen.  
6 TWA Flight 800, a Boeing 747-131, Registration Number  
7 November 93119 was a scheduled air carrier flight  
8 operated under Title 14, Code of Federal Regulations  
9 Part 121.

10 There were 230 people on board, eighteen crew  
11 and 212 passengers. The flight was to have been the  
12 initial flight of a scheduled three-day flight sequence  
13 for the flight crew.

14 The flight crew consisted of four flight deck  
15 crew members. The captain and captain/check airman who  
16 were -- who was acting as first officer, both had  
17 worked for TWA for approximately thirty years and were  
18 considered senior flight crew members.

19 The flight engineer who had only about thirty  
20 hours as a flight engineer, was on a training flight.  
21 The check engineer who occupied the jump seat was  
22 considered a senior flight crew member.

23 The flight was scheduled to depart at 7:00  
24 p.m. for Charles DeGaulle Airport in Paris. However,  
25 the flight was delayed due to a passenger/baggage

1 mismatch and a disabled piece of ground equipment.  
2 Flight 800 took off from runway 22 right at 8:19 p.m.  
3 Visual meteorological conditions prevailed, and  
4 instrument flight rules flight plan was filed.

5 Air Traffic Control communications with  
6 Flight 800 were routine. The last transmission from  
7 the flight crew was recorded at nineteen seconds past  
8 8:30 p.m. when they acknowledged clearance to 15,000  
9 feet. A minute thereafter, Flight 800 disappeared from  
10 radar.

11 As one of six investigators in the Major  
12 Investigations Division at the Safety Board, I was on  
13 call that evening of July 17th, 1996. I was at home  
14 when at about 8:30 I received a phone call notifying me  
15 that a Trans World Airlines Boeing 747 was missing off  
16 the coast of Long Island, New York.

17 While the go-team coordinated in Washington,  
18 investigators from the NTSB Regional Office in New  
19 Jersey went immediately to the scene of the accident.  
20 The go-team arrived on scene early the next morning.  
21 The go-team was accompanied by Safety Board Vice  
22 Chairman, Robert Francis, and his Assistant, Denise  
23 Daniels, as well as Peter Goelz and Shelly Hazle from  
24 the Office of Government, Public and Family Affairs.

25 Upon arrival at Islip Airport we went

1 directly to the Coast Guard Station at East Moriches.  
2 The Coast Guard, police and private mariners were  
3 bringing in wreckage and victims. It was like nothing  
4 any of us had ever witnessed.

5 The NTSB utilizes a party system in its  
6 investigations . Parties providing technical assistance  
7 to this investigation, as the Chairman reiterated, the  
8 Federal Aviation Administration, Boeing Commercial  
9 Airplane Group, Trans World Airlines, the International  
10 Association of Machinists, Aerospace Workers and Flight  
11 Attendants, the Air Line Pilots Association, the  
12 National Air Traffic Controllers Association, Pratt &  
13 Whitney, Honeywell and the Crane Company, Hydro-Aire.

14 In all major Safety Board investigations,  
15 groups are formed to look at different aspects of the  
16 accident. Each group is headed by an NTSB investigator  
17 and made up of members from the parties who can lend  
18 specific technical expertise.

19 Due to the magnitude of this investigation,  
20 more than one NTSB investigator was assigned to many of  
21 the groups, and as the investigation progressed,  
22 several new groups were formed. To date, eighteen  
23 groups have participated, by far the most groups ever  
24 to participate in an investigation in the Safety  
25 Board's history.

1                   The groups are: Systems, Structures,  
2 Maintenance, Airplane Interior Documentation,  
3 Witnesses, Radar, Flight Data Recorder, Cockpit Voice  
4 Recorder, Medical Forensic, Fire and Explosion,  
5 Powerplants, Air Traffic Control, Operations, Aircraft  
6 Performance, Airport Security, Trawling, Flight Test  
7 and Sequencing.

8                   For assistance in recovering the aircraft and  
9 victims, the Safety Board called on the Supervisor of  
10 Salvage of the U.S. Navy. The National Transportation  
11 Safety Board has a longstanding Memorandum of Agreement  
12 with the Navy and, in fact, this was the second time in  
13 a year in which we had called on them for assistance.

14                   The Navy was on scene by the 19th, and by the  
15 time they completed the effort, over ninety-five  
16 percent of the 400,000 pounds of aircraft and remains  
17 of all the 230 people on board had been recovered.

18                   The Navy was assisted by the U.S. Coast  
19 Guard, Oceaneering, Underwater Search and Survey, the  
20 National Guard and the National Oceanic and Atmospheric  
21 Administration, as well as dive teams from Suffolk  
22 County, New York City and State Police, Suffolk County  
23 and New York City Fire Departments and the FBI.

24                   The recovery effort was an amazing feat, and  
25 all men and women who were part of that effort deserve

1 our admiration and gratitude. Captain McCord will  
2 discuss the Navy operations shortly.

3 From an investigative standpoint, one of our  
4 first priorities was, as always, the retrieval of  
5 flight recorders. After an extensive search, Navy  
6 divers recovered both the cockpit voice recorder and  
7 the flight data recorder on the evening of July 24th.

8 They were flown by a Coast Guard Falcon  
9 aircraft to NTSB Headquarters in Washington, DC where  
10 NTSB engineers immediately began analyzing them. Both  
11 contained good data and revealed a routine flight until  
12 ending within a fraction of a second of one another at  
13 approximately twelve seconds after 8:31 p.m.

14 Through detailed mapping, the Navy identified  
15 three debris fields which were labelled red, yellow and  
16 green. The red debris field was the farthest west,  
17 thereby containing the pieces of wreckage that exited  
18 the aircraft first, including some structure from the  
19 center wing tank and fuselage just forward of the  
20 wings .

21 The yellow debris field, which was actually  
22 part of the red debris field, located in its northeast  
23 corner contained the nose of the aircraft, and the  
24 green debris field, some 1.5 miles east of the red,  
25 contained the wings, all four engines and the aft

1 section of the aircraft.

2 After the aircraft wreckage was recovered  
3 from the ocean, it was transported to an abandoned navy  
4 facility in Calverton, New York. The wreckage pieces  
5 were documented, noting the extent and type of damage  
6 to each piece, and the latitude and longitude of its  
7 recovery.

8 This information, along with photographs and  
9 engineering drawings, filled approximately fifteen  
10 volumes of three-inch binders, and was incorporated  
11 into an electronic database. The wreckage was also  
12 thoroughly examined and tested for chemical residues by  
13 the FBI.

14 The hangar floor was marked and the wreckage  
15 was laid out as to its position on the aircraft. It  
16 was a twenty-four hour a day operation for two shifts  
17 working twelve hours each, seven days a week. Early in  
18 this investigation it became clear that an explosion  
19 had occurred in the center wing tank.

20 The Safety Board contracted with Dr. Joe  
21 Shepherd from the California Institute of Technology to  
22 conduct research on the explosive properties of Jet-A-  
23 fuel, and he will be discussing his work later this  
24 week.

25 To better understand the accident, we built a

1 three dimensional reconstruction, including the  
2 structure around the center wing tank from about  
3 fuselage station 520 to station 1640. The  
4 reconstruction, the largest in the world, took over two  
5 months to construct and contains over 876 pieces of  
6 wreckage, weighing over 60,000 pounds.

7 The Fire and Explosion Group analyzed the  
8 soot and fire patterns, and the metallurgists from the  
9 Structures Group thoroughly investigated each piece of  
10 aircraft, examining holes and penetrations, and  
11 conducting a sequence study to determine the sequence  
12 in which the pieces came off the aircraft.

13 In addition, a trajectory study was conducted  
14 in an effort to understand how the aircraft responded  
15 after the explosion. The findings of these studies  
16 will be discussed today as part of this hearing.

17 The interior - the cabin interior, seats,  
18 galleys and lavatories, was also reconstructed in a  
19 hangar at Calverton. Every piece was thoroughly  
20 examined for evidence as an explosive device. None was  
21 found.

22 Medical and forensic information was reviewed  
23 and correlated with cabin damage in an effort to  
24 identify injury and damage patterns. The findings of  
25 these efforts will be discussed later today.

1                   Radar data were obtained from the FAA,  
2                   Department of Defense and Sikorsy. Radar from nine  
3                   locations in five states were reviewed and correlated  
4                   with data from the CVR and FDR.

5                   No sequence of radar returns intersected TWA  
6                   800's position at any point in time, nor were there any  
7                   radar returns consistent with a missile or other  
8                   projectile traveling towards TWA 800. This data will  
9                   be discussed later today.

10                  All four engines were recovered and torn down  
11                  at a hangar at Calverton. There was no evidence that  
12                  the engines were struck by anything, or that any of  
13                  them experienced an un-contained engine failure that  
14                  could have ignited the center tank by throwing debris  
15                  into it. Fuel from the engines was analyzed and found  
16                  to conform to the specifications of the fuel used at  
17                  JFK and Athens.

18                  The Maintenance Group assembled in Kansas  
19                  City, Missouri to review the maintenance records of the  
20                  aircraft. The aircraft which was manufactured in July  
21                  of 1971 was purchased new from the Boeing Company by  
22                  TWA .

23                  The aircraft was utilized for commercial  
24                  transport until it was sold to Iran on December 15th,  
25                  1975. Although the aircraft was ferried to the Boeing

1 Military Aircraft Company in Wichita, Kansas for  
2 modifications, Iran never took possession of the  
3 aircraft, and the modifications were never accomplished  
4 before it was returned to TWA's certificate on December  
5 16th, 1976.

6 The Maintenance Group reviewed all  
7 maintenance records from the date of manufacture until  
8 **July** 17th, 1996. The records indicated that TWA had  
9 accomplished mandatory directives, maintained scheduled  
10 maintenance and maintained a continuous airworthiness  
11 maintenance program on the accident aircraft. All  
12 applicable airworthiness directives had been complied  
13 with, and no maintenance items were deferred. We will  
14 address some of these issues later in the hearing.

15 Just prior to the accident flight, while the  
16 airplane was on the ground at JFK Airport, routine  
17 periodic maintenance service was accomplished, and the  
18 dispatch release for the flight contained three open  
19 minimum equipment lists, or MEL items. These items  
20 included a missing number two left canoe flap track  
21 fairing, an inoperative number three engine thrust  
22 reverser, and one inoperative weather radar  
23 transmitter.

24 As I mentioned earlier, neither the CVR nor  
25 the FDR indicated any problems with the aircraft before

1 the explosion. The FDR contained eighteen parameters  
2 and indicated that at the time the recording stopped  
3 the aircraft was in a wings level climb. The  
4 interruption in the recording was consistent with a  
5 sudden loss of electrical power to the recorder.

6 The CVR indicated a routine flight with the  
7 captain sitting in the left seat flying the airplane  
8 and the check captain sitting in the right seat  
9 handling the radio transmissions. Conversation with  
10 the cockpit was routine and included all the  
11 appropriate checklist requirements.

12 The flight crew discussed a sticky fuel flow  
13 gauge, a common occurrence in the 747, and mentioned  
14 that they would begin to cross-feed fuel to the  
15 engines. The last 170 milliseconds of the CVR  
16 recording contained a unique sound signature.

17 We have done extensive sound spectrum  
18 analysis comparing the sound signature both visually  
19 and mathematically to other recordings -- including  
20 bombs, fuel/air explosions and structural failures.  
21 The FAA conducted explosive tests addressing cargo hold  
22 hardening on a Boeing 747 in Bruntingthorpe, England,  
23 and we placed small explosives on the center wing tank  
24 of the same plane.

25 As part of both of these tests, we recorded

1 the explosions on voice recorders in hopes of aiding  
2 our analysis of the sound spectrum from the cockpit  
3 voice recorder of TWA 800.

4 In addition to examining the fuel pumps and  
5 the fuel quantity indicating system from Flight 800 for  
6 evidence of malfunction, the Systems Group has  
7 conducted extensive testing to identify possible  
8 ignition sources.

9 The tests were conducted concerning static  
10 electricity at the Naval Research Laboratories and  
11 Wright Laboratories at Wright Patterson Air Force Base,  
12 and the Group has done extensive work to better  
13 understand the possible failure modes that could lead  
14 to a spark entering the center wing tank. These tests  
15 will be discussed later this week.

16 Last July, in an effort to learn more about  
17 the atmosphere in the center wing tank and possible  
18 remedies, the Safety Board conducted a series of flight  
19 tests. A leased Boeing 747 was outfitted with more  
20 than 150 sensors to measure temperature, vibration and  
21 pressure in the center wing tank, and vapor samples  
22 were taken.

23 Nine flights were flown, including  
24 simulations of TWA Flight 800, for a total of forty-  
25 three hours of flight time. The results of these tests

1 will be discussed this week.

2           During this extended investigation, weekly  
3 telephone conference calls have take place with all the  
4 parties to the investigation participating in these  
5 calls. These tele-conferences were necessary to  
6 provide for an open exchange of information and ideas  
7 and to keep all of the parties informed as to the  
8 progress of the investigative groups.

9           Additionally, we have had all-hands meetings  
10 periodically during the investigation at the hangar in  
11 Calverton. These meetings were held with all of the  
12 parties to the investigation to further discuss the  
13 activities of the investigation and to define  
14 additional areas for research.

15           During these meetings, the parties were asked  
16 to provide their comments on the scope of the  
17 investigation. Additionally, as you mentioned, Mr.  
18 Chairman, the Safety Board had received hundreds of  
19 unsolicited letters and telephone calls from person  
20 offering their opinions and thoughts on this accident.

21           At this time, I am not aware of any party to  
22 the investigation, or any other persons or  
23 organizations that have raised avenues of investigation  
24 that we have not pursued fully, or are not currently  
25 examining.

1           This investigation has marked a lot of firsts  
2           for the Safety Board. It has been by far the most  
3           expensive and most extensive in the history of the  
4           Board. It was the longest on-scene investigation and  
5           has involved more Safety Board staff members than any  
6           investigation, almost one-third of the Board's 370  
7           employees.

8           This investigation has truly known no bounds.  
9           We have utilized a variety of resources, calling on  
10          experts from different disciplines, as well as  
11          countries, including NASA, Sandia National  
12          Laboratories, the University of Nevada, Reno, Applied  
13          Research Associates in Denver, Brookhaven Laboratories,  
14          the California Institute of Technology, Wright  
15          Laboratory at Wright Patterson Air Force Base, the  
16          Naval Research Laboratory, China Lake, Britain's  
17          Defense Evaluation and Research Administration and the  
18          Christian Michelson Research Institute in Norway.

19          In addition, under the rules of the  
20          International Civil Aviation Organization, air safety  
21          investigators from the United Kingdom, France,  
22          Singapore, Australia, Canada and New Zealand  
23          participated in the investigation as technical  
24          observers.

25          Mr. Chairman, this concludes my statement.

1 The record of the investigation is contained in the  
2 documents in our public docket. The Court Reporter has  
3 a list of them.

4 CHAIRMAN HALL: Thank you, Mr. Dickinson. At  
5 this point, then, we will call this morning's first  
6 witness, Captain Chip McCord, the Director of the  
7 Salvage and Diving for the Naval Sea Systems Command.

8 Mr. McCord, if you would please approach.  
9 Captain McCord? Under agreement, Mr. -- Captain McCord  
10 will make a presentation, and we will not have  
11 extensive questioning. The Chairman may ask for some  
12 clarifications on some of his presentation, which is  
13 going to be limited to the work on research and  
14 recovery.

15 (Witness approaches the witness stand.)

16 Mr. Dickinson, would you please swear in the  
17 witness?

18 Whereupon,

19 **CAPTAIN MCCORD,**  
20 was called as a witness by and on behalf of the NTSB,  
21 and, after having been duly sworn, was examined and  
22 testified on his oath as follows.

23 MR. DICKINSON: Thank you. Please be seated.  
24 Captain McCord, is the Director of Ocean Engineering,  
25 Supervisor of Salvage and Diving for the U.S. Navy a

1 detailed description of Captain McCord's biography is  
2 on the NTSB web site today. Captain McCord served as  
3 the Coordinator for Salvage and Diving for many -- for  
4 the recovery of the wreckage of TWA 800.

5 Since being commissioned in the Navy in 1973,  
6 in addition to obtaining two degrees at MIT, he has had  
7 many assignments involving diving and salvage recovery.  
8 Captain McCord will now present a briefing outlining  
9 the Navy's participation in the investigation of TWA  
10 800.

11 CHAIRMAN HALL: Welcome, Captain McCord, and  
12 please proceed with your statement. Is your microphone  
13 on, Captain?

14 WITNESS McCORD: Thank you, Mr. Chairman. I  
15 think I have got my microphone working now.

16 CHAIRMAN HALL: Okay, if you would please  
17 identify yourself for the record, and then proceed.

18  
19  
20  
21  
22  
23  
24  
25

**DIRECT EXAMINATION**

1  
2 WITNESS McCORD: Mr. Chairman, my name is  
3 Captain Chip McCord. I am the Director of Ocean  
4 Engineering, Supervisor of Salvage for the United  
5 States Navy.

6 With me today I have also brought Commander  
7 Bobbie Sculley who was serving as the Supervisor of  
8 Diving for the United States Navy at the time of the  
9 recovery. She was the Salvage Officer and Commander of  
10 Combat Logistics Group Two; and Rear Admiral Ed  
11 Christiansen who headed up the Navy's effort.

12 In addition to Commander Sculley with me  
13 today is Mr. Tom Salmon who is the Chief of the Salvage  
14 Division in the Navy. He has been in that position for  
15 about eight years. He has been in the Salvage business  
16 for well over twenty-five years.

17 Mr. Chairman, today I would like to conduct a  
18 presentation and discuss the Navy and the salvage  
19 effort on the search and recovery for the TWA 800.

20 Mr. Chairman, the Navy has had a sense of  
21 experience in recovering things from the ocean and has  
22 an agreement with the National Transportation Safety  
23 Board for many years.

24 On the night of the 17th of July, the Navy  
25 was well aware of the problems with the TWA after the

1 crash after we saw that on the TV that night. We were  
2 in contact with the NTSB the next day, and mobilized  
3 equipment to the site. What I would like to do in my  
4 presentation this morning is discuss how we conducted  
5 this operation.

6 The Navy has a great deal of experience, as I  
7 said. On average, we recover about one military  
8 aircraft from the ocean every three weeks. Currently,  
9 at this time we are working on three airplanes at two  
10 separate crash sites in the world.

11 Other experiences that we have done in the  
12 civilian world is the recovery of the Dominican  
13 Republic 757 Flight, the Bergen Air 757 that went off  
14 the coast of the Dominican Republic in February of '96,  
15 extensive recovery with the Challenger, the Space  
16 Shuttle Challenger in 1989, the search and recovery for  
17 Air India in 1985 and South African Airways in 1987.

18 We conduct search and recovery in the ocean  
19 in a very methodical and disciplined approach, and in  
20 this particular operation on TWA 800, it was conducted  
21 in three phases. The first was locating the debris  
22 field, the second was the victim recovery and the third  
23 phase was the wreckage recovery.

24 I would like to point out that all three of  
25 these phases, although they are somewhat sequenced,

1 continued out through the entire operation. I think  
2 you will appreciate from some of the slides I have this  
3 morning the importance of following a very disciplined  
4 approach in this search and recovery.

5 The first thing we do in this phase approach  
6 of locating and mapping the debris field is to analyze  
7 all data that is available. We look at Air Traffic  
8 Control, military radars, eyewitnesses and we plot  
9 winds current. We do this in order to find our best  
10 guess of where we think the aircraft went in the water.

11 Once we do that, and we have found what we  
12 consider to be the best opportunity for success in  
13 finding the aircraft, we select our search equipment,  
14 we conduct a thorough -- thorough search, we map the  
15 debris so we know where all the debris is on the  
16 bottom, then we identify the debris that is on the  
17 bottom and then we prioritize the wreckage recovery,  
18 working with the NTSB investigators.

19 In the second phase where we are recovering  
20 victims, we -- then, after we have identified and  
21 mapped the debris, we select our recovery equipment and  
22 then we actually conduct the recovery.

23 This slide here, I just want to point out  
24 some of the assets that we used in the search phase.

25 (Slide shown.)

1                   On there is an odd shaped box, and that was  
2                   the -- what we call our datum -- the point where we  
3                   felt -- the center of this box, and I will use the  
4                   laser pointer if I can get it to work.

5                   **(Pause.)**

6                   In the center of the middle box we estimated  
7                   that we would find the aircraft -- the debris. That  
8                   box is approximately five miles by five miles. On  
9                   scene the night of the --

10                  CHAIRMAN HALL: There are two little red  
11                  boxes there, Chip. Which one are you referring to?  
12                  Are you referring --

13                  WITNESS McCORD: I am referring to the blue  
14                  box that is around the two red boxes.

15                  CHAIRMAN HALL: The blue box, okay. Thank  
16                  you .

17                  WITNESS McCORD: The blue box, without the  
18                  two blue box tails, and I will discuss those in a  
19                  minute .

20                  Again, we looked at this -- analyzed the data  
21                  in conjunction with the NTSB to make sure that we were  
22                  all on -- looking at the same information for the  
23                  radars . On scene that night of the accident was the  
24                  NOAA Ship Rude who had come out of Newport, Rhode  
25                  Island to help in the assistance and possible recovery

1 of victims, and also to -- wreckage that was floating  
2 on the surface that night. Rude had a small side scan  
3 sonar on her, and we were able to utilize her.

4 The Navy has a contract with a deep ocean  
5 search and recovery contractor, Oceaneering, and they  
6 husband our equipment. On that night we asked  
7 Oceaneering to send side scan sonar, a small underwater  
8 vehicle and to contract a ship of opportunity out of  
9 New Jersey, and that is the motor vessel Pirouette.

10 We sent that equipment up through New Jersey,  
11 loaded it on board Pirouette and Pirouette was on  
12 station to commence her search for the debris by Friday  
13 night .

14 CHAIRMAN HALL: Could you explain to us what  
15 a side scan sonar is?

16 WITNESS McCORD: Yes, sir. On my next slide  
17 I will go into that in a little bit more detail. We  
18 also, then, as the seas got rougher, I just -- we  
19 utilized the motor vessel Marian C to take over for  
20 Pirouette later in the operation, and then we also  
21 brought in the research vessel, Diane G., which had a  
22 new type of identification equipment called the laser  
23 line scan, which is a scanning blue-green laser that we  
24 contracted for to help us identify and prioritize  
25 targets to recover.

1           On the issue of side scan sonar, side scan  
2 sonar is a very high resolution sonar that looks off to  
3 the side of a towed body. We are able to tow the body  
4 back and forth over the area of interest at about two  
5 to three miles per hour.

6           The side scan sonar can look out -- typically  
7 out to about 150 yards on either side of the sonar.  
8 That is why we are able to cover such a large area in a  
9 relatively short, two to three-day period, using both  
10 NOAA Ship Rude and Pirouette.

11           The laser line scan has a much narrower width  
12 of view, but can get us some much more detailed  
13 pictures. Again, we use these both in conjunction with  
14 each other to help us locate and then prioritize the  
15 items on the bottom.

16           **(Pause.)**

17           Mr. Chairman, I will spend a few minutes on  
18 this slide here.

19           **(Next slide shown.)**

20           In the lower left hand corner, mid way up is  
21 the -- is a 747 drawn to scale. This map is about  
22 three miles by three miles square. On this map are a  
23 series of dots, and I won't go into the color of the  
24 dots right now, but they were different stages of the  
25 investigation. The dots would change color as to

1 whether we had investigated a sonar contact, or  
2 recovered it.

3 Each of those dots represents a sonar contact  
4 that we got from our side scan sonar operations. All  
5 the dots are the same size, all the wreckage that it  
6 symbolizes is not the same size.

7 In the lower left is a side scan sonar  
8 representation of a small item approximately two by  
9 three feet. That is what one of those dots represents.  
10 One of those dots could represent -- on the bottom of  
11 the page is a laser line scan picture of three seats  
12 together. Or, one of those dots could represent  
13 something that we show up in the upper right hand  
14 corner, which is about a twenty-five yard square box  
15 with literally thousands of pieces of aircraft wreckage  
16 in there. The largest piece that we recovered on this  
17 operation was part of the starboard wing which measured  
18 eighty feet by fifteen feet by thirty feet.

19 The flight path of the 747 was, from lower  
20 left to upper right, northeast projector. In the red  
21 area, or the area that we call the red zone, were the  
22 first things that came out of the airplane.

23 In the small box where a picture called USS  
24 Grapple is pointed to is where we discovered the  
25 cockpit and the first class section. In the upper

1 right hand box of the major debris field where we have  
2 a line showing the USS Grapple is where the after part  
3 of the airplane from just forward of the wings to the  
4 tail ended up.

5 As we were developing these side scan sonar  
6 representations and determining what we had out there,  
7 and it was very important for us to do this in a  
8 methodical method so that we had this picture and knew  
9 where to place our assets, we sailed the USS Grasp from  
10 Norfolk, Virginia.

11 It had just arrived back from the States on  
12 Friday and was underway on Sunday. It was seen in Long  
13 Island on Monday, although we were not ready for Grasp  
14 at that time, we were still doing a high resolution  
15 sonar of that area where we were going to put Grasp.

16 What we ended up doing was putting three  
17 anchors, chain and wire rope 9,000 -- 900 feet of wire  
18 rope an inch and five-eighths in diameter to a mooring  
19 buoy and then moored the ship with the eight inch  
20 mooring lines so that the ship would stay in position  
21 over that one debris field and not move no matter what  
22 the winds and current did.

23 This method and this approach proved to be  
24 very beneficial for us, because Grasp was able to stay  
25 in that position for thirty-six days able to conduct

1 diving and ROV operations around the clock for thirty-  
2 three of those thirty-six days.

3 As we were developing our sonar targets and  
4 analyzing our data, we then also discovered another --  
5 what we called another major debris field, and that is  
6 where we have the line that USS Grapple is. We brought  
7 USS Grapple on scene and put her into a moor in the  
8 similar position that we did with Grasp, and Grapple  
9 stayed in that spot for over twenty-one days until she  
10 had cleared all the wreckage and all the victims from  
11 that area.

12 I will talk a little bit about the Navy  
13 assets that we brought up there. The first Navy ship  
14 on scene was the USS Grasp, home port Norfolk,  
15 Virginia, followed by the USS Oak Hill, an amphibian  
16 ship that was brought out of Norfolk, Virginia also.

17 We used the Oak Hill as a command and control  
18 platform for Admiral Christianson's staff and also  
19 conducted transportation of the wreckage to the beach.  
20 We had landing craft on board that could handle the  
21 wreckage and helicopters to ferry wreckage and  
22 personnel around. It had medical and dental facilities  
23 on board, it had berthing, it had showers, and I will  
24 explain why that was important. After Oak Hill came on  
25 scene we brought USS Grapple to that position where I

1 described where she was.

2 Later in September we relieved Oak Hill with  
3 the USS Trenton to provide the same services on scene.  
4 In all there were over 1,300 military participants,  
5 mostly from the Navy in this operation.

6 The shore facilities in Long Island were  
7 austere and over-crowded, obviously, there in the  
8 summertime. The Navy with its sea-based power  
9 projection was able to be able to bring all the  
10 logistics needed and run this operation from the sea  
11 for this great length of time.

12 Our mainstay of this operation was the ARS-50  
13 class salvage ship. Out there we had the USS Grapple,  
14 ARS-53, and USS Grasp, ARS-51. These are 255 foot  
15 ships, over 3,000 tons with a crew of about 100. On  
16 each of these ships there is -- of these 100 crew  
17 members there is about twenty-three divers.

18 In order for us to go around the clock and  
19 conduct diving operations, we needed to add another  
20 twenty divers to each of these ships. The ships are  
21 small, they are crowded, they are noisy by doing these  
22 operations around the clock.

23 It is very dangerous diving, and so what --  
24 we used the Trenton and the Oak Hill to berth the  
25 divers when they were not on their shifts and, so,

1 what -- we went to two twelve-hour shifts with about  
2 twenty divers on each ship.

3 I would like to explain now that the recovery  
4 techniques that we used on this process, and I have got  
5 a cartoon up here to explain it.

6 **(Next slide shown.)**

7 I mention where both the USS Grasp and USS  
8 Grapple were moored and anchored, the way we approached  
9 this operation was on both Grasp and Grapple we had  
10 installed an underwater vehicle, an underwater robot,  
11 if you will, that had cameras, sonars, robotic arms,  
12 propellers to drive it around.

13 It is an unmanned vehicle, it is driven by a  
14 person on the surface and it is controlled through a  
15 cable. These ROV'S we use extensively in deep ocean  
16 search and recovery, and they proved invaluable on this  
17 operation. The ROV would go down and investigate the  
18 site. When the ROV came across a victim, the ROV would  
19 stop, we would launch divers into the water and then  
20 recover the victim. It was a very quick, efficient  
21 method of using an ROV and man together.

22 Later on when we were starting to recover  
23 some of the large pieces of wreckage, the ROV would go  
24 down, the divers would look at the site before they  
25 would go down and they would know what tools and

1 techniques that they were going to use when they got  
2 down on the bottom. The divers would then lift the  
3 big, heavy pieces straight up from the bottom to the  
4 ship with a boom. The smaller pieces would be put into  
5 a wire mesh.

6 Because we were diving at 120 feet, we had  
7 decompression issues to consider, and while the divers  
8 were decompressing the ROV would remain on the bottom  
9 picking up pieces, putting them in baskets, or  
10 determining what the next operation for the divers  
11 would be.

12 This is how we approached the surface supply  
13 diving under both the Grasp and the Grapple. In  
14 addition to that, we had literally thousands of  
15 contacts out there that we had to investigate with  
16 mobile dive teams.

17 It was extremely important on that debris  
18 field map that I showed you earlier that we know  
19 exactly where each of those dots are. The navigation  
20 system that we used with our search equipment is  
21 accurate to within about three yards.

22 We then use a couple of specifically military  
23 pieces of equipment in the recovery phase. On the  
24 small boats we had a hand-held military global  
25 positioning system, navigation system, GPS, that

1        allowed -- that fixed the small boats' position to  
2        within about two to three yards.

3                A small boat would go out, we would drop a  
4        weight on the bottom to a buoy on the surface at the  
5        exact position of where the target was to be  
6        investigated. A diver would descend down the line on  
7        the bottom. If I had a two yard error from the navi --  
8        from the debris field plot and a two yard error on  
9        this, I could be off as much as twelve to fifteen feet.

10               On the best days out there, our visibility  
11        with the divers was about ten to twelve feet; on the  
12        worst days less than one foot. So, it was important  
13        not only to be in the right area, but also to be able  
14        to conduct a search.

15               so, the divers would go down and we used the  
16        ordinance detectors that we use in the military to  
17        detect underwater ordinance, basically what we call  
18        hand-held sonars. In these the divers would come down  
19        at the bottom of their descent line, do a 360 degree  
20        sweep and swim out to the areas that they would find,  
21        as you can see on the chart depicted there.

22               One of the issues that we did have to contend  
23        with on this was that all evidence was treated as  
24        evidence and a chain of custody was maintained by the  
25        FBI.

1                   **(Next slide shown.)**

2                   There was just one dive team out there and  
3                   there was one consolidated dive team led by the Navy.  
4                   We were fortunate enough to be offered the assistance  
5                   of our civilian counterpart divers from the New York  
6                   City Police, the New York State Police, the Suffolk  
7                   County Police, the Fire Departments from New York City  
8                   and Suffolk County and dive teams from the FBI.

9                   There were over twenty-one Navy diving  
10                  commands that contributed divers to this operation. In  
11                  total, there were over 375 divers in New York for this  
12                  operation, 225 of them being Navy divers.

13                 Just briefly, going on to the recovery of the  
14                 wreckage, we initially started to recover wreckage as  
15                 it became necessary for us to pick up large pieces of  
16                 the wreckage to look under those wreckage for the  
17                 victims .

18                 Victim recovery was our number one task, our  
19                 number one priority from the start of this operation to  
20                 the end of this operation when we completed it ten  
21                 months later in the trawling phase. But, in order to  
22                 look under the wreckage, it was necessary to pick it up  
23                 off the bottom.

24                 To do this, it made much more sense to  
25                 recover the wreckage. In the upper right-hand corner

1 of the picture on this, you see a small wire mesh  
2 basket in the forefront. That was the type of basket  
3 that we used to put the smaller pieces in. The back  
4 shows larger pieces of fuselage that was rigged  
5 directly from the divers down on the bottom and picked  
6 up and put on the deck of the ship.

7 At the end of the operation, divers were not  
8 picking up pieces like this, but rather were picking up  
9 pieces and putting them in the canvas bags that they  
10 carried down, pieces the size of your hand, the size of  
11 wallets.

12 **(Next slide shown.)**

13 This next picture shows the largest piece  
14 that we recovered during this operation. This was a  
15 piece of the starboard wing. It measured about eighty  
16 feet by thirty feet by twelve feet. It was recovered  
17 under the USS Grasp, all rigged by divers under water  
18 in very limited visibility and brought up to the  
19 surface and put on board the ship. We had to cut the  
20 wing in three pieces to transport it to the beach, and  
21 from the beach to the hangar.

22 In addition to the two salvage ships, we had  
23 a small tug that we brought with us on board the USS  
24 Oak Hill and later on the Trenton. This allowed us to  
25 conduct recovery at remote sites from the salvage

1 ships, but still needing a large lift capability, and  
2 this small tug had a ten ton capability to pick debris  
3 off the bottom.

4 This goes to diving operations now, Mr.  
5 Chairman. Diving operations on both Grapple and Grasp  
6 were conducted around the clock. Scuba diving was  
7 conducted during daylight hours only. As I said  
8 before, there were over 375 divers assigned on this  
9 operation. 225 of them were Navy divers.

10 The maximum number of dives we had in one day  
11 was 175 divers in one day, 130 of those being Navy  
12 divers. The depth of the operation was fairly uniform  
13 at 120 feet. The bottom temperature was about the  
14 upper 40's to 50 degrees. Scuba diving we limited to  
15 fifteen minutes so that they would not need to  
16 decompress in the water, and we averaged around one  
17 hour bottom time for the surface supplied diving.

18 We did suffer some set-backs with weather out  
19 there, the largest being Hurricane Edward which came by  
20 and shut the operation down for a few days.

21 I would just like to mention what it is like  
22 for the divers under water there. It is a very large  
23 aircraft. When it breaks up like this it is extremely  
24 dangerous. There are hundreds of miles of electrical  
25 cable, the wreckage is very sharp, razor sharp, there

1 is limited visibility.

2 We have decompression problems that we have  
3 to deal with, and on top of that there was the very  
4 jaunting task of recovering the victims from the bottom  
5 of the ocean.

6 In all, as you said in your opening comments,  
7 Mr. Chairman, we conducted 677 surface supply dives for  
8 over 856 hours. These were done solely by the military  
9 divers, the Navy divers off of Grasp and Grapple. We  
10 conducted 3,667 scuba dives for 917 hours. This was  
11 done by this consolidated dive team of both Navy and  
12 civilian divers.

13 Just as important as the diving, we spent  
14 over 110 days on the bottom of the ocean with ROV'S.  
15 We had three ROV'S out on scene; one on Grasp, one on  
16 Grapple and one on Pirouette that was later transferred  
17 to the motor vessel, Marian C.

18 One point just to -- as a point of  
19 comparison, the Navy's number one salvage ROV is the  
20 ROV Deep Drone which is shown in the upper left-hand  
21 corner. In this particular operation, Deep Drone spent  
22 over two and a half times the bottom time on TWA 800 as  
23 it did on the Challenger, the Space Shuttle Challenger  
24 recovery.

25 In November it became apparent that we were

1 having limited return with the divers, and we were  
2 having more and more trouble with weather. It was  
3 playing in the diving operations. The Navy made  
4 recommendations to the National Transportation Safety  
5 Board on how to continue this operation, and it was  
6 selected that we would conduct a scallop trawling  
7 operation starting in November.

8 In all, we had five scallop trawlers, four  
9 operating at one time. In this picture here, we have a  
10 picture of the fishing vessel Kathy Ann and the fishing  
11 vessel Christian/Alexa, all contracted out of both New  
12 Jersey and Massachusetts, and they stayed on station  
13 basically from 4, November until 30, April.

14 **(Next slide shown.)**

15 This picture represents what we did in the  
16 trawling effort, and at some areas we trawled the  
17 bottom, and we kept trawling until we did not recover  
18 anymore debris, in some areas where we trawled over  
19 thirty times.

20 The area we actually trawled in the upper  
21 left-hand corner is forty and a half square miles,  
22 about forty-one square miles. This compares to the  
23 area of search that we initially laid out at about  
24 twenty-five square miles.

25 In the trawling, we conducted 13,000 trawl

1 lines for over 19,000 miles. To put this in  
2 perspective, if that trawling vessel was laying its  
3 nets down there, it would be sweeping one side of an  
4 interstate from Boston to Los Angeles and back seven  
5 times.

6 I have got a video here that I would like to  
7 show. Before I run that, at the end of the trawling  
8 operation we conducted an ROV quality assurance  
9 inspection on eighty-five sites to ensure that there  
10 was no wreckage left. Of those eighty-five sites, one  
11 site yielded one small piece of wreckage. At each site  
12 we put the ROV down, we used its sonar and its camera,  
13 and inspected a circle of about 100 yards.

14 If I could run that video?

15 **(Videotape shown.)**

16 CHAIRMAN HALL: Could you describe what we  
17 are looking at there, Captain?

18 WITNESS McCORD: This is a video from an ROV,  
19 an underwater vehicle, and it is just showing the  
20 bottom of the ocean and showed some marine life, some  
21 shells, and that was all we found in any of these sites  
22 that we investigated. There was no wreckage of the --  
23 left on the bottom at the end of this trawling  
24 operation.

25 Mr. Chairman, in summary, this operation this

1 was one of the largest divers-assisted salvage  
2 operations ever conducted. All 230 victims have been  
3 recovered and probably well in excess of 95 percent of  
4 the aircraft has been recovered. 4,344 dives were  
5 conducted for a bottom time of 1,773 hours. 2,679  
6 hours of ROV underwater time was conducted.

7 Mr. Chairman, the Navy was honored to assist  
8 our nation in the aftermath of this terrible tragedy,  
9 and that concludes my comments.

10 CHAIRMAN HALL: Captain McCord, thank you for  
11 that presentation. I wanted to have you here so that  
12 the public had an understanding of the magnitude we  
13 went to on the recovery of the wreckage and, of course,  
14 the important recovery of the victims.

15 I just have a few clarifications that I would  
16 like to ask you. We were able to complete this without  
17 any substantial -- without any loss of life. Were  
18 there any injuries to any of the individuals that were  
19 participating in the dives?

20 WITNESS McCORD: Mr. Chairman, in -- with  
21 those over 4,000 dives we had approximately sixteen  
22 cases of decompression sickness that we had to treat in  
23 the recompression chambers on site, which is what we  
24 considered a very remarkable aspect.

25 One of our primary concerns was the safety of

1 the divers because of the hard work that we were doing,  
2 and safety was paramount in this operation. We were  
3 very proud of the low numbers of decompression  
4 sicknesses that we solved, or had in this case.  
5 Decompression sickness is something like the bends that  
6 you have talked about and heard about in the movies.

7 We also had two broken bones on the Navy  
8 team, a broken jaw and a broken collar bone. This was  
9 from working around the rough waves out there. So, the  
10 police divers also suffered some injuries going through  
11 the very rough surf zone going out of Moriches. But,  
12 no life threatening injuries, and it was very safely  
13 conducted.

14 CHAIRMAN HALL: Well, I appreciate that,  
15 Captain. I went out on the ships myself and, clearly,  
16 the individuals that performed these dive operations  
17 were endangering their own safety in conducting them,  
18 and we appreciate their work and the work of all the  
19 individuals .

20 Could you tell us again how much of the ocean  
21 floor was searched and examined during the recovery of  
22 the wreckage from the accident aircraft?

23 WITNESS McCORD: Yes, sir. We searched --  
24 the initial search area was about a five by five mile  
25 box, twenty-five miles. We then conducted two other

1 searches along the flight path going back towards the  
2 airport, about another twenty-five square miles back  
3 that way, and then another twenty-five miles further  
4 out -- twenty-five square miles further out. So, a  
5 total of about seventy-five square miles was our  
6 initial search box.

7 After each of the storms we brought the side  
8 scan sonar back out there to conduct -- to continue  
9 searching in these areas to make sure that we -- the  
10 storms did not move any of the debris around, or we  
11 knew where all the wreckage was on the bottom.

12 so, we continued the search, and probably  
13 well over 150 square miles is what we searched out  
14 there in the ocean.

15 CHAIRMAN HALL: These remote operated  
16 vehicles all have video capability?

17 WITNESS McCORD: The searching was done using  
18 the sonar. The ROV'S were used to investigate the  
19 bottom in specific areas that were identified by the  
20 sonar that we should go and look.

21 CHAIRMAN HALL: All of those videos have been  
22 maintained, is that correct?

23 WITNESS McCORD: Yes, sir. All those videos  
24 have been turned over to the NTSB.

25 CHAIRMAN HALL: Thank you. In your opinion,

1 do you have any idea how much of the wreckage was  
2 recovered and brought to the hangar at Calverton?

3 WITNESS McCORD: Mr. Chairman, when we  
4 started the trawling operations in November, we went  
5 through the holidays over the winter and trawled until  
6 April . It is our estimation that that trawling effort  
7 recovered no more than about two tons of wreckage,  
8 which is slightly over one percent of the aircraft.

9 There is probably very, very little left in  
10 the ocean, much less than was already recovered by that  
11 trawling effort. We were basically unable to recover  
12 any out there.

13 So, my own guess off the top of my head is  
14 probably a good ninety-eight percent. Over ninety-  
15 eight percent of the aircraft was recovered, and most  
16 of it by -- a majority of it, ninety-seven, ninety-  
17 eight percent by the divers.

18 CHAIRMAN HALL: Since you are in the business  
19 of recovering aircraft from oceans all over the world,  
20 and you stated that your organization is involved in  
21 recoveries monthly, could you tell me, is trawling a  
22 normal recovery operation?

23 WITNESS McCORD: No, sir, trawling is not a  
24 normal recovery operation. This was not a normal  
25 operation. We do a lot of aircraft recovery, and

1 normally we are in and out. We get something that the  
2 investigators can clue on very quickly.

3 We have never been involved in an operation  
4 where we had to get this much of an aircraft back. So,  
5 that is why we went to these extreme measures of using  
6 trawling to basically drag and scour the entire bottom  
7 as thoroughly as we did.

8 CHAIRMAN HALL: Has your organization ever  
9 been involved in a more thorough or extensive recovery  
10 operation?

11 WITNESS McCORD: The only one I think that  
12 would be in comparison would probably be the Space  
13 Shuttle Challenger, but I would say that this one, from  
14 the effort that was put in and the amount of wreckage  
15 that was recovered, probably dwarfs that one, also.

16 CHAIRMAN HALL: Did the recovery of the  
17 victims hamper the wreckage recovery?

18 WITNESS McCORD: Well, they didn't hamper the  
19 recovery, Mr. Chairman. The victim recovery was our  
20 number one priority. The members of the team, the  
21 divers, all the support people there were totally  
22 dedicated to recovering the victims throughout the  
23 entire operation; not just the Navy divers, the  
24 civilian divers, but even the trawling captains, too.  
25 That was our number one priority. It did not hamper

1 us . It was just another aspect of the salvage  
2 operation that we had to conduct at that time.

3 CHAIRMAN HALL: Okay. You mentioned, of  
4 course, that the hurricane went through. Do you think  
5 that had any effect on the wreckage locations that we  
6 got either before or after that?

7 WITNESS McCORD: We had several storms that  
8 went through, and we put current profilers in the ocean  
9 during the storms when we were chased out of there, and  
10 we looked at the current profile on the bottom.

11 Basically this is a tidal area in the  
12 southern part of Long Island, and though the waves were  
13 fairly fierce during these several storms that we had  
14 go through there, it was mostly in a cyclical manner.  
15 so, it would move it one way and move it back the other  
16 way.

17 so, when we went back and did side scan sonar  
18 out there, we found most of our targets. They weren't  
19 necessarily in the same spot, but we came back and  
20 found all the targets that we had from before the  
21 storm.

22 CHAIRMAN HALL: Very well. Well, Captain, I  
23 appreciate very much your being here this morning  
24 making this presentation, and let me thank you again on  
25 behalf of the National Transportation Safety Board, and

1 I am sure the families as well as the American people  
2 for the dedication of the individuals that were  
3 involved in this recovery. It was a job well done.

4 WITNESS McCORD: Thank you, sir.

5 CHAIRMAN HALL: You are excused, Captain.

6 WITNESS McCORD: Thank you.

7 CHAIRMAN HALL: Before we move to the next  
8 witness, which Witness Panel will include the  
9 investigation of recorded data, we will take a break.  
10 This session will continue again promptly at 10:45. We  
11 stand in recess until 10:45.

12 (Whereupon, **a brief recess was taken.**)

13 CHAIRMAN HALL: We will reconvene this  
14 hearing of the National Transportation Safety Board.  
15 Before I ask Mr. Dickinson to call the next witness, I  
16 would like to take this opportunity to thank the City  
17 of Baltimore and the Baltimore Convention Center  
18 providing the facilities for this hearing.

19 Specifically, I would like to thank Mr.  
20 Albert Mills, the Security Officer here. Mr. Mills  
21 just escorted our free speech guest out. In the  
22 process, one of the media cameras that was escorting --  
23 traveling along with Mr. Mills and the escort, swung  
24 around and sprained -- damaged his hand.

25 Mr. Mills has now got an ace bandage around

1 his hand, and I guess you are the first casualty of  
2 this hearing. We hope we don't have anymore, Mr.  
3 Mills. We appreciate you exercising your  
4 responsibilities, and we appreciate the citizens of the  
5 great City of Baltimore for hosting this most important  
6 hearing.

7 Mr. Dickinson, would you please call the next  
8 witness and swear that individual in?

9 MR. DICKINSON: Thank you, Mr. Chairman.  
10 John, please stand up.

11 Whereupon,

12 **JOHN CLARK,**  
13 was called as a witness by and on behalf of the NTSB,  
14 and, after having been duly sworn, was examined and  
15 testified on his oath as follows.

16 MR. DICKINSON: Thank you. This is Mr. John  
17 Clark. He is the Deputy Director for the Office of  
18 Research and Engineering for the National  
19 Transportation Safety Board, and his complete biography  
20 is also included on our web page today. Mr. Clark?

21

22

23

24

25

**DIRECT EXAMINATION**

1  
2 WITNESS CLARK: Good morning, Mr. Chairman,  
3 ladies and gentlemen. In an airplane accident  
4 investigation, one of the first tasks for us is to  
5 define the motion of the airplane and determine the  
6 sequence of events related to the accident. We will  
7 usually use any information available to us, especially  
8 the recorded data.

9 I am going to present some of that  
10 information about Flight TWA 800 and describe how we  
11 handled the data and what that data told us about this  
12 accident. This data were gathered by several of the  
13 Safety Board's investigative groups, including the  
14 Airplane Performance Group, Flight Data Recorder Group  
15 and the Cockpit Voice Recorder Group.

16 Those groups were staffed by NTSB Group  
17 Chairmen, each a specialist in his field and employees  
18 from the various parties to the investigation. We will  
19 have a short video as an overview.

20 CHAIRMAN HALL: Mr. Clark, I would appreciate  
21 it if you would give me some notice. Is this the video  
22 now?

23 WITNESS CLARK: **No**, this is an overhead view  
24 of the radar data.

25 CHAIRMAN HALL: All right, very good.

1 WITNESS CLARK: So, we are okay.

2 (Slide shown.)

3 This animation is derived from recorded radar  
4 data. It is an overhead view and shows the ground  
5 track of TWA 800 from take-off at JFK. The animation  
6 will continue in a moment to the position at which the  
7 center wing tank exploded. The animation is presented  
8 three times faster than real time.

9 Later in this animation you will see the  
10 ground tracks of several other airplanes and a surface  
11 vehicle appears. We will show only a small segment of  
12 those tracks, even though they were present before and  
13 after the explosion. We will end all of the tracks at  
14 the time of the explosion so we can show the relative  
15 positions of the various airplanes.

16 You can see the Navy P-3 moving through the  
17 area at 20,000 feet to the southeast. A thirty naut  
18 target was present. It appeared up near the coast and  
19 continued on out of radar coverage over several  
20 minutes, or many minutes later. USAir is flying  
21 overhead and is approaching - and will fly in back of  
22 TWA 800.

23 TWA 900 is about eight miles behind, USAir is  
24 about 8,000 feet above and the Navy P-3 is about 6,000  
25 feet above flight 800.

1                   **(Discussion off the record.)**

2                   We started receiving print-outs of radar data  
3                   from the FAA by Thursday morning, the day after the  
4                   accident. We received magnetic tapes of data late that  
5                   afternoon, and by the mid afternoon on Friday we had  
6                   recovered large amounts of radar data into our computer  
7                   files.

8                   In the subsequent days we received more data  
9                   from FAA, military and private facilities. Let's go to  
10                  the first view graph.

11                  **(Slide shown.)**

12                  This map shows the location of the pertinent  
13                  radar sites. Air route traffic control centers use  
14                  long range radars as they control airplanes over large  
15                  sections of the country. Center radars can track  
16                  airplanes out to about 200 nautical miles in complete  
17                  sweeps or revolution about every twelve seconds. Thus ,  
18                  each radar site can provide updates for a given  
19                  airplane every twelve seconds.

20                  There were three long range radar sites that  
21                  were receiving signals from Flight 800. They were  
22                  located at Trevos, Pennsylvania, Riverhead, New York  
23                  and Northborough, Massachusetts.

24                  Those radar sites feed data into air route  
25                  traffic control centers at Boston, New York and

1 Washington. We receive large volumes of recorded data  
2 from those facilities. Those radar sites also feed  
3 into NORAD and Navy facilities. Riverhead radar also  
4 feeds into a private facility operated by Sikorsky  
5 Aircraft.

6 New York Air Traffic Approach Control uses  
7 airport surveillance radars, commonly called ASR'S, to  
8 monitor air traffic in the New York City area and the  
9 Long Island area. ASR'S can track airplanes out to  
10 about sixty miles and can complete a sweep every 4.7  
11 seconds.

12 There were four airport surveillance radars  
13 receiving signals from Flight 800. They were located  
14 at Islip, JFK Airport, Newark and White Plains, New  
15 York. On average, we were receiving radar data from  
16 Flight 800 about once every second.

17 Radar data is received in two forms,  
18 secondary and primary returns. A secondary radar sends  
19 a radio signal out that reaches an airplane. An  
20 airplane equipped with a transponder, an electronic  
21 device, detects the radar's secondary signal and  
22 returns a coded message to the radar antenna. That  
23 return is called a secondary return. Secondary returns  
24 include altitude and identification information that  
25 help define -- and information that help define the

1 airplane's position.

2 The primary transmitter sends out a radar  
3 signal that can reflect off of an airplane and return  
4 to the radar receiver as a primary return, or a skim  
5 paint. There are no identification or altitude data  
6 associated with primary returns.

7 Parts from airplanes such as doors or  
8 propellers that may separate are also frequently seen  
9 on radar in our business. Radars are not perfect.  
10 Sometimes we see things other than airplanes on radar  
11 scopes. We have seen trucks, ships, flocks of birds,  
12 radio towers, weather and smoke, for example.

13 Sometimes reflections from buildings near the  
14 radar site or other structures create false targets.  
15 An example is when a return from an airplane is  
16 reflected by a building, thus resulting in both a good  
17 return for the airplane and a false return that shows  
18 the airplane to be somewhere else.

19 **(Next slide shown.)**

20 This graph shows some of the data that were  
21 recovered. The vertical axis represents the distance  
22 south of Islip radar. The horizontal axis represents  
23 the distance east of Islip radar.

24 CHAIRMAN HALL: Could you identify those  
25 things as you describe them, or someone -- Charlie

1 could on the screen, so --

2 WITNESS CLARK: Okay.

3 CHAIRMAN HALL: -- people observing this can  
4 follow what your description is, please, Mr. Clark?

5 WITNESS CLARK: Certainly.

6 CHAIRMAN HALL: Okay.

7 WITNESS CLARK: The vertical axis represents  
8 the distance south of Islip radar. The units are in  
9 nautical miles. The horizontal axis represents the  
10 distance east of Islip radar. Most of the data is  
11 between ten and fifteen -- or, ten and twenty miles  
12 east of Islip radar, for example.

13 The Flight 800 track contains multiple sets  
14 of secondary returns from four airport surveillance  
15 radar sites and three center radar sites. Also, the P-  
16 3 track consists of multiple primary data sets from the  
17 radar site. Again, the P-3's transponder was not  
18 operating, so we only have the skim paint, or the  
19 primary returns for that airplane.

20 There are large numbers of primaries that do  
21 not form tracks. We will point out several.

22 **(Next slide shown.)**

23 Okay. In actuality, you can see those types  
24 of single hits all over that graph. They just appear  
25 at random for one or two returns, and then disappear.

1 That is a perfectly normal occurrence for radar data,  
2 especially older units such as the Islip model which is  
3 an ASR-8 radar.

4 On this graph there are two heavy  
5 concentrations of primaries that come for the next  
6 twenty minutes of recording, mostly from Islip radar.  
7 The two trails are from the two main events of the  
8 Flight 800 accident. The field to the left is  
9 consistent with the explosion, and the field to the  
10 right is consistent with the final major break-up, or  
11 the fireball.

12 Please note that you are looking at twenty  
13 minutes of data. If I were to present this data on a  
14 radar sweep, by radar sweep basis, you would typically  
15 see a few returns every 4.7 seconds. In many sweeps  
16 data would not be present over that next twenty  
17 minutes.

18 It is possible that we are seeing light  
19 debris drifting downwind, or possible thermal  
20 signatures in the atmosphere. Those signatures may be  
21 created by the explosion or the fireball. The drift  
22 speed and the direction of these primaries are  
23 consistent with the reported winds of seventeen to  
24 twenty nauts from the northeast to the southwest.

25 The aft section of the airplane is tracked

1 through the groups of primaries to its location in the  
2 water. We could identify several primaries that we  
3 believed to be that aft section. We can also track  
4 several primaries of the forward section to its  
5 location in the water.

6 In summary, we have excellent position and  
7 altitude data before the explosion, and we have good  
8 position data after the explosion.

9 CHAIRMAN HALL: I assume that the thirty naut  
10 track is on the -- is about on the surface?

11 WITNESS CLARK: That's what -- we assume that  
12 to be -- yes.

13 CHAIRMAN HALL: Because of the speed?

14 WITNESS CLARK: Yes, the speed, yes.

15 **(Pause.)**

16 We've been -- you have been hearing about  
17 red, yellow and green zones, and Captain McCord showed  
18 you some of the lay-out of their recovery area. There  
19 were three areas -- three areas of ocean where parts  
20 from Flight 800 were found. We have chosen to call  
21 them the red, yellow and green zones.

22 We have color coded the zones in the  
23 corresponding sections of the 747 in this graph to  
24 better correlate the airplane sections to their  
25 recovery zones.

1           I would point out that this chart does not  
2 show the motion of those parts; that is, the yellow  
3 section did not move down and to the left. I will show  
4 you those motions later.

5           Numerous pieces of the airplane separated at  
6 the time of the explosion and fell in the red area.  
7 Wreckage recovered from the red zone consisted of parts  
8 from or near the wing center section tank, such as a  
9 piece from the front spar, the keel beam and air  
10 conditioning units which are located directly under the  
11 center wing tank and seats and fuselage structure from  
12 just above and forward of that tank.

13           Most of the wreckage was found concentrated  
14 in a small section of the red area. The forward  
15 seventy foot section of the fuselage came off within  
16 seconds of the explosion and fell in the yellow area.  
17 The remaining aft portions of the airplane with the  
18 wings and engines in place flew alone for about fifty  
19 seconds and then fell in the green area. Most of that  
20 wreckage was found concentrated in a small section of  
21 the green area.

22           **(Next slide shown.)**

23           We conducted ballistic trajectory studies to  
24 help us understand how parts separated from the  
25 airplane and ended up in those debris fields. The

1 ballistic trajectory is the path of a falling part that  
2 is affected only by gravity and friction -- to us that  
3 is drag -- and wind.

4 This chart shows how wind, shape and weight  
5 affect the trajectory of various parts. In this case,  
6 I am showing an airplane flight path in a cross-wind.  
7 The horizontal line is the flight path and the vertical  
8 line represents the cross-wind component.

9 If a part separated from an airplane, it  
10 would -- let's start off if there were no winds present  
11 and if a part separated from the airplane, it would  
12 fall along the flight path. It would land on that  
13 line. Heavy, low drag parts such as engines would have  
14 greater throw. That is, they would go further, fall  
15 faster and remain aloft for a shorter period of time.

16 Lighter, high drag parts such as fuselage  
17 skins and insulation would have less throw and they  
18 would not travel as far along the flight path. Some  
19 parts would fall for many minutes and land almost  
20 directly under the point of separation if there were no  
21 wind.

22 In the presence of a cross-wind heavy, low  
23 drag parts will tend to continue along the original  
24 flight path, but would drift slightly downwind. Light  
25 weight, high drag parts can drift long distances

1 downwind as they settle to earth. Parts that have  
2 trajectory characteristics that are between engines and  
3 insulation would fall somewhere on that parabolic  
4 curve.

5           If a heavy, low drag part were ejected from  
6 the airplane at a high speed, it would not necessarily  
7 fall on that curve. For example, if it were ejected to  
8 the left, it could move well to the north and then  
9 drift back with the wind to the south as it fell. It  
10 would most likely land above or on the north -- north  
11 of that parabolic curve in this case.

12           If a part were generating small amounts of  
13 lift as it came down, it would tend to fly and would  
14 not follow a ballistic flight path and therefore  
15 probably would not land on the parabola. Some parts  
16 can assume an attitude, and as it comes down they may  
17 glide a little bit.

18           From 14,000 feet small amounts of lift could  
19 easily move the landing position of a part an  
20 additional one-half mile. Some parts are capable of  
21 generating lift that would cause it to move even  
22 further off of its predicted point.

23           (Next slide shown.)

24           This graph shows ballistic trajectories of  
25 several parts that were separated at the time of the

1 explosion. It is an overhead view looking down, so we  
2 were looking at the ground track. Again, the vertical  
3 axis is distance south of Islip radar and the  
4 horizontal axis is distance east of Islip radar.

5 In each case it is assumed when we did our  
6 calculations that only drag was affecting a part and  
7 not lift. It is also assumed that each part fell off  
8 of Flight 800 and was not ejected at a different speed.  
9 Each symbol in one of those tracks represents ten  
10 seconds of motion.

11 The tracks curve because the wind is changing  
12 direction as the parts fall. At higher altitudes the  
13 wind is more northerly, and as the parts -- and the  
14 parts will drift southerly. At lower altitudes the  
15 wind is more out of the west and the parts will drift  
16 in a more easterly direction.

17 The heavier parts, like the one with the  
18 motor attached, will move further along the flight  
19 path, and as it slowed down would drift some with the  
20 wind. A piece of fuselage skin would not come down as  
21 fast and therefore would drift with the wind for a much  
22 longer period of time.

23 In this graph most of the predicted  
24 separation points -- the ends of those tracks are  
25 positioned at the point where the part was found. For

1 example, the pointer --

2 (Demonstrating.)

3 At that point is the point in the water where  
4 that particular part was found. Thus , the beginning of  
5 the track would be consistent with the point where the  
6 part separated from the airplane. That method of  
7 positioning all of those tracks is acceptable as long  
8 as the part was not ejected and did not generate lift.

9 In this graph most of the predicted  
10 separation points are located a small distance after  
11 the last Islip primary, which is shown as an "x." That  
12 is about one second after the Islip primary. Of course  
13 there is some scatter in that grouping because all of  
14 the parts would not be purely ballistic, and there  
15 would be some latitude in knowing exactly where some of  
16 the parts were recovered.

17 Some of the parts that would be grouped in  
18 this area, this small area of one second after the  
19 Islip primary, would be, for example, the air cycle  
20 machines and the keel beam from under -- and ram air  
21 ducts -- from under the center wing tank; some of the  
22 structure and tracks from the lower forward cargo bay  
23 just ahead of the wing tank; the fifth right side door,  
24 for example; and some seats and fuselage structure from  
25 just forward and above the center wing tank.

1           This graph tells us that many substantial  
2 parts and fuselage structure, as well as many center  
3 wing tank parts, were separated from the airplane in a  
4 very short time at that point. It also indicates that  
5 the forward section --

6           (Pause.)

7           We also have the trajectory calculations of  
8 the forward section. This graph also indicates that  
9 the forward section was probably completely separated  
10 from the aft section of the airplane several seconds  
11 after the explosion.

12           The aft section of the airplane, including  
13 the wings and engines, travelled for about 2.2 nautical  
14 miles after the explosion. A ballistic trajectory for  
15 those parts could not reach the -- could not reach from  
16 the initial separation point we are showing here to the  
17 point where they were found in the water.

18           That fact and the radar data showing the  
19 movement of the aft section indicated to us that the  
20 airplane had to continue to fly after the explosion and  
21 after the loss of the nose section.

22           There were numerous parts that continued to  
23 separate over the next several seconds up to the point  
24 noted for the fuselage section. Our calculations show  
25 that most of the big pieces of the airplane were in the

1 water within fifty to ninety seconds of the explosion.

2 Now, we will show a video in a moment,  
3 looking at those trajectories. In that video we have  
4 picked out some key pieces. You will see the aft  
5 section that will move into the green area, you will  
6 see the forward section move into the yellow area.

7 The following parts will move into the red  
8 area: LF-14 (a) is a section of the keel beam; air  
9 cycle machine number one is the left front air cycle  
10 machine next to the keel beam under the center wing  
11 tank; CW-608 is a piece from the front wall of the  
12 center wing tank at span-wise beam three -- and we will  
13 get into those definitions in a minute.

14 LF-6(a) is a very large piece of lower  
15 fuselage skin in front of the tank.

16 (Discussion off the record.)

17 LF-6(a) comes from that area; RF-1 is a large  
18 piece of fuselage skin below the right side windows;  
19 and RF-32 is a small section of the fuselage below RF-  
20 1.

21 We will queue that video up here in a second  
22 to show those trajectories.

23 CHAIRMAN HALL: As I explained to the family  
24 members -- could we hold the video, please?

25 (Pause.)

1                   We will be showing a number of videos and  
2                   animations through the hearings that -- this one is not  
3                   as graphic as some -- but show the break-up of the  
4                   aircraft, and clearly I will pause before each video in  
5                   case any of the family members would choose to exit the  
6                   room.

7                   Mr. Clark, if you will then proceed with your  
8                   description and the next video.

9                   WITNESS CLARK:    Yes, sir.

10                  (Pause.)

11                  You will note that the aft section continues  
12                  to fly.  I will discuss that later.  Of course the red  
13                  parts come down at various places and at various speeds  
14                  based on their weight and shape.  That accounts for the  
15                  scatter in those parts.  The forward section is further  
16                  east, which is partially a result of the later time in  
17                  separation.

18                  This video is being played in real time.

19                  (Video presentation.)

20                  CHAIRMAN HALL:  Again, what do the various  
21                  colors signify?

22                  WITNESS CLARK:  The green line is the aft  
23                  section of the airplane.  It includes the wings, the  
24                  engines and the aft section.  The yellow line is that  
25                  seventy-foot forward section that separated, and the

1 red lines are the several parts of various sizes and  
2 weights from in and around the center wing tank.

3 I would point out that there were numerous  
4 other parts that we studied for their trajectory  
5 characteristics, and those are in the reports and in  
6 the docket. These are just some examples.

7 CHAIRMAN HALL: The information you went over  
8 previously outlines how you came with the calculations  
9 to produce this particular video?

10 WITNESS CLARK: Yes, sir.

11 (Video presentation continued.)

12 I think we can cut the video and proceed  
13 ahead.

14 (Pause. )

15 We will move into our next section talking  
16 about correlating all of the recorded data. Data were  
17 being recorded on the airplane and on the ground, so we  
18 know a great deal about the condition and the motion of  
19 the airplane until the explosion.

20 The flight data recorder records information  
21 about the operation of the airplane, such as pitch,  
22 roll, speed and thrust. The cockpit voice recorder  
23 records true conversations, radio transmissions and  
24 other noises that may reach the cockpit.

25 Air traffic voice recordings record

1       communications between the crew and the controllers,  
2       and air traffic radar recordings record position,  
3       altitude and identifying information, as we have  
4       discussed earlier. At the moment of the explosion,  
5       much of the recording stopped, except for basic  
6       position data from air traffic primary radar.

7                 One of the most important aspects of our work  
8       in the lab is to correlate the timing of all of that  
9       available data. This is to insure that we can properly  
10      sequence the events leading to the accident and events  
11      that may occur subsequent to the accident.

12                All of these data sources are time based, but  
13      unfortunately the clocks are not all set to the same  
14      time. However, there is sufficient commonality in the  
15      data to establish a time correlation.

16                Microphone keying -- that is, turning the  
17      microphones on and off -- leave signatures on the  
18      cockpit voice recorder and air traffic voice  
19      statements. Microphone keying is also recorded on the  
20      flight data recorder, so we can correlate the timing of  
21      all of these data sources.

22                The flight data recorder also records  
23      altitude, as do the eight radar sites. We can compare  
24      those altitudes which allows us to correlate the timing  
25      of all sources.

1                   **(Next slide shown.)**

2                   This graph shows one of the final time  
3                   alignments we achieved. The vertical axis is altitude  
4                   and the horizontal axis is time. On this graph we  
5                   presented altitude data from all of the radar sites and  
6                   the flight data recorder.

7                   The last transponder return came from Trevos  
8                   radar at 8:31 and 12 seconds. The last signature from  
9                   the FDR would have occurred after 8:31 and 12.26  
10                  seconds, one quarter second later. The CVR quit at  
11                  8:31 and 12.5 seconds.

12                  This correlation is consistent with the  
13                  trajectory study and the position of the last secondary  
14                  target on the radar maps. It is clear that all of the  
15                  recorded data ceased at nearly the same time.

16                  Beyond that time, we have no FDR data, CVR  
17                  data, or radar transponder returns. In fact, the very  
18                  next sweep of the radar generated only skim paints of  
19                  the airplane and parts that were coming off. It is  
20                  reasonable to assume that electrical power to many of  
21                  the airplane's systems were also lost at this time.

22                  **(Next slide shown.)**

23                  This is a graph of frequency and time.  
24                  Frequency is the vertical axis and time, again, is the  
25                  horizontal axis. It is from the -- near the end of the

1 CVR recording. The total time from side to side  
2 represents about 2.2 seconds.

3 A loud noise appears here and it is the last  
4 signature picked up by the cockpit area microphone. It  
5 is present for about one-tenth of a second and ends  
6 when the CVR quits at 8:31 and 12.5 seconds.

7 The color represents the amount of energy at  
8 any given frequency. The bright yellow represents high  
9 energy, which is consistent with the loud noise. We  
10 believe this signature is the result of the exploding  
11 center wing tank.

12 We conducted fuel explosion tests on an old  
13 747 at Brunting Thorpe, England. Our testing indicates  
14 to us that this signature that appears here is from the  
15 cockpit area microphone picking up vibrations  
16 traveling through the structure that were generated by  
17 the rupture of the center wing tank.

18 The microphone picks up vibrations whether  
19 they are airborne or whether the structure itself is  
20 vibrating. We found that the vibrations created as  
21 structure is tearing apart can travel through the metal  
22 fuselage at over ten thousand feet per second.  
23 Airborne sounds travel at about one thousand feet per  
24 second.

25 No other unusual noise signatures have been

1 found near the end of the CVR tape. Of significance,  
2 there were no signatures on the FDR that indicated to  
3 us that something was wrong until that last one-tenth  
4 of a second signature on the CVR. Thus , the very last  
5 signature of the CVR is to us undoubtedly the start of  
6 the structural break-up of the center wing tank.

7 (Next slide shown.)

8 The motion of the airplane is well defined  
9 prior to the explosion of the center wing tank. After  
10 the explosion there was little recorded data. After  
11 the explosion we are dealing with a severely damaged  
12 airplane. There were large changes in weight, the  
13 weight distribution and the aerodynamic properties.

14 The time history of the thrust is unknown.  
15 However, we simulate -- however, simulations show that  
16 thrust had a minimum effect on the continued fly-out of  
17 the aft section of the fuselage. The changes of the  
18 center of gravity to the forward section falling off  
19 and related aerodynamic changes would cause the  
20 airplane to pitch up in flying. That is, if it  
21 remained upright.

22 This graph, again, is of radar data with the  
23 vertical axis showing distance south of Islip and the  
24 horizontal axis showing distance east of Islip. The  
25 two balls are the last two second radar returns for

1 Flight 800. The nine diamonds are the primary returns  
2 that we picked out of that pile of data that we showed  
3 you earlier. We believe they represent the motion of  
4 the aft section of the fuselage.

5 The primary returns indicate that after the  
6 explosion the aft section of the airplane turned left  
7 to the north before hooking south toward the accident  
8 wreckage, or towards the wreckage site which is noted  
9 as a star. That is the point where the aft section of  
10 the fuselage was found in the water.

11 The primaries are erratically placed, which  
12 is normal for recording -- for radar recordings of  
13 unstable events. One of our simulation engineers  
14 developed several roll and pitch time histories that  
15 resulted in a simulated airplane flying near those  
16 radar points and arriving at the wreckage site. As is  
17 normal for these types of simulations, precisely  
18 matching position and time of all primary returns is  
19 not possible.

20 (Next slide shown.)

21 This graph shows the ground track of one  
22 simulation that tends to fit the radar primary even to  
23 the point of the uncharacteristic bend in the data.  
24 However, this simulation produced an adequate, but not  
25 one of the better matches of timing of the event.

1 Other simulations had better timing matches, but  
2 matching the primary positions were less precise.

3 In most simulations that obtained reasonable  
4 matches, the airplane had to roll to the left in climb  
5 and then start its downward descent. Therefore, we  
6 believe we have captured the general motion of the  
7 airplane after the explosion.

8 In this scenario the airplane had to  
9 initially roll to the left about fifty degrees and then  
10 start a roll back to the right until it rolled  
11 completely inverted and ended up in a vertical descent.  
12 The hook in the data was matched by the airplane  
13 rolling inverted to the right while pointed straight  
14 down.

15 The airplane was pulling out on a slight  
16 heading and a rolling heading off to the northeast that  
17 turned back to the south. The maximum altitude in this  
18 case was about 15,000 feet, and the maximum climb angle  
19 was about twenty degrees.

20 Now, we are -- this gets into the more  
21 graphic animations, and --

22 (Next slide shown.)

23 The following animation --

24 CHAIRMAN HALL: Well, let's pause a moment,  
25 and if there are any of the family members or others of

1 the audience that don't wish to view the upcoming  
2 video, please -- we will give you a moment to excuse  
3 yourself.

4 (Pause.)

5 Please proceed, Mr. Clark.

6 WITNESS CLARK: The following animation of  
7 Flight 800 will show our understanding of the motion  
8 from about forty-five seconds prior to the explosion,  
9 continuing through to water impact.

10 This video does not attempt to duplicate the  
11 airplane size, lighting conditions, visibility, the  
12 size or brightness of the explosion of the fireball, or  
13 other visual cues. That type of data is quite  
14 subjective.

15 Although there was restricted visibility  
16 along the surface at airports, visibility was reported  
17 good over the water. The sun was shining on the left  
18 side of the fuselage. That is the side toward Long  
19 Island.

20 At eight minutes and thirty-one seconds you  
21 will see the center wing tank explosion, the forward  
22 fuselage will separate a few seconds later and the  
23 remainder of the airplane will climb and turn left. It  
24 will reach a peak altitude of about 15,000 feet twenty  
25 seconds later and start a descending turn to the right

1 with increasing bank angle.

2 The flight will transition into a steep  
3 accelerating descent. Just before water contact, you  
4 will see a big fireball as the left wing starts to  
5 break away from the fuselage.

6 (Video presentation.)

7 The white line shows the previous flight path  
8 of Flight 800 as it came up from JFK Airport.

9 (Video presentation continued.)

10 I should have pointed out that this view was  
11 from out at sea looking over TWA inward towards Long  
12 Island. I would also point out that the nature of the  
13 flight of the forward section of the fuselage is  
14 unknown to us.

15 This next video uses a visual reference point  
16 from on shore. The upward angle of the flight path is  
17 actually about twenty degrees, but will appear steeper,  
18 about forty-five degrees.

19 The steeper angle is an illusion because the  
20 airplane is turning toward the viewer. If the airplane  
21 had continued moving directly across from the viewer,  
22 the viewer would have seen the true twenty degree  
23 flight path angle.

24 (Video presentation.)

25 Mr. Chairman, we believe we have accurately

1 defined the motion of the airplane and we have  
2 correlated all of the data. We see no evidence of any  
3 unusual events prior to the signature that appears on  
4 the CVR, and we also know that many parts separated  
5 immediately at the time of that first explosion.

6 That concludes my presentation.

7 CHAIRMAN HALL: Thank you, Mr. Clark. Mr.  
8 Clark, for the record, we failed at the beginning to  
9 have you identify yourself and briefly present your  
10 qualifications in terms of your years with the Board so  
11 that folks who were not familiar with you would know of  
12 your background. If you would do that, I would  
13 appreciate it.

14 WITNESS CLARK: Certainly. My name is John  
15 Clark. I am the Deputy Director of the Office of  
16 Research and Engineering. I have been at the Board for  
17 sixteen years, and prior to that I spent two years at  
18 Flight Safety designing simulators, and then thirteen  
19 years at Beach Aircraft prior to that designing  
20 missiles, airplanes and conducting accident  
21 investigation.

22 CHAIRMAN HALL: Are there questions from the  
23 Technical Panel for this witness?

24 (Pause.)

25 Mr. Crider?

1 MR. CRIDER: No, sir.

2 CHAIRMAN HALL: No. Very well. Well, we  
3 will move to the party tables. Now, this will be our  
4 procedures through the -- all the witnesses for the  
5 five days we are here, as once we have had the witness  
6 presentation, we have had an opportunity for the  
7 Technical Panel to ask questions, and we will then move  
8 to the parties before we then finish up with questions  
9 from the Board of Inquiry.

10 For the purpose of beginning this I am going  
11 to call on the party table to my right beginning with  
12 Crane Company Hydro-Aire, and to my left, Honeywell,  
13 Inc. I will call on you individually and ask you to  
14 identify yourself, and then if you have questions for  
15 him or that Mr. Chairman, we have no questions. I will  
16 then move to the next table.

17 I will rotate this sequence for future  
18 witnesses so everyone is not on first or on last. Once  
19 we have completed all the questioning from the party  
20 table, I will come back to ask if there are any  
21 additional questions. I would appreciate it if there  
22 are additional questions you have at that time if you  
23 would raise your hand and signify. Otherwise, I will  
24 move up to the Board of Inquiry for our questions.

25 so, we will begin the questioning of this

1 witness with Crane Company Hydro-Aire, and I would  
2 request if you could -- and I apologize for this, but  
3 evidently if you can remove the microphone and stand  
4 the cameras could see you and you could -- the  
5 viewing -- people who are viewing this event would have  
6 an opportunity to see the person answering the  
7 question.

8 That is your choice. If you would rather not  
9 be seen, you can remain seated, but if you would  
10 accommodate the viewing audience if you could stand and  
11 ask your question.

12 Crane Company Hydro-Aire?

13 MR. BOUSHIE: Yes, Ray Boushie, Crane Co. No  
14 questions, Mr. Chairman.

15 CHAIRMAN HALL: Okay, thank you. The  
16 International Association of Machinists and Aerospace  
17 Workers?

18 MR. LIDDELL: Yes, Mr. Chairman, Fred  
19 Liddell. We have no questions.

20 CHAIRMAN HALL: Thank you. Trans World  
21 Airlines, Inc.

22 CAPTAIN YOUNG: Yes, sir, Captain Bob Young.  
23 One question for Mr. Clark. You mentioned it before,  
24 and I just want to re-verify. No radar data showed any  
25 altitude after the event occurred. In other words, we

1 have no height finding radar, or any system that would  
2 show us the altitude of the parts of the airplane after  
3 the explosion. Is that correct?

4 WITNESS CLARK: That is correct.

5 CAPTAIN YOUNG: Thank you. TWA has no  
6 further questions at this time, sir.

7 CHAIRMAN HALL: Thank you, Mr. Young. The  
8 Federal Aviation Administration?

9 MR. STREETER: Lyle Streeter, sir. The FAA  
10 has no questions.

11 CHAIRMAN HALL: Boeing Commercial Airplane  
12 Group?

13 MR. RODRIGUES: Dennis Rodrigues. No  
14 questions from Boeing, Mr. Chairman.

15 CHAIRMAN HALL: Okay, and the Air Line Pilots  
16 Association?

17 CAPTAIN REKART: The Air Line Pilots  
18 Association has two questions, and I realize that  
19 during your presentation --

20 CHAIRMAN HALL: Captain, you are aware you  
21 could stand if you wanted to, but you are comfortable  
22 remaining seated if you prefer. I am only doing that  
23 on behalf of the viewing audience.

24 CAPTAIN REKART: Well, I have my notes and my  
25 questions here, and I am afraid that if I stood up I --

1 CHAIRMAN HALL: Okay, that's fine.

2 CAPTAIN REKART: -- wouldn't have access to  
3 them as readily, sir. You mentioned in your  
4 presentation that the track of the nose and the  
5 characteristics of the nose on its departure from the  
6 aircraft to the ground wasn't really addressed in  
7 your -- in the facts that you had.

8 Can you discuss a little bit more how you  
9 arrived at that behavior?

10 WITNESS CLARK: If you are referring to the  
11 spiraling motion of the forward section of the  
12 fuselage, that should not have been in there. We don't  
13 have data to support that, and typically we don't try  
14 to put that motion in unless we know specifically that  
15 it was there. That is an unfortunate addition to the  
16 animation I wish weren't there.

17 CAPTAIN REKART: Okay, could you also discuss  
18 for me why the nose section reaches the ground so much  
19 later than the aft section, and it appears that the aft  
20 section took about forty-nine seconds to make its  
21 descent, and then it was an additional forty-five  
22 seconds for the nose which is nearly twice as long.  
23 Could you discuss a little bit the parameters that went  
24 into that equation?

25 WITNESS CLARK: Well, there is a difference

1 in the weight of each section and the drag, or the  
2 size, or the shapes. For example, the nose section is  
3 relatively light with a large frontal area. That would  
4 be similar to putting your hand out of a car window and  
5 feeling a lot of pressure. It tends to slow the --  
6 what we call the terminal velocity of that part, the  
7 steady state speed that it will reach, and then as it  
8 falls to earth.

9 The aft section of the fuselage with the  
10 engines and the tanks and the fuel is more dense, if  
11 you will, and since it did remain - or appeared to  
12 remain in a stable attitude, aerodynamically-wise,  
13 small angles, it would tend to remain more streamlined,  
14 and once it started down and the nose pointed down it  
15 would pick up speed much more rapidly.

16 Some of the timing of the events, when the  
17 nose first came off we believe the aft section pitched  
18 up and slowed down a dramatic amount down to well in  
19 the 150-naut range, and then as it pitched over and  
20 rolled over and started down we think these speeds  
21 picked up well over two or three hundred nauts.

22 CAPTAIN REKART: Thank you. There was  
23 another area on the descent of the aft section of the  
24 aircraft where it showed several green pieces that were  
25 split off from the main portion of the aircraft. Can

1 you go into that a little bit, please?

2 WITNESS CLARK: That was based on trying to  
3 estimate the height of the fireball, and we will get  
4 more into that in the sequencing report. At that point  
5 we believe we picked up enough speed and went into an  
6 aerodynamic break-up.

7 That is where the aerodynamic loads on the  
8 wings were sufficient to cause it to break away from  
9 the fuselage. At that point we believe we spilled the  
10 fuel on the airplane into the atmosphere, creating a  
11 fuel -- creating a fireball.

12 CAPTAIN REKART: Thank you very much, Mr.  
13 Chairman.

14 CHAIRMAN HALL: Honeywell, Inc.?

15 MR. THOMAS: Hal Thomas. Honeywell has no  
16 questions, Mr. Chairman.

17 CHAIRMAN HALL: Thank you. Do any of the  
18 other parties -- do any of the parties have additional  
19 questions or follow-up questions for this witness?

20 (No response.)

21 If not, we will move up to the Board of  
22 Inquiry and call on Mr. Sweedler.

23 MR. SWEEDLER: I have no questions of this  
24 witness, Mr. Chairman.

25 CHAIRMAN HALL: Mr. Ellingstad? Dr.

1 Ellingstad, I apologize.

2 MR. ELLINGSTAD: Just one quick question, Mr.  
3 Clark. With respect to the radar data, you talked some  
4 about ghosts and false targets. Does the fact that we  
5 were dealing with radar from five or six different  
6 sources tend to assist the explanation for those kinds  
7 of phenomena?

8 WITNESS CLARK: It can, and in this case we  
9 may find a target that pops up on the radar screen from  
10 one radar site, and then we look at the data from the  
11 other radar sites to see if it is also there.

12 When it shows up on two or three of the five  
13 or six radar sites we have, we would believe we have a  
14 real object out there. When it only shows up randomly  
15 on one site and disappears, we usually consider that as  
16 a false target.

17 MR. ELLINGSTAD: Okay. Are you confident  
18 that we have exhaustively treated the radar data  
19 sources that were available?

20 WITNESS CLARK: I am. We -- the radar data  
21 as we see it makes sense. There is a lot of things  
22 that happen in radar that is just typical in the radar  
23 environment, and everything we see is no different than  
24 what we have seen in the past on other investigations.

25 MR. ELLINGSTAD: Thank you, Mr. Clark.

1 DR. LOEB: Mr. Clark, I do have one  
2 clarification that I would like to ask about, and that  
3 is the P-3. You had mentioned that the transponder was  
4 inoperative, and if memory serves me correctly I  
5 believe it did operate intermittently and gave us a  
6 couple of read-backs that helped us to verify that, in  
7 fact, it was the P-3. Is that correct?

8 WITNESS CLARK: Yes, we have two independent  
9 verifications . Air Traffic were controlling the  
10 airplane and brought him down from the coast of New  
11 England and handed him off into the -- I don't remember  
12 the facility that was working. I think it was Boston  
13 Center at that time.

14 But, the airplane was routinely handed off,  
15 so we could track him through those records. Then,  
16 also, within the data from Sikorsky radar we could  
17 track that primary target on the scope, and then to the  
18 south several minutes or fifteen minutes later the  
19 airplane started to make a turn and turned back to the  
20 north, and during that turn the beacon operated for one  
21 hit, and we can clearly identify the call sign and the  
22 altitude of the P-3 at that time.

23 DR. LOEB: Thank you.

24 CHAIRMAN HALL: Mr. Clark, I appreciate your  
25 presentation and the visual presentation that is

1 easier, obviously, than the charts, graphs and columns  
2 of data in trying to understand the motion of the  
3 aircraft for the individuals who aren't specifically  
4 trained in that expertise.

5 Is there anything else that you or the  
6 individuals that worked with you on this think is  
7 pertinent that should be brought up or discussed at  
8 this time?

9 (No response.)

10 WITNESS CLARK: No, sir.

11 CHAIRMAN HALL: Would you introduce the two  
12 individuals that worked with you on this, as well?

13 WITNESS CLARK: Well, I will be glad to. I  
14 will take the liberty to introduce several more here.  
15 Dennis Crider worked on much of the trajectory study  
16 and the simulations. He is an airplane performance  
17 engineer in the Vehicle Performance Division.

18 Mr. Charlie Pereira is a vehicle performance  
19 engineer in that same division. He worked to great  
20 lengths on all of the radar data; Mr. Dennis Grosse  
21 (sic) sitting behind me is one of our senior engineers.  
22 He has probably read out more recorders than anybody  
23 else in the world, and he was responsible for reading  
24 out the flight data recorder.

25 Jim Cash is over at the visualizer, and Jim

1 Cash is our CVR expert, and he was responsible for  
2 reading out the cockpit voice recorder and creating the  
3 transcript, and he is also responsible for conducting a  
4 lot of the explosion testing at Brunting Thorpe and  
5 around the country to capture additional signatures  
6 that may be showing up on the voice recorders so we can  
7 use those in future investigations.

8 CHAIRMAN HALL: And you all did your own  
9 independent analysis of this information that you  
10 acquired?

11 WITNESS CLARK: Yes, what we presented is  
12 primarily our investigation.

13 CHAIRMAN HALL: Very well. Well, I  
14 appreciate that, and obviously, Mr. Clark, you and the  
15 other technical staff will be here with us through the  
16 five days and if there is additional questions or  
17 information, we can explore it at that time. But, that  
18 is a very good presentation. I appreciate it.

19 We are now going to take a break for lunch  
20 before we go to our next witness and panel which is a  
21 presentation that will follow up on this investigation  
22 of the radar data that was presented by Mr. Clark which  
23 will deal with the wreckage examination and the  
24 sequence of the break-up.

25 I would like to announce for the families

1       that Mr. Jim Calstrom from the Federal Bureau of  
2       Investigation will be meeting with the family members  
3       in Room 307 during the lunch break and, so, if you  
4       would proceed as soon as this meeting is adjourned, or  
5       this hearing is adjourned for our lunch break to Room  
6       307, Mr. Calstrom is here to meet with you.

7                I appreciate everyone's attention and decorum  
8       this morning, and we will reconvene this hearing of the  
9       National Transportation Safety Board promptly at 1:00  
10      p.m. eastern standard time. We stand in recess.

11               (Whereupon, at 11:45 a.m. a luncheon recess  
12      was taken, to reconvene promptly at 1:00 p.m.)

13



1                   MR. DICKINSON: Thank you. Mr. Wildey is a  
2 National Resources Specialist. He has been with the  
3 Safety Board for twenty-two years. His experience  
4 includes investigations involving Aloha's 737 in 1988.  
5 He assisted in the Lockerby (sic) Pan Am Flight 101-103  
6 in 1989.

7                   He also was involved in the United 747 cargo  
8 door loss in Honolulu and the Sioux City investigation  
9 of DC-10. He has a degree in metallurgy and  
10 engineering from Virginia Polytechnic Institute and  
11 State University. Mr. Wildey.

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**DIRECT EXAMINATION**1  
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WITNESS WILDEY: Good afternoon, Mr. Chairman, ladies and gentlemen. In my presentation today I will discuss how the pieces of the airplane were identified, how the various mock-ups and reconstructions of the airplane were formed and the purpose and results of the Metallurgy and Structures Sequencing Group.

Also, at the end of my presentation I will discuss some of the possible causes of the break-up that were eliminated as factors in the accident.

The effort to identify how the airplane broke apart cannot really begin until a majority of the important structural pieces were recovered and identified. This task was done primarily by the engineers of the Structures Group and Fire and Explosion Group.

As each piece of wreckage was recovered from the ocean and brought to the hangar at Calverton on Long Island, these engineers examined it for tell-tale marks and identified it when possible. They also labelled the structural members found on the piece, made drawings, created a written description and cataloged the results with an enlarged set of notebooks and computer database.

1           As pieces were identified they were placed in  
2 a two-dimensional mock-up of the fuselage just as --  
3 such as you can see here in this photograph  
4 (demonstrating), and that is they were laid out on the  
5 ground and could be examined in this position.

6           Placement of the parts was guided by a grid  
7 taped to the floor. The grid contained fuselage  
8 station numbers that made it easier to determine where  
9 parts were located.

10           The effort to identify parts and place them  
11 in the mock-ups involved data connections directly to  
12 Boeing and the review of large numbers of drawings for  
13 details of construction methods, materials and  
14 component thicknesses.

15           Many drawings were hung on walls or on large  
16 plywood easels for ease of reference, and some full  
17 size drawings were placed directly on the floor with  
18 the pieces on them so that they could be matched to  
19 other nearby pieces.

20           The Fire and Explosion Group and the  
21 Structures Group also made several smaller scale three-  
22 dimensional mock-ups of the wing center section and the  
23 adjacent portions of the fuselage. These mock-ups that  
24 were constructed on scaffolding were small enough that  
25 the fractures were readily accessible and the various

1 interactions between pieces could be explored.

2 Most of the Sequencing Group's work was  
3 performed while the pieces were configured on the two-  
4 dimensional grid and were on these early mock-ups of  
5 portions of the airplane.

6 Before I begin with the details of the break-  
7 up sequence I would like to describe the large scale  
8 three-dimensional reconstruction of the body of the  
9 airplane.

10 To better display the important portions of  
11 the airplane as well as to further examine the  
12 structure for the later stages of the sequence and for  
13 possible evidence of criminal acts, the Safety Board  
14 decided to reconstruct ninety-four feet of the fuselage  
15 from station 510 to station 1630 in a three-dimensional  
16 reconstruction.

17 The station numbers that you see at the top  
18 of this photograph here are measured in inches from the  
19 reference point in front of the nose.

20 CHAIRMAN HALL: Can we sharpen the focus on  
21 that a little.

22 (Slide shown.)

23 WITNESS WILDEY: Maybe not. Okay. For  
24 example, the station 520 there at the forward end is a  
25 point which would be about 520 inches from the nose of

1 the airplane, and similarly on back through the rest of  
2 the labels there.

3 The sequencing effort had to be nearly  
4 completed before this reconstruction began because some  
5 of the fractures would have limited access within the  
6 reconstruction, or would be located high above the  
7 floor making them much more difficult to examine.

8 (Next slide shown.)

9 The photograph we see here shows the main  
10 portion of the airplane after the reconstruction was  
11 completed. The portions of the airplane recovered  
12 primarily from the yellow, red and green areas just a  
13 few seconds ago were tinted with their appropriate  
14 colors. So, you can see that the nose section was  
15 primarily yellow, the red area pieces are in the middle  
16 there and they are tinted red, and similarly the green  
17 pieces in the back.

18 Well before the reconstruction was begun an  
19 outside contractor was hired to design and build the  
20 framework for the reconstruction. An NTSB civil  
21 engineer with experience in reconstruction supervised  
22 the project, including the contracting phase and the  
23 hanging of parts.

24 All the major parties to the investigation --

25 CHAIRMAN HALL: Are we going to give his

1 name ?

2 WITNESS WILDEY: That was Mr. Larry Jackson  
3 who was --

4 CHAIRMAN HALL: Yeah, he did a lot of work.  
5 I would like him to get some credit, so give his name.  
6 Go ahead.

7 WITNESS WILDEY: All the major parties to the  
8 investigation, Boeing, Trans World Airlines,  
9 International Association of Machinists, Air Line  
10 Pilots Association and the Federal Aviation  
11 Administration also contributed to the project. The  
12 Federal Bureau of Investigation also provided  
13 substantial manpower during the process of hanging  
14 parts on the reconstruction framework.

15 A large steel frame truss capable of carrying  
16 the weight of the reconstructed portion of the airplane  
17 was built in place on the hangar floor. Once the main  
18 part of the sequencing examinations were completed, the  
19 actual hanging of parts on the large reconstruction  
20 began.

21 Also included in the reconstruction were  
22 pieces from the inboard ends of the wings, which are a  
23 little difficult to see here because you kind of are  
24 seeing them in profile, but they are pieces of the  
25 wings that are added on there, also.

1           The wing pieces had to be cut from much  
2 larger wing sections in order to be at a reasonable  
3 size to fit on the reconstruction. Exhibit 17(a)  
4 contains Mr. Jackson's report on the reconstruction of  
5 the airplane that we see here.

6           One of the decisions that had to be made  
7 regarding this three-dimensional reconstruction is what  
8 to do with some of the pieces that were heavily  
9 deformed, curled, or folded.

10           It was decided to leave the deformation in  
11 the pieces and add the piece to the reconstruction with  
12 the largest undeformed area in its correct position.  
13 The result of that is what you see here  
14 (demonstrating) . The pieces have been added pretty  
15 much with the most flat area on the framework in its  
16 correct position.

17           Therefore, almost all the obvious holes or  
18 areas with no structure that you see in the photograph  
19 here are actually areas where the structure was  
20 actually recovered and identified, but it is deformed  
21 and it is harder to see.

22           For example, there is a large hole in the  
23 fuselage above the right wing, which is being pointed  
24 out there (demonstrating) , and there is also a linear  
25 hole above the nose section window belt. The fuselage

1 skin for both of these areas was contained on adjacent  
2 structure, but has been folded or deformed.

3 If the deformed or folded metal was flattened  
4 out, these large holes would be completely filled. For  
5 example, you can see in the hole above the window belt  
6 there is a -- excuse me, above the wing -- that there  
7 is a large piece that is folded out of the airplane.  
8 If you can imagine folding that back in, it would cover  
9 half of that hole. There is a similar folded piece on  
10 the aft edge of the hole that is folded inward. You  
11 can't see that one at all.

12 The Metallurgy and Structure Sequencing Group  
13 was formed to determine the sequence of the structural  
14 break-up of the airplane based on factual observations  
15 and examinations of the structure. The purpose of our  
16 groups was to find out, if we could, where and how the  
17 break-up began so that the investigation could begin to  
18 focus on why the break-up occurred.

19 The main sequencing report is contained in  
20 Exhibits 18(a) and 18(b). The Sequencing Group  
21 included representatives from NTSB, TWA, Alpha, Boeing,  
22 the FAA and IAM. Group members brought expertise in  
23 metallurgy and materials, structures, design, repair  
24 and stress analysis to the group.

25 Initial examinations of the earlier mock-ups

1 show that a portion of the aft fuselage and the nose  
2 section of the airplane remained relatively intact and  
3 impacted the water nearly flat, though the structure  
4 rotated somewhat to the right.

5 The nose section forward of about station 800  
6 was crushed upward along this lower right hand side,  
7 and you can see some of that damage in the photograph  
8 here. The crushing damage on the nose section extended  
9 up above the window belts on the right side. On the  
10 left side it was much lower.

11 Similar damage was found on the fuselage aft  
12 of station 1480. The damage in these portions of the  
13 fuselage consisted of a severe upward crushing,  
14 fracturing and deformation of the areas on the bottom  
15 as they hit the water. As it turned out -- and if we  
16 can add the overlay back on here.

17 (Next slide shown.)

18 Except for a very few pieces, everything from  
19 the nose section was recovered from the yellow zone,  
20 and now you can begin to see how this whole section was  
21 intact, and as it hit the water this crushing damage  
22 occurred.

23 The pieces from the aft portion of the  
24 fuselage similarly were recovered from the green zone,  
25 and those pieces also have the same kind of upward

1 crushing damage and indicates that this whole section  
2 of the airplane was intact when it hit the water.

3 I should also point out at this time, though,  
4 that the sequencing results in -- the sequence of the  
5 break-up of the airplane really is independent of the  
6 recovery positions of the parts, especially for  
7 individual parts, and is really based on factually  
8 observable features on the pieces. Many of these  
9 features can still be seen on the pieces as they are  
10 situated within the recovered airplane.

11 The major interest of the Sequencing Group  
12 became the fractures at the edges of the nose section  
13 and the aft fuselage and the structure in between.  
14 This included the red zone pieces, as you can see them  
15 here (demonstrating) .

16 To provide specific sequencing details from  
17 this area, the Sequencing Group members spent many days  
18 developing fracture propagation directions and  
19 examining each important structural piece for damage  
20 characteristics .

21 CHAIRMAN HALL: Mr. Wildey, you might tell us  
22 what a fracture propagation is.

23 WITNESS WILDEY: Well, a fracture propagation  
24 simply is the direction that a fracture, or a crack  
25 takes as going through a piece of metal, and we can

1 look at the individual characteristics of the metal and  
2 of the fracture surface itself, and many times you can  
3 read the direction of propagation, or the running  
4 direction of the crack in this area.

5 CHAIRMAN HALL: Thank you.

6 WITNESS WILDEY: You are very welcome. We  
7 had to examine each and every edge and surface of every  
8 significant piece, usually with a hand-held magnifying  
9 glass, and often while on hands and knees or hanging  
10 from a scaffolding.

11 In addition, the group used the presence of  
12 fire effects, deformation and witness marks to  
13 determine some of the elements of our sequence. For  
14 critical pieces, these effects were repeatedly reviewed  
15 by the appropriate specialists.

16 The group also used stress analysis to  
17 provide confidence that proposed scenarios were  
18 consistent with structural properties and expected  
19 failure modes.

20 CHAIRMAN HALL: Could you tell us what stress  
21 analysis is?

22 WITNESS WILDEY: I am with you on that one.  
23 Stress analysis is basically number crunching to try to  
24 show with the expected loads on pieces what the stress  
25 is in the local and individual areas, and basically by

1 knowing the material properties and the loads you can  
2 determine at what stress levels the individual parts  
3 would be failing.

4 so, we did this to make sure that if we  
5 proposed a scenario that it would be reasonable and  
6 consistent with the properties of the material based on  
7 the strengths and the thicknesses of the various  
8 pieces .

9 CHAIRMAN HALL: This was done on all these  
10 pieces of the airplane you are talking about and,  
11 again, tell us the groups of people that were involved  
12 in this project.

13 WITNESS WILDEY: Well, the people that did  
14 this were the -- some of the members on the Sequencing  
15 Group. Not everybody could bring this expertise to the  
16 group, but we had specifically an FAA engineer that was  
17 very capable in this area, and also Boeing provided a  
18 lot of resources in stress analysis to try to confirm  
19 or refute the proposed scenarios that we came up with  
20 were actually feasible and predictable with the  
21 properties of the material.

22 CHAIRMAN HALL: Very well.

23 WITNESS WILDEY: The Sequencing Group  
24 determined that the break-up of the airplane was  
25 initiated from an explosion of the wing center section

1 fuel tank.

2 This explosion caused a build-up of pressure  
3 that generated the earliest identified events, which  
4 are the forward rotation of span-wise beam three and  
5 corresponding slight upper bulging of the upper skin of  
6 the wing center section fuel tank at this beam.

7 To help understand the relationships between  
8 the components involved in the break-up of the  
9 airplane, I will give a brief review of the  
10 construction of the wing center section and connections  
11 to adjacent fuselage members before we get into the  
12 specific sequencing details.

13 (Next slide shown.)

14 The wing center section of the Boeing 747 is  
15 a large box, and here the view graph shows the wing  
16 center section and then a larger view of the center  
17 section down below here.

18 The box is about twenty-one feet wide from  
19 side to side, about twenty feet long in the fore and  
20 aft direction, and about four and a half to six feet  
21 tall. This box is comparable in size to a two-car  
22 garage up to about eye level. So, it is quite a large  
23 structure.

24 CHAIRMAN HALL: You could stand in part of  
25 that?

1 WITNESS WILDEY: Well, I can't, but --

2 CHAIRMAN HALL: No, well --

3 WITNESS WILDEY: Most people can.

4 (Laughter. )

5 CHAIRMAN HALL: Right . Well, how tall are  
6 you so -- we know you can't stand in it.

7 WITNESS WILDEY: I am six foot seven, so --

8 CHAIRMAN HALL: Right, I am sorry. I could  
9 stand in it. Okay.

10 WITNESS WILDEY: The wing center section  
11 carries the wing bending loads and assisted by the keel  
12 beam supports the fuselage during flight. It is  
13 basically the fulcrum of the whole airplane.

14 The wing center section is bound at its aft  
15 end by the rear spar and its forward end by the front  
16 spar and on its sides by the side of body ribs.

17 CHAIRMAN HALL: This is also the center fuel  
18 tank, is that correct?

19 WITNESS WILDEY: Well, not all of it is. I  
20 was going to get to that here.

21 CHAIRMAN HALL: Oh, okay, I am sorry. Go  
22 ahead.

23 WITNESS WILDEY: That's all right. The upper  
24 and lower skins of the wing center section are a  
25 thicker gage aluminum to carry the wing loads. The

1 wing center section also contains a series of lateral  
2 or span-wise beams, and we will be referring to those.  
3 These beams connect the upper and lower skin to each  
4 other and provide stiffness.

5           These beams also include the midst bar which  
6 continues into the outboard wing and span-wise beams 1,  
7 2 and 3, which do not continue into the outboard wing.  
8 As far as the fuel tank is concerned, most of the wing  
9 center section is the fuel tank. The tank extends from  
10 the rear spar all the way up to span-wise beam three.  
11 so, it is by far the majority of the wing center  
12 section is the fuel tank.

13           You do need to be a little bit careful in  
14 your discussions to make sure that you are talking  
15 about the fuel tank or the wing center section. So, I  
16 am trying to make sure I make that distinction.

17           CHAIRMAN HALL: My only point, Mr. Wildey,  
18 was that there is no separate center -- there is no  
19 separate tank, that when we say center fuel tank some  
20 people may visualize in their mind a separate tank that  
21 is laying within the body of the structure. This is  
22 part of the structure?

23           WITNESS WILDEY: That is exactly correct.  
24 There is no bladder, or no can, or anything like that.  
25 It is actually physically located between the

1 structural members that are sealed to keep the fuel  
2 inside .

3 CHAIRMAN HALL: Thank you.

4 WITNESS WILDEY: The fuel capacity of the  
5 tank is about 13,000 gallons of fuel which weighs about  
6 87,000 pounds, which is over forty tons. So, again,  
7 this is just another description of how large this fuel  
8 tank actually is.

9 The beams internal to the center fuel tank  
10 have significant cut-outs for tubing, as well as holes  
11 specifically designed to allow fuel to move between the  
12 various bays. The fuel tank structure will begin to  
13 fail at a pressure differential slightly above twenty  
14 PSI.

15 The bay between span-wise beam three near the  
16 front of the tank and the front spar is a dry bay and  
17 contains neither fuel -- and should not contain fuel  
18 vapors, either. Many more details on the construction  
19 of the tank will be presented in the Fuel Tank Design  
20 Panel which will be later on in the hearing.

21 Below the wing center section along the  
22 center line of the airplane is the keel beam. In this  
23 drawing we can only see the forward end of the keel  
24 beam, but it extends aft underneath the tank. The beam  
25 carries loads from the forward cargo compartment

1 through to the aft cargo compartment along the bottom  
2 of the airplane.

3 The fuselage in front of the wing center  
4 section is nearly circular and cross sectioned.

5 CHAIRMAN HALL: The keel beam is sort of the  
6 backbone of the airplane; is that correct, or not?

7 WITNESS WILDEY: Well, I don't know if that  
8 is a good description, or not. It certainly -- it  
9 completes the load carrying capacity underneath the  
10 tank and does provide stiffness underneath the tank.

11 It extends from the pressure vessel at a  
12 circular cross section in front of the wing center  
13 section back to the aft cargo compartment which again  
14 picks up the circular cross section.

15 Between those two locations there is landing  
16 gear bays and the tank itself, which aren't circular  
17 and cross sectioned, so it completes the structural  
18 integrity in the area from the forward cargo  
19 compartment back to the aft cargo compartment.

20 CHAIRMAN HALL: Okay.

21 WITNESS WILDEY: As I was saying, the  
22 fuselage is merely circular and cross sectioned in  
23 front of the tank, and where the fuselage joins the  
24 front spar is attached at the ring core and, Mr. Joshi,  
25 if you could point out the ring core there?

1                   **(Visual aid demonstration.)**

2                   **Now**, at the very bottom the fuselage is also  
3 connected to the bottom of the keel beam, and it is  
4 forward, and if you could also point that out, please.

5                   (Visual aid demonstration. )

6                   There we go, at the bottom of the keel beam.  
7 The fuselage consists of external skin and the internal  
8 circumvential frames and longitudinal stiffening  
9 members which are called stringers.

10                  The entire portion of the airplane below the  
11 wing center section is covered by an aerodynamic faring  
12 that blends into the leading edge faring, and this  
13 faring will become a little bit more important later on  
14 when we have a brief video on the recovered pieces of  
15 the tank.

16                  CHAIRMAN HALL: Could you give us just a  
17 brief -- what's a faring?

18                  WITNESS WILDEY: A faring is usually a  
19 honeycomb structure that is provided for aerodynamic  
20 smoothness, and it covers all the structure which is  
21 underneath the tank.

22                  Some of the structures underneath there  
23 include the air cycle machines, and basically just  
24 provides a smooth surface. It is not structural in  
25 that it does not carry bending loads or anything like

1 that.

2 Now I would like to begin the description of  
3 how the airplane broke apart. Please keep in mind that  
4 the earliest portions of the break-up occurred very  
5 rapidly, undoubtedly in less than one second. So, even  
6 though my explanation may take several minutes, the  
7 actual events associated with the initial explosion are  
8 happening much faster.

9 The explosion within the wing center section  
10 fuel tank caused structural damage within the tank,  
11 including fracturing span-wise beam three at its upper  
12 end, a rotation of span-wise beam three forward at its  
13 lower end and a corresponding slight upper bulging of  
14 the upper skin above span-wise beam three.

15 Again, span-wise beam three is the forward  
16 extent of the wing center section fuel tank and is the  
17 tank boundary member that would be expected to fracture  
18 first in response to a fast build-up of over pressure  
19 within the tank.

20 CHAIRMAN HALL: That failed because it  
21 exceeded the twenty PSI you mentioned?

22 WITNESS WILDEY: That is correct. The  
23 forward rotation of span-wise beam three caused its  
24 upper end to impact the aft side of a front spar. This  
25 impact left behind very distinct witness marks across

1 most of the aft side of the front spar.

2 The impact of span-wise beam three with the  
3 front spar also initiated fractures along the top of  
4 the front spar -- and Deepak, if you could go to figure  
5 four, please.

6 (Next slide shown.)

7 Also, upper pressure --

8 CHAIRMAN HALL: You need to describe what we  
9 are looking at now.

10 WITNESS WILDEY: Okay, what we are looking at  
11 here is a view looking from the forward toward the back  
12 part of the airplane, and the red number we see in the  
13 front is the front spar where it intersects at the aft  
14 end of the forward cargo compartment, and the greener  
15 part towards the top is the wing center section,  
16 including span-wise beam three, span-wise beam two and  
17 back to the rear spar.

18 so, in this drawing the wing, the very dark  
19 lines on each side indicate the front spar extending  
20 out into the wing. So, we are basically looking back  
21 from a viewpoint kind of above the wing center section  
22 and the fuel tank.

23 Here we tried to draw in the motion of span-  
24 wise beam three, which is the red arrows you see coming  
25 forward. That is the motion of the upper end of the

1 end of span-wise beam three as it comes forward and  
2 hits the front spar.

3 At the same time span-wise beam three is  
4 moving forward the pressure is escaping from within the  
5 wing center section, and this over pressure caused the  
6 front spar to bow forward. We tried to depict that in  
7 this drawing, also.

8 The bowing took the shape of two loaves, one  
9 on each side of the spar, and this bowing deformation  
10 was determined by careful examination and documentation  
11 of the fracture directions and deformations on the  
12 multiple pieces from the upper edge of this front spar.

13 The creation of these two loaves was  
14 attributed to the inertia resistance provided by the  
15 two large water bottles that are attached to the center  
16 of the front spar. Those are shown here in this  
17 diagram, also. These bottles were full when the  
18 airplane left New York, and the combined weight is over  
19 3,000 pounds.

20 The bowing forward of the front spar caused  
21 fractures to develop approximately in the center of  
22 each of the loaves. In addition, the front spar was  
23 being damaged by pieces of span-wise beam three as they  
24 knifed into the front spar web.

25 As this photograph shows, the light arrows

1 coming down indicate the fractures that are initiating  
2 in the front spar, and they are progressing from the  
3 top down. We didn't try to draw in all the damage, but  
4 there is significant other damage as span-wise beam  
5 three is hitting the front spar.

6 The upper end of the front spar -- and if you  
7 could point that out, also.

8 (Visual aid demonstration. )

9 It was also nearly -- it was also completely  
10 separated from the top skin of the wing center section,  
11 with fractures progressing from the centers of the  
12 bulged areas towards the center line of the airplane.  
13 so, again, this is additional evidence that the bulges  
14 kind of occurred first, and the fractures progressed  
15 into the middle. Next figure, please.

16 (Next slide shown.)

17 The fractures and damage at this point in  
18 time in the break-up are happening rapidly enough that  
19 the over pressure within the wing center section,  
20 again, generated by the explosion of the fuel tank, has  
21 not yet had an opportunity to dissipate significantly.

22 Once the upper end of the front spar becomes  
23 totally separated from the upper skin, as is shown in  
24 the figure here, the over pressure within the wing  
25 center section could then force the lower skin of the

1 center section and the forward end of the keel beam  
2 downward.

3 Before the skin -- before the front spar  
4 broke from the upper skin, the keel beam front end  
5 would be stabilized and it wouldn't really be able to  
6 move that much. The downward load on the keel beam is  
7 represented by the yellow arrow, and it is being  
8 pointed out here (demonstrating) .

9 The keel beam's downward motion damaged the  
10 still intact lower pressure bulkhead. This bulkhead is  
11 the continuation of the web of the front spar and  
12 completes the pressure bulkhead at the aft end of the  
13 forward cargo compartment.

14 Did you point out the lower pressure  
15 bulkhead?

16 (Visual aid demonstration. )

17 It is basically the white area on either side  
18 of the keel beam. As the fractures reached this point  
19 resistance to the downward motion of the keel beam was  
20 carried only by a portion of the lower pressure  
21 bulkhead, the ring cord and the fuselage structure in  
22 front of the front spar. The ring core, which I  
23 haven't mentioned before, is simply an angle member  
24 that attaches the fuselage to a lower pressure bulkhead  
25 and to the front spar.

1                   Continued downward loading on the forward end  
2 of the keel beam, again, still from the fuel tank  
3 explosion, greatly increased the stresses carried by  
4 the ring core and by the fuselage skin adjacent to the  
5 front spar. These stresses are indicated by the larger  
6 black arrows that you see in this figure.

7                   As the keel beam was being forced downward,  
8 cracking propagated down through the lower pressure  
9 bulkhead and through the ring core and immediately  
10 entered the fuselage skin at stringer forty right.

11                   CHAIRMAN HALL: What's a stringer?

12                   WITNESS WILDEY: The stringer, again, are  
13 these longitudinal stiffening members that are  
14 represented by the black lines. You see the series of  
15 black lines coming basically down through the figure.  
16 They are little -- stringers are the little aluminum  
17 structure that is rivetted to the skin and provides  
18 stiffening members in a longitudinal direction.

19                   The fuselage structure was also subjected to  
20 loads from the normal pressurization of the airplane  
21 cabin and cargo compartments, as well as additional  
22 loads from any vented over pressure from the wing  
23 center section fuel tank explosion.

24                   One of the features we tried to explain was  
25 how did this fracturing initiate. We found that the

1 stress analysis indicated that the downward motion of  
2 the keel beam by itself, as a result of the internal  
3 pressure from the explosion of the fuel tank would be  
4 enough to initiate cracking at stringer forty right.  
5 However, I should also emphasize this area is subjected  
6 to normal loads during typical airplane flights.

7 Using detailed examinations of the fuselage  
8 skin fractures it was then possible to determine which  
9 fractures were earlier and in what directions the  
10 fractures progressed. As you can see from previous  
11 photographs, the skin and the fuselage in this area was  
12 broken up into a large number of pieces.

13 so, we basically went through and looked at  
14 each of these fractures and tried to tell which ones  
15 occurred earliest and which ones occurred later, and I  
16 am not going to go into all the details of that, but  
17 suffice it to say that we were able to determine the  
18 directions and the timing of some of these fractures,  
19 and that is indicated by these white arrows in this  
20 figure that we are looking at now.

21 The cracking progressed forward -- from the  
22 initiation area, the cracking progressed forward and  
23 toward the bottom center line of the airplane, reaching  
24 an access panel about two hundred inches forward of the  
25 front spar.

1           The continuation of this fuselage cracking  
2           can be followed in several directions, and quickly  
3           progressing around three sides of a large piece of  
4           belly structure, primarily this piece at LF-6 (a), which  
5           was a very famous piece in our discussions here.

6           (Next slide shown.)

7           Normal cabin pressurizations, as well as any  
8           vented wing center section over pressure, generated a  
9           downward load on this isolated belly structure piece.  
10          Again, piece LF-6(a), as it is labelled there.

11          The combined load on this piece was  
12          transmitted as a downward acting load on the forward  
13          end of the keel beam, and this load was sufficient to  
14          peel the forward piece of the keel beam off of the  
15          lower skin of the wing center section and separate the  
16          keel beam after the mid spar. So, the forward end of  
17          the keel beam is a piece that broke off very early and  
18          was found in the red zone that has been previously  
19          described.

20          Continued downward motion of the belly  
21          structure caused it to separate from the forward  
22          portion of the keel beam, and the very early and  
23          dynamic loss of this belly structure created a large  
24          opening in the fuselage through which the wing center  
25          section pieces could exit the airplane.

1           so, very, very quickly after the explosion of  
2 the wing center section this piece LF-6(a) and  
3 associated pieces departed the airplane along with the  
4 keel beam. The pieces of the front spar and pieces of  
5 span-wise beam three could then exit right through this  
6 large hole, and this occurred very, very rapidly,  
7 immediately right after the explosion of the wing  
8 center section fuel tank.

9           (Next slide shown.)

10           This is a photograph that shows the right  
11 side of the reconstructed airplane. Again, the overlay  
12 shows the yellow, red and green portions of the  
13 airplane which were from the recovery fields.

14           After loss of the belly structure -- and  
15 perhaps you could try to indicate where the belly  
16 structure would be.

17           (Visual aid demonstration. )

18           It is basically the bottom piece that you see  
19 right here (demonstrating) . That is the belly  
20 structure piece that departed early. There was a large  
21 hole in the bottom of the airplane just in front of the  
22 front spar.

23           Nearly symmetric pieces on each side of this  
24 hole then departed the airplane by motioning in an  
25 outward, upward and aft direction creating a curl of

1 metal as the final corner peeled from the underlying  
2 structure.

3 In this photograph, which is the right side  
4 of the fuselage, the curl at the upper, aft end of  
5 piece RF-1 is clearly visible in this photograph. So,  
6 this is the next piece that came off after the belly  
7 skin departed.

8 (Next slide shown.)

9 The next figure and the next photograph shows  
10 the symmetric piece on the left side of the airplane.  
11 This is piece LF-5 and, again, the curl on the upper  
12 aft edge of the piece is visible, and if you could take  
13 off the overlay. Yes, thank you.

14 (Visual aid demonstration. )

15 There is the curl on this symmetric piece on  
16 the left side. Forward is to the left in this figure.

17 At this point in the sequence after  
18 separation of pieces RF-1 and LF-5, the speed of the  
19 break-up may have slowed down or even slightly paused.  
20 As the depressurization of the airplane continued  
21 through the large belly hole, the nose of the airplane  
22 then bent down and created bending -- excuse me,  
23 created compression stresses in the window belts above  
24 the hole.

25 The window belts are stiffened structures.

1       Because of the presence of the windows, they have to  
2       beef up the aluminum around the windows, so they are a  
3       much thicker and stronger belt of material along the  
4       windows . The window belts then collapsed from these  
5       compression loads, and compression buckling spread  
6       upward toward the crown of the airplane.

7               The compression damage here is somewhat  
8       visible, although it is a little bit over exposed.  
9       But, it was very visible on both sides of the airplane  
10      and extended up towards the crown of the airplane.

11             The buckling is less noticeable in the window  
12      belt itself because the window belt is stiffer, it is  
13      thicker and it buckles with much less overall  
14      deformation than does the fuselage skin.

15             The red zone fuselage pieces from the top of  
16      the airplane then sequentially separated from the  
17      remaining structure from the right to the left across  
18      the top of the airplane. Many of these pieces -- in  
19      fact, most of them have curls that are similar to the  
20      pieces below the window belt.

21             At the top of the airplane, here you can see  
22      a couple of these pieces that have very similar curling  
23      damage which is similar to those pieces from below the  
24      window belt.

25             At this point in time now, the red zone

1 pieces in the nose section were completely separated  
2 from the remainder of the airplane. Although most of  
3 the front spar and span-wise beam three had been blown  
4 out and span-wise beam two had been damaged, the other  
5 structural members of the wing center section remained  
6 largely intact at this time.

7 The main part of the airplane included much  
8 of the wing center section, the wing, the aft fuselage  
9 and the tail. So, it is -- basically, most of the  
10 airplane from the front spar back is still intact and  
11 in one piece at this time.

12 Now, based on radar tracking of the damaged  
13 plane and performance considerations which are subjects  
14 outside of the Sequencing Group's area of expertise,  
15 the aft fuselage, the tail and the wings may have  
16 remained relatively intact for a period of time,  
17 actually many seconds after the explosion, and a large  
18 portion of the way towards the water impact. These are  
19 subjects that John Clark covered in previous  
20 discussions .

21 Following some period of crippled flight  
22 after the explosion, the outboard ends of the left and  
23 right wings separated symmetrically in upward bending.  
24 Concurrently with or immediately after these wing tip  
25 separations, the weakened wing center section failed

1 with the left wing separating away from the right wing  
2 and aft fuselage.

3 Aerodynamic considerations clearly indicate  
4 that separation of the outboard portions of the wings  
5 is not at all probable unless the wing is continuous  
6 from tip to tip through the wing center section.  
7 However, we initially thought that it seemed far more  
8 likely for the weakened wing center section to fail  
9 before the wing tips. Therefore, a more detailed wing  
10 bending moment analysis was performed.

11 This analysis showed that under the  
12 conditions of the TWA airplane it would be possible for  
13 the outboard wings to fracture before the wing center  
14 section, even with the front spar and span-wise beam  
15 three blown out.

16 This is because a large portion of the wing  
17 bending loads is carried by the mid spar, the rear spar  
18 and the landing gear beam, and we believe that it is  
19 these members that continued to keep the airplane  
20 together and intact after the explosion.

21 Also, the airplane itself was relatively  
22 lightly loaded to begin with, and the loss of the nose  
23 section would disrupt the lift from the inboard portion  
24 of the wings, thereby reducing the loads in the wing  
25 center section without affecting the loads further

1 outboard where the wings initially fractured. We  
2 concluded that it is indeed possible for the wing tips  
3 to separate before the wing center section.

4 As the final structural break-up continued,  
5 the inboard fuel tank on the right wing was  
6 sufficiently ruptured to produce an escalating fuel-fed  
7 fire associated with the right wing and aft fuselage.  
8 The aft fuselage then quickly separated away from the  
9 right wing in stages.

10 The right wing, a few attached fuselage  
11 pieces and most of the wing center section then fell as  
12 one piece the remaining distance to the water enveloped  
13 in a severe fuel-fed fire originating from the right  
14 side of body area. It is likely that this fire would  
15 have been clearly visible from the shoreline.

16 The dramatic differences in fire and soot  
17 damage are visible in this photograph, particularly  
18 comparing the passenger entry door above the right wing  
19 with the fuselage structure above and aft. So, here  
20 you can see this door is burned to the point where this  
21 metal has actually been melted away and nearby portions  
22 of the structure have very little, or almost no soot  
23 accumulation.

24 The break-up sequence ends as the wing tips,  
25 the left wing and the right wing with much of the wing

1 center section and the fuselage aft of station 1480  
2 then impacted the water separately, but relatively  
3 closely dispersed in the green area. The right wing  
4 was recovered mostly in one piece.

5 When the left wing impacted the water  
6 hydraulic forces broke the upper skin of the wing and  
7 the left side of body rib into a large number of  
8 pieces .

9 This completes the findings of the Sequence  
10 Group. I would like to iterate that our group had no  
11 way to precisely quantify the time between portions of  
12 the sequence. Timing issues are best resolved by  
13 information from other sources, including recovery  
14 positions of the airplane parts, radar returns,  
15 performance analysis, explosion testing and eyewitness  
16 statements.

17 Before I finish my presentation, I would also  
18 like to go over a few of the areas that we rejected as  
19 possible causes of the explosion of the wing center  
20 section fuel tank.

21 First of all, the conclusions reached by the  
22 Sequencing Group eliminated a large scale structural  
23 problem away from the wing center section fuel tank.  
24 Specific areas that were eliminated as factors include  
25 the section 4142 fuselage joint in the forward cargo

1 door. A report on these subjects is contained in  
2 Exhibit 15(c) .

3 The section 4142 fuselage joint is located in  
4 station 520 at the forward end of the reconstructed  
5 portion of the airplane, and you can see that right  
6 here (demonstrating) .

7 Although there have been some manufacturing  
8 alignment problems associated with this joint, the  
9 accident airplane contained absolutely no evidence of  
10 pre-existing weaknesses at this point, or that the  
11 joint separated in any manner before the nose section  
12 impacted the water relatively intact.

13 Similarly, the forward cargo door which is  
14 just aft of station 520 on the lower side of the  
15 airplane has had some latching problems in the past.  
16 The examinations of the TWA airplane, however,  
17 conclusively show that this door was latched and locked  
18 along its bottom edge through the entire break-up  
19 sequence.

20 The door was in this position and was part of  
21 the nose section when it impacted the water.  
22 Basically, for these two items you can see they are  
23 both part of the nose section and that there are no  
24 separations or failures prior to water impact in this  
25 area.

1           The Sequencing Group also studied the nose  
2 landing gear doors and surrounding structure. Our  
3 report on this subject is in Exhibit 18(c) . We  
4 concluded that three of the four landing gear doors did  
5 separate from the airplane early in the sequence,  
6 consistent with their recovery positions in the red  
7 zone.

8           The Group determined that it is possible that  
9 the doors became unlocked very early in the sequence as  
10 a result of fractures or deformations associated with  
11 the red zone fuselage parts.

12           Unlocking of the doors would allow them to  
13 open, and they would be subjected to flutter damage  
14 causing them to separate. No evidence was found to  
15 suggest that the damage to the nose landing gear doors  
16 preceded the explosion of the wing center section fuel  
17 tank.

18           The Sequencing Group and the Structures Group  
19 also identified several areas of petite cracking on the  
20 accident airplane. This information is summarized in a  
21 portion of Exhibit 18(b), the Sequencing report.

22           The Sequencing Group concluded that the  
23 petite cracks did not cause or contribute to the  
24 explosion of the wing center section fuel tank, or even  
25 significantly alter or affect the manner in which the

1 airplane broke apart.

2           Lastly, the Safety Board investigators have  
3 found no physical evidence that a bomb or a missile was  
4 involved in the structural break-up. While some  
5 portions of the structure were not recovered and could  
6 therefore not be examined, a very large percentage of  
7 the wing center section was recovered and examined in  
8 great detail.

9           To illustrate what pieces of the wing center  
10 section were recovered, the Safety Board has prepared a  
11 video animation of the wing center section. It has  
12 mapped each recovered piece from this portion of the  
13 airplane into the animation.

14           Chairman Hall, I am not sure if this is an  
15 animation that is graphic, at all. So, I don't think  
16 we have a problem in that respect.

17           (Video presentation. )

18           Initially we mapped the main surfaces of an  
19 intact wing center section. Here, the upper skin  
20 labelled "tank top" is shown. Dissolving the upper  
21 skin shows the internal members, including the mid  
22 spar, the center line rib and span-wise beams 3, 2 and  
23 1. Labelling for the mid spar and span-wise beam two  
24 has been inadvertently reversed in this video. Sorry  
25 about that.

1           Now we dissolve to the actual recovered and  
2 identified pieces of the wing center section. Holes in  
3 various members are areas where the structure was not  
4 positively identified in recovered wreckage. Removing  
5 the upper skin shows the recovered and identified  
6 internal members. Again, the labels for span-wise beam  
7 2 and the mid spar are reversed.

8           (Video presentation continued. )

9           The wing center section fuel tank again  
10 extends from the rear spar to span-wise beam 3, most of  
11 the wing center section.

12           (Video presentation continued. )

13           There is more.

14           (Video presentation continued. )

15           Now the wing center section model will be  
16 rotated in various directions to show possible lines of  
17 entry where a stretcher is unidentified. As you will  
18 see, using just the wing center section members there  
19 are many entry points into the fuel tank where  
20 structure is unidentified.

21           (Video presentation continued. )

22           The unidentified structure on the left side  
23 of the rear spar, this one here (indicating), and along  
24 the left side of the upper skin is caused by  
25 fragmentation associated with compression buckling as

1 the left wing separated.

2 (Video presentation continued. )

3 You can see that most of the lower skin was  
4 recovered.

5 (Video presentation continued. )

6 The next several steps in the animation will  
7 add additional identified structure to the model,  
8 starting with fuselage pieces around the wing center  
9 section and faring pieces in the keel beam under the  
10 wing center section.

11 Rotating the model in various directions now  
12 shows that there are far fewer entry lines directly  
13 into the tank.

14 (Video presentation continued. )

15 We saw just a second ago how the farings  
16 along the bottom of the tank covered almost all holes  
17 in the lower skin.

18 (Video presentation continued. )

19 Those are the faring pieces there on the  
20 bottom (indicating) .

21 (Video presentation continued. )

22 Next, the inboard wing pieces are added to  
23 the model.

24 (Video presentation continued. )

25 We had almost all the inboard portions of the

1 upper and lower surfaces of the wings to some degree.  
2 Rotating the model now shows that there are only very  
3 few or limited direct line entry points into the wing  
4 center section tank.

5 (Video presentation continued. )

6 Mismatch at the top of the fuselage here does  
7 not represent missing structure, but where the model  
8 sections were folded together with some small amount of  
9 misalignment . That is also true for the inboard ends  
10 of the wings where you can see through there.

11 Actually, that structure is complete through that area.

12 I would also like to point out that much more  
13 of the side of body ribs was probably recovered,  
14 particularly for the left side of body, but the severe  
15 fragmentation of these members made it difficult to  
16 determine exactly where individual pieces were from.  
17 so, they were therefore excluded from the model.

18 Outside experts were also asked to review the  
19 Safety Board's findings regarding evidence of bombs or  
20 missiles. We have asked two of these outside experts  
21 to present their findings as part of this panel.

22 Mr. Chairman, I believe we are ready to hear  
23 their testimony at this time.

24 CHAIRMAN HALL: Very well. We will call  
25 those two individuals forward. Mr. Richard Bott from

1 China Lake, and Dr. Barry Shabel who is retired from  
2 the Alcoa Company.

3 Mr. Dickinson, if you would please swear  
4 these witnesses in.

5 MR. DICKINSON: Mr. Chairman, before I swear  
6 the next two witnesses in, I would just like to mention  
7 that Mr. Deepak Joshi assisted by Mr. Alex Lamishco  
8 (sic) and Mr. Frank Hilldrup headed up a group of over  
9 sixty people from all the parties for close to six  
10 months of continuous work that enabled Mr. Wildey's  
11 group to form the sequence that he just went through.

12 In addition, Mr. Frank Zavhar, one of our --  
13 the Board's senior metallurgists, examined every piece  
14 of wreckage as they were recovered during that time.

15 Now, if you would raise your right hands,  
16 please?

17

1 Whereupon,

2 RICHARD BOTT and BARRY SHABEL,  
3 were called as a witnesses by and on behalf of the  
4 NTSB, and, after having been duly sworn, were examined  
5 and testified on their oath as follows.

6 MR. DICKINSON: Thank you. Please be seated.  
7 At the table we have Mr. Richard Bott, who is an  
8 Aerospace Engineer for the Naval Air Warfare Center --  
9 excuse me -- China Lake, California.

10 Mr. Bott has extensive experience conducting  
11 live fire ballistic tests on numerous aircraft  
12 involving operational flight control systems, wings,  
13 fuselages and fuel cells. He has assisted in the  
14 examination of the wreckage of TWA 800 at the hangar in  
15 Calverton, Long Island on numerous occasions.

16 Dr. Barry Shabel is a Consultant in Material  
17 Science and Metallurgy, retired from Alcoa as a Senior  
18 Scientific Associated. Dr. Shabel's primary experience  
19 is in mechanical and physical metallurgy and materials  
20 characterization.

21 He has worked on a wide range of materials,  
22 including brain refining, sheet metal forming and alloy  
23 process development. He has spent months examining the  
24 wreckage of TWA 800 in Calverton, New York. Jim?

25 CHAIRMAN HALL: Please proceed with the

1 questioning.

2 MR. HILLDRUP: Yeah, good afternoon. My name  
3 is Frank Hilldrup, and I will be questioning Mr. Bott.

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**DIRECT EXAMINATION**

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BY MR. HILLDRUP:

Q You mentioned that -- or, Mr. Dickinson mentioned that you have some experience with testing of ballistic testing. Does that include warheads, as well?

A It does. We typically take aircraft components, subsystems or filled up aircraft and subject them to threats that are typical to be encountered in combat, such as bullets, single warhead fragments, or multiple warhead fragments from a live, filled up warhead.

Q How many times have you been to Calverton to review the wreckage?

A I believe I have been up there four or five times, I don't recall exactly, beginning in September of '96, and my last visit was made just a few weeks ago.

Q What portion of the wreckage did you examine during these visits?

A Well, every piece up there. Just like every other investigator, I spent hours walking through the hallways and looking at every single piece for any evidence that we could find that may point to a cause.

Q Okay, thank you. We will get back to the

1 wreckage, the TWA wreckage examination in a minute. If  
2 you would, I would like you to go over perhaps the  
3 different scenarios involving missile impact of an  
4 aircraft.

5 A Well, there is no question that a missile  
6 could have reached TWA Flight 800. The investigation  
7 was quickly narrowed to an examination for shoulder  
8 launch missile evidence.

9 Shoulder launched missiles are nearly always  
10 contact fused. They must impact their target in order  
11 to be effected. That means there will normally be  
12 about four regions of damage with different  
13 characteristics within each region.

14 The first region in the immediate vicinity of  
15 the warhead usually experiences complete material  
16 removal due to the fragment penetrations weakening the  
17 structure and blast over pressure the removing that  
18 structure.

19 Just because that structure is removed  
20 doesn't mean that it vaporizes. There is still broken  
21 pieces of structure laying around. They are available  
22 for recovery, both in testing and in actual incidents.

23 The second region of damage; slightly further  
24 away there will be numerous high velocity impact  
25 penetrations from the fragments on the warhead. I

1 believe Dr. Shabel will go over the characteristics of  
2 high velocity and low velocity fragment impacts, but  
3 let me just quickly summarize some characteristics of  
4 high velocity impact.

5           One is material splash-back around the hole,  
6 melting, re-solidification around the hole wall of the  
7 penetration due to the high speed impact, and in high  
8 speed impacts there will also be a lack of overall  
9 deformation around the hole, whereas in lower velocity  
10 impacts there will be severe distortion in the form of  
11 petaling or bulging around it. So, in this second  
12 region there are numerous high velocity impacts and  
13 probably very few low velocity impacts.

14           In the third region, further yet away from  
15 the warhead detonation, characterized by a more widely  
16 spaced high velocity impact damage and more low  
17 velocity impact -- excuse me -- more low velocity  
18 impacts in this area, and then the fourth region beyond  
19 that is typically very few impact of any kind either  
20 low velocity or high velocity.

21           so, I will give you some idea on shoulder  
22 launched missiles, how large those areas may be.  
23 Variables are numerous. It is difficult to say  
24 exactly, but if a warhead detonated somewhere near the  
25 surface of this aircraft there would be complete

1 material removal -- region one of an area of, say, two  
2 to three feet in diameter.

3           Beyond that, region two, which has numerous  
4 high velocity impacts; it could be four to six feet  
5 across. Beyond that, region three, the widely spaced  
6 high velocity impact; that region could be up to -- up  
7 to twenty feet across at the most, and the lower  
8 density fragment impacts beyond that would extend ad  
9 infinitum, decreasing in density as it goes.

10           The regions don't have distinct boundaries  
11 between each other, and there will be overlapping of  
12 the damage characteristics in each one, between them.  
13 Some characteristics caused by warheads can also be  
14 caused by other mechanisms, as well.

15           For example, a fuel-fed fire can create  
16 sooting on the structure. Warheads also will create  
17 minor sooting due to the explosive. Warheads, although  
18 they inflict low velocity impact damage, it is always  
19 encountered in post ground impacts of a mishap  
20 aircraft, as well.

21           However, the high velocity fragments, those  
22 typically occur at speeds -- again, it is dependent on  
23 materials -- in excess of, say, 4,000 feet per second.  
24 Those speeds are usually not encountered in post  
25 impact -- post-mishap ground impacts. I have never

1       seen them in a mishap aircraft cause by anything other  
2       than an explosive event, either a bomb or a warhead.

3           Q       If you could, if you could comment, also; is  
4       there, of course, the possibility of a missile impact  
5       without a destination, and what kind of damage would  
6       that leave?

7           A       Certainly there is a possibility that a  
8       missile can malfunction for some reason and the warhead  
9       won't go off. Of course, the approach for looking for  
10      that kind of damage is slightly different than looking  
11      for easily identifiable high velocity impact damage.

12                  What you would need to look for there is a  
13      large body impact on the structure. That is easy to  
14      find if you have a lot of material recovered from a  
15      mishap aircraft. It is not so easy if you don't.

16           Q       Now, you talked about the type of fragment  
17      damage that you would have with a detonating warhead  
18      upon contacting the airplane or the target. What  
19      about -- what about fragmentation from destination at  
20      some distance, perhaps a self-destruct scenario?

21           A       Well, the possibility that a missile --  
22      shoulder launch missiles typically come with a self-  
23      destruct feature that will after a certain pre-set  
24      amount of time self destruct a missile if it doesn't  
25      impact its target and fuse, so you don't have live

1 explosives laying around on the battle field.

2 Certainly, every missile that doesn't impact  
3 something is going to self-destruct. It is possible  
4 based on a number of simulations that were performed  
5 for this investigation and other investigations that  
6 several types of missiles could have been in the  
7 vicinity of TWA Flight 800 at the time of the mishap.

8 But, the possibility that that occurred is --  
9 is hard to imagine. There is a number of different  
10 events that would have to occur in order for that  
11 scenario to take place. The shooter of the missile has  
12 to be in one certain position and launch the missile at  
13 one certain time. He may pass up better launch  
14 opportunities in order to make this time critical  
15 launch for this scenario.

16 The aircraft would have to be just beyond the  
17 reach of the missile, the missile would have to be  
18 positioned perfectly at the time it self-destructed,  
19 the number of fragments with sufficient energy to  
20 impact the center wing tank and penetrate that thick  
21 wing skin, get inside and still have enough energy to  
22 ignite an explosion. That number of fragments is  
23 extremely few.

24 In fact, if it was based on calculations, if  
25 you take one of these shoulder launch missile warheads

1 and hang it out in space and put a 1,000 square foot  
2 target 100 feet away, which isn't too far, the number  
3 of large fragments coming off that warhead that will  
4 impact the 1,000 square foot target is only one or two.

5 so, there will be numerous smaller fragments,  
6 but the possibility that one with enough energy got  
7 through surrounding structure and into the center wing  
8 tank is difficult to envision.

9 Q Could you go over some examination -- or,  
10 discussion of your examination of the wreckage with  
11 respect to the different types of missile scenarios  
12 that we just discussed?

13 A Yeah, I did break my analysis into three  
14 different possibilities just to make it a little  
15 easier. The first possibility was that a missile with  
16 a live warhead impacted the aircraft, the warhead went  
17 off and somehow brought down the airplane.

18 The second possibility was that a missile  
19 impacted and the warhead didn't go off, but still  
20 somehow ignited the center wing tank fuselage explosion  
21 and brought down the aircraft.

22 The third possibility, as we just talked  
23 about, was that a missile was launched, failed to  
24 intercept and then self-destructed in proximity to the  
25 aircraft, somehow igniting that center wing tank

1 explosion.

2 For the first possibility, the missile impact  
3 with warhead destination, it was really -- it took a  
4 long time, but it is very easy to determine if that  
5 happened or not simply by finding a single piece of  
6 wreckage with high velocity impact damage on it.

7 There was none found in Calverton despite  
8 over ninety-five percent of the aircraft being  
9 recovered. There are no places on that aircraft, and  
10 no places of missing structure large enough to contain  
11 enough damage -- that have not been recovered.

12 In other words, there is no large areas of  
13 missing structure on the aircraft that would contain  
14 all the damage from the warhead. There is small pieces  
15 missing from random places throughout the structure,  
16 but none large enough to be the central location of a  
17 missile impact, so that the possibility that a missile  
18 with a live warhead impacting that aircraft is  
19 conclusive evidence that it did not occur.

20 For the second possibility, missile impact  
21 without warhead destination which, as I said, was  
22 slightly different, there is - there won't be any high  
23 speed fragment penetrations. However, there would have  
24 to be a large blunt body penetration of the aircraft  
25 somewhere in the vicinity of that center wing tank in

1 order for it to ignite a ullage explosion in it.

2 A missile impacting back in the tail surface,  
3 for instance, the mechanism for it to ignite a ullage  
4 explosion in that center wing tank is very difficult to  
5 envision, at best. So, for a dud missile to impact  
6 near that center wing section, you have got to have a  
7 large blunt body penetration in the recovered wreckage.

8 There has been enough time and effort spent  
9 on that large scale reconstruction up at Calverton to  
10 conclusively determine that there are no areas where a  
11 body as large as a missile could have penetrated that  
12 aircraft anywhere near the center wing section and  
13 ignited a ullage explosion.

14 I felt a little less comfortable about that  
15 until my last visit up there when I inspected the front  
16 spar and rear spar wing spar reconstructions that the  
17 FBI investigators have done an excellent job on  
18 building up.

19 Once I looked at those, there is just clearly  
20 nowhere in the vicinity of that center wing tank a  
21 large penetration, blunt body penetration that could  
22 have been caused by a missile. I think that can  
23 conclusively rule out the possibility that a dud  
24 missile impacted the airplane.

25 Additionally, previous 747 mishaps have

1 occurred. Although this is not my area of expertise,  
2 it is typically how we analyze military airplanes.  
3 Previous mishaps have occurred where large holes have  
4 been inflicted in the fuselage of 747's. For instance,  
5 the United Airlines Flight 811 off of Hawaii where it  
6 lost, I believe, 200 square feet of fuselage skin and  
7 still managed to return to Honolulu and land safely.  
8 so, a missile penetrating the skin is just not enough  
9 to bring down an airplane, at least on some occasions.  
10 That may not hold always.

11 The final possibility that the missile self-  
12 destructed somewhere close to the airplane; again, I  
13 outlined my reasons for discounting that earlier. Just  
14 the sheer improbability piled upon improbability of  
15 that occurrence happening can discount it as a valid  
16 area of pursuit for the cause of this investigation.

17 Q Are you familiar with the --

18 CHAIRMAN HALL: Mr. Hilldrup?

19 MR. HILLDRUP: Yes, sir.

20 CHAIRMAN HALL: I was wondering if Mr. Bott  
21 could, just for those who may not be familiar, explain  
22 the difference between high velocity and low velocity  
23 which you have referred to.

24 WITNESS BOTT: Sure. I think Dr. Shabel will  
25 go into this in more detail, but --

1                   CHAIRMAN HALL: Well, I don't want to take  
2 his piece away, but go ahead.

3                   WITNESS BOTT: Well, for my purposes, I am  
4 not a metallurgist, so I will tell you what we look for  
5 when we do tests on our aircraft. That is high  
6 velocity impacts from the fragments are always caused  
7 by high speed -- and by high speed I mean in excess of  
8 around 4,000 feet per second fragments.

9                   Those holes are visually quite different from  
10 low velocity impacts. Those differences are that there  
11 is materials flashback around the hole. In other  
12 words, material splashes back towards the direction of  
13 travel from the impacting fragment. There will be  
14 melting and resolidification of the hole wall which is  
15 caused by the energy released in the impact. You never  
16 see that type of phenomenon on a low velocity impact.

17                   The third attribute is the surrounding  
18 material around the hole would be distorted away from  
19 the direction of travel in low velocity impacts where  
20 you will see no distortion in high velocity impacts.  
21 so, in other words, picture your finger going through a  
22 piece of paper. You will get petaling of the paper on  
23 the other side. It will stretch away from the  
24 direction of travel of the penetrating object.

25                   CHAIRMAN HALL: Thank you for that -- thank

1 you .

2 BY MR. HILLDRUP: (Resuming. )

3 Q I believe there is some testimony or some  
4 documentation to this effect in Exhibit 15(b) involving  
5 tests conducted by Boeing shot at test plates. Are you  
6 familiar with those tests?

7 A I have seen the test plates and I have seen  
8 some of the reports that were done on them, yes.

9 Q You looked at the wreckage to compare those  
10 two types of damage?

11 A Yes.

12 Q Okay.

13 A Myself and hundreds of other investigators  
14 from different agencies and from my own agency all  
15 searched for days in that wreckage to identify any  
16 evidence of high velocity impact damage, and found  
17 none.

18 Q Okay, you have talked about a lot of  
19 different characteristics of missiles and missile  
20 related damage. Just to review again, have you seen  
21 anything in the wreckage or during the investigation to  
22 suggest that a missile was involved in this?

23 A I have seen nothing.

24 MR. HILLDRUP: Thank you, Mr. Chairman. That  
25 is all I have.

1                   CHAIRMAN HALL: I am trying to see something.

2                   MR. WILDEY: Richard, I have one further  
3 question for you before we move on to Dr. Shabel.  
4 Would all damage characteristics associated with a  
5 shoulder launch missile or a personal launch missile,  
6 would that be the same or would that apply also to  
7 missiles of other types launched from other sources?

8                   WITNESS BOTT: It would also apply to larger  
9 missiles, either air launched or larger surface to air  
10 missiles. However, the impacts left by those are  
11 spread over much larger areas of the target, are much  
12 more easily identifiable and usually faster moving  
13 fragments.

14                   so, yes, those can be exhibited by other  
15 systems, as well, and this analysis can apply equally  
16 to those systems, although we didn't look into those in  
17 too much detail after doing some original computer  
18 simulations .

19                   MR. WILDEY: Okay, thank you. I would like  
20 to address some questions to Dr. Shabel now.

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BY MR. WILDEY:

Q First of all, can you give us some of your background and experience that you brought to this investigation, please?

A (Inaudible response. )

MALE VOICE: Check your microphone.

WITNESS SHABEL: My primary background, of course, is in the aluminum alloys rather than in --

CHAIRMAN HALL: Dr. Shabel, if I could ask you to pull that microphone up to you, please.

(Witness complies. )

There we go, so we can get -- hear your voice, I would appreciate it. We are having a little trouble and, audio/visual people, my microphone is out. That never fails. It happens at these affairs. Go ahead.

WITNESS SHABEL: Sorry. My background was in aluminum alloys as per my thirty year experience with Alcoa, and I do a lot of mechanical testing and formability testing and things of that sort. So, I am familiar with the appearances of deformation and fracture, at least in those kind of typical situations, if you will, as opposed specifically to a bomb or missile.

1                   so, I could at least judge if the conditions  
2                   and fractures and things that I was looking at were  
3                   normal, if you will, as opposed to unusual and, again,  
4                   my familiarity with the alloys and structures,  
5                   microstructure and things of that sort that would be  
6                   potentially relevant to the investigation.

7                   BY MR. WILDEY:     (Resuming. )

8                   Q           Can you tell us how you got involved in the  
9                   TWA accident, please?

10                  A           I was approached by the FBI, and not long  
11                  after I retired, and asked me if I would be interested.  
12                  I said "yes," and subsequently I was hired by them as  
13                  an independent consultant on this project.

14                  Q           What exactly was your tasks, or what did the  
15                  FBI ask you to do as part of this project?

16                  A           The basic task, and functioning somewhat  
17                  independently of other investigators on this, but was  
18                  to examine the recovered samples from TWA and examine  
19                  them and help determine if there were any unusual  
20                  features that might have been associated with a bomb or  
21                  missile or other kinds of abnormal, if you will,  
22                  damage.

23                  Q           Were you asked to examine specific features,  
24                  or were you - did you develop these features  
25                  independently, by yourself?

1           A     We basically identified, I guess in a sense  
2 mutually, through discussion and awareness of the  
3 problems, an indication that because of the possible  
4 FBI interest in the high velocity, which I will get to  
5 in a moment, or higher energy deformations, higher  
6 rates of deformation types of fractures and  
7 appearances.

8                     We had some evidence in the literature, so we  
9 agreed on looking at a certain subset of features that  
10 might have the higher possibility of finding anything  
11 unusual in the structure.

12                    so, while we looked at many, many things, we  
13 did kind of focus on some things because we thought  
14 that if there were any unusual features to be found,  
15 those areas would have a somewhat better chance of  
16 finding something.

17           Q     All right. Can you just go ahead and give us  
18 what these features that you concentrated on were, and  
19 some of the results or classifications of your  
20 analysis, please?

21           A     Okay. One of the features that we started  
22 with was what is called a spike fracture or spike  
23 feature. This is an appearance of the fracture in  
24 which you have a sharp, almost teeth-like proturbations  
25 on the fracture surface of the material.

1           It can occur in various materials, and does  
2 occur in aluminum alloys. It had been shown from some  
3 older work from about I think almost thirty years ago  
4 now that in a test of an explosive placed near a panel  
5 of aluminum the fractures in the panel would form these  
6 teeth-like proturbations.

7           It almost looks like the teeth of a zipper,  
8 if you will, sharp, pointy little features on a small  
9 scale. Typically, say, it can be as small as a  
10 sixteenth of an inch, or so, for example.

11           so, we wanted to look for those kinds of  
12 features and see if they were clustered, for example,  
13 in a particular area or something like that, because  
14 that might be a feature of either an explosion or, in a  
15 way, a high rate of deformation kind of behavior.

16           I would also -- I also looked, as Richard  
17 did, in a lot of the penetrations with a view towards  
18 identifying whether they might be high or -- relatively  
19 high or relatively low velocity types of situations.  
20 In that regard, we also looked -- and it was available  
21 to me at Calverton, that NTSB in Boeing generated a  
22 series of test panels where a variety of projectiles  
23 had been fired at aluminum panels representing the  
24 alloys of the aircraft, and typically 2024 type of  
25 aluminum, and some 7075 aluminum alloy, also.

1           We were looking for the appearance of the  
2 hole, or perforation, or penetration. Also, in some  
3 cases where -- particularly in the thicker material  
4 where you could see the wall of the hole, you could  
5 examine that for damage even at a relatively modest  
6 magnification.

7           so, you could look for tearing, melting,  
8 cracking in a circumferential sense around the hole  
9 which would occur at the very highest velocity. We did  
10 see some evidence of this kind of damage in a few of  
11 the tests that occurred at somewhere in the 3,000 plus  
12 feet per second velocity range.

13           We also did note an example in those tests  
14 that if a projectile was fired at something like a  
15 forty-five degree angle, you could actually create this  
16 spike type proturbation on the fractured surfaces, or  
17 the entry and exit surfaces.

18           But, again, that only occurred in a few  
19 instances and, again, at high -- relatively high  
20 velocities, better than 2,400 feet per second and,  
21 again, I think if I recall correctly, there was only  
22 one for lighter gage panels. It did not occur in all  
23 of the thicknesses that were tested.

24           so, in any event, we looked at the -- like I  
25 said, we had this background of comparative damage from

1 the Boeing tests and some evidence from the literature  
2 on the kind of damages that one might see in  
3 penetrations and the nature of fracture surfaces.  
4 Then, also, the appearance of the spike type features.

5 We found in examining both the reconstructed  
6 portions of the aircraft, the fore and aft areas that  
7 you have seen pictures of there, and then also many of  
8 the parts on the hangar floor and in other areas at the  
9 Calverton hangar, we found about 117 or so spike type  
10 features.

11 Actually, most of the ones we found were on  
12 what we call the off reconstruction section. That is  
13 to say, they weren't all located in areas that  
14 comprised of forward reconstruction or near the central  
15 wing tank area, although there were spike features  
16 evident in those areas in some of the span-wise beam  
17 sections.

18 But, again, the spike features occurred in  
19 both the 2024 and 7075 type alloys in over a range of  
20 thicknesses in a variety of circumstances. So, from  
21 that type of evidence, I was led to in a sense to  
22 speculate or partly conclude that the spike feature was  
23 not as unique an indication of an explosion type of  
24 phenomenon as might have been inferred from some of  
25 those earlier papers which only tested the appearance

1 and the presence of an explosion.

2           They may well be on a higher road to the  
3 higher strain rate kind of phenomenon that indicated  
4 that the fracture of the aircraft occurred quite  
5 rapidly after all. So, it certainly seems very likely  
6 that we would have a rapid -- what would be called a  
7 relatively high strain rate in this situation. But,  
8 again, as I said, the spikes were not as unique as we  
9 might have expected at the outset of my investigation.

10           In terms of the penetrations, we looked at a  
11 wide number of areas of the aircraft, in a sense as  
12 Richard did, almost -- many of the areas that were  
13 available to us, both the fore and aft constructions  
14 and the off construction areas on the hangar floor,  
15 cargo bed areas, there was some seat back areas that we  
16 looked at -- quite a range of samples. I think we had  
17 documented something like 1,400 instances that we  
18 looked at.

19           We really in no cases found -- again, by --  
20 partly by some calibration in a sense with the Boeing  
21 test panels, we really found no evidence of the unusual  
22 high velocity or characteristic that we might have  
23 thought would have been apparent if a bomb or missile  
24 had occurred.

25           So, basically, I concluded from the extent of

1 what I looked at that there was no evidence of a bomb  
2 or missile type of phenomenon.

3 Q Just as a point of clarification, you  
4 mentioned the spike tooth fractures. Did you examine  
5 the whole -- all the airplane structure for this type  
6 of feature?

7 A Yes, we did. We found -- well, we examined  
8 many pieces. We looked -- in all of the areas that I  
9 looked, we also did look for spike tooth for this spike  
10 fracture phenomenon. So, we did find some in the  
11 central wing tank area, but we found it -- in fact,  
12 most of the ones we found, I think 90 out of the 117  
13 were actually found on just stray pieces off hangar and  
14 off reconstruction and elsewhere in a variety of  
15 locations.

16 so, we didn't see that these were unique to  
17 the central wing tank, or, you know, any particular  
18 area, in that sense. But, I didn't have locations on a  
19 lot of the individual parts that were on the Calverton  
20 floor, because those hadn't been located specifically  
21 with respect to the sites in the aircraft where they  
22 were.

23 Q so, just as another point of clarification,  
24 does the presence of these features throughout widely  
25 disbursed portions of the airplane, that is pretty much

1 the largest factor in your conclusion that this is not  
2 a feature that can only be created by a high order  
3 explosion such as a bomb or a missile; is that correct?

4 A Yes, that would be -- I felt that the  
5 prevalence -- because, again, there were so many  
6 different parts, and then each of those parts then was  
7 in so many different locations around the aircraft that  
8 it didn't seem, you know, to fit with the hypothesis of  
9 a site being the focus of a -- of such an event.

10 Q Okay. Similarly, when you said -- you  
11 mentioned 1,400 penetrations. How many of those would  
12 you classify as small holes, or something like that,  
13 approximately?

14 A Well, in a way the bulk of them were small.  
15 I guess we characterized their sizes in at least an  
16 approximate way, and most of them were on the order of  
17 a quarter inch to less than a half an inch.

18 In one case where I did attempt, from the off  
19 reconstruction area parts that were lying on the floor  
20 of the hangar, there was one group of about 850, I  
21 believe, and the vast -- I would say most of them were  
22 under half a square inch in area.

23 so, quite a large number of them were  
24 probably less than a tenth of a square inch in area,  
25 which would correspond to diameters on the order of a

1 quarter inch or perhaps a little bit larger. But,  
2 there were a number of larger holes, too, of course.

3 Q Okay, and just to complete this area, you  
4 found these holes, again, disbursed throughout the  
5 entire -- in all portions of the airplane structure; is  
6 that correct?

7 A Yes. We also -- we were looking at the  
8 fracture surfaces of the holes, and I should have added  
9 we also looked in some areas where we had what we  
10 called a missing area.

11 You had mentioned the reconstruction, but in  
12 some of the areas of the reconstruction, while some of  
13 the areas were -- where metal had curled back, as you  
14 had noted, Jim, actually there was no missing material,  
15 but in other cases there were just simply gaps, small  
16 gaps between located parts.

17 What we did was look at the fracture surfaces  
18 of the pieces we had which would have formed the  
19 perimeters of these missing areas. Again, all of the  
20 fracture surfaces that we looked at were quite  
21 consistent with normal -- or, what I would call normal  
22 velocity or normal mechanical testing deformation  
23 shaping types of processes in the metal.

24 They were not -- they were in typical kinds  
25 of failure surfaces that one sees in these aluminum

1 alloys under normal conditions.

2 Q Were you able to reach a hypothesis or  
3 conclusion as to what was the cause of these holes, or  
4 penetrations if they were so widely disbursed?

5 A Well, I didn't really reach -- no, I can't  
6 say I reached a hypothesis as to the cause of the holes  
7 specifically, but they didn't have the features that  
8 we, you know, in a sense were looking for at least in  
9 terms of the possibility of a criminal activity, a  
10 bomb, or missile.

11 When I said that they looked like they could  
12 have been rivet hole -- you know, they were of a size  
13 that would be commensurate with a rivet flying through  
14 the metal, but I did not establish that as a cause by  
15 any means.

16 Q All right, thank you. Based on all of your  
17 examinations, can you give - again, give us your  
18 conclusions that you could reach regarding the  
19 fractures and damage patterns found on the recovered  
20 portions of the airplane?

21 A Okay, my basic conclusion was that all of the  
22 fracture surfaces, penetrations and these -- and, you  
23 know, wide spread locations of the various spike  
24 features, led me to conclude that there was no specific  
25 evidence of a bomb or missile type of -- no bomb or

1 missile type damage.

2 Q Thank you.

3 MR. WILDEY: That is all the questions I  
4 have.

5 CHAIRMAN HALL: Are there other questions  
6 from the Technical Panel for the witnesses? Mr.  
7 Hauter?

8 MR. HAUTER: For Jim Wildey, on the -- you  
9 were talking about the big holes that you could fill  
10 back in. About how big were the holes where you did  
11 not have material, would you say? Just, you know, you  
12 gave some estimate of the small ones, but the larger  
13 ones?

14 WITNESS WILDEY: Well, there were no large  
15 areas. If you are talking about something several  
16 feet, three or four feet in diameter, there were no  
17 holes like that where there was absolutely no missing  
18 structure.

19 I guess the possible exception might be  
20 internal to the tank where there was severe fire  
21 damage. I am thinking of span-wise beam 2. The left  
22 side of it had severe fire damage and it appeared that  
23 part of that had simply burned away.

24 As far as the fuselage and the skin of that,  
25 there were no large holes to the extent where you could

1 say there is like a ten-foot hole, or anything like  
2 that. Everything could be filled in, certainly to a  
3 size less than ten feet, or so.

4 MR. HAUTER: To go any smaller than that,  
5 holes in the one, two foot diameter?

6 WITNESS WILDEY: Well, yes, there were areas  
7 where there were -- fuselage skin was missing, for  
8 example, over areas of about maybe a foot or so. Some  
9 maybe even larger than that.

10 There is one area on the left side down below  
11 the window belt in the red zone where the fuselage skin  
12 piece was not recovered. It may be five feet by two  
13 feet. But, fortunately in that particular area we  
14 recovered all the frames -- nearly all the frames and  
15 stringers that went right underneath the skin, and they  
16 showed no unusual patterns of any kind.

17 Then, of course, there were other areas,  
18 relatively small areas, that the fuselage skin itself  
19 wasn't recovered and many areas where the frames and  
20 stringers weren't identifiable because they didn't have  
21 any unique characteristics that you could take them  
22 back to their specific location.

23 MR. HAUTER: I guess I mentioned these holes  
24 are --

25 CHAIRMAN HALL: Mr. Hauter, you need to get

1 closer to that microphone, as well, sir.

2 MR. HAUTER: Okay, on mentioning these holes  
3 that are one and two feet in diameter, did they show  
4 any penetrations where it went through one surface and  
5 then through another? Did you line any penetrations  
6 up?

7 MR. HAUTER: Well, I hate to give a one word  
8 answer, but if I were it would be no, we did not. The  
9 holes that I saw were typical of the structure breaking  
10 apart, and certainly in the red zone the holes are --  
11 would be a part of the sequence and wouldn't be the  
12 initial point. They would be interpreted as  
13 identifiable by the surrounding fractures and things of  
14 that nature.

15 so, the bottom line on that is that the holes  
16 that are there seem to be part of the normal sequence,  
17 especially in the red zone pieces that you could  
18 identify.

19 MR. HAUTER: Thank you.

20 CHAIRMAN HALL: Okay. Any other questions  
21 from the Technical Panel?

22 (No response. )

23 Mr. Wildey, it is my understanding that you  
24 all -- you say you looked at all this wreckage and now  
25 all of our folks -- and we have had the folks from

1 China Lake and this gentleman look at the wreckage and  
2 you have examined all of it even down to -- with a  
3 magnifying glass?

4 WITNESS WILDEY: I can safely say that this  
5 is some of the most examined metal there is anywhere in  
6 the world, especially between the nose section and the  
7 aft section. Every -- literally, ever inch, every  
8 quarter inch of the fracture in the fuselage skin and  
9 the frames and the stringers and the center fuel tank  
10 in the wing center section, every inch of that  
11 structure has been examined in great detail.

12 Fracture directions have been mapped. We  
13 have looked at the surfaces for evidence of hot gas  
14 erosion and pitting and features that might be  
15 associated with bombs or missiles using excruciating  
16 detail on all these fractures on the whole airplane.

17 CHAIRMAN HALL: All that is in your report  
18 that has been submitted as part of the public record?

19 WITNESS WILDEY: Yes, it is.

20 CHAIRMAN HALL: Very well. We will move to  
21 the party tables now for your questions, and we will  
22 just proceed to give now the first opportunity to the  
23 International Association of Machinists and Aerospace  
24 Workers for their questions.

25 MR. LIDDELL: Thank you, Mr. Chairman. I

1 would like to ask Jim Wildey, was there any evidence of  
2 any pre-existing corrosion or failures in the wreckage  
3 found?

4 WITNESS WILDEY: Well, I will kind of divide  
5 that into two pieces. Pre-existing failures is the  
6 easy one, I think, and that answer is there is no  
7 evidence of any pre-existing failure.

8 Now, we do have the petite cracks that I  
9 mentioned on the airplane. Our group concluded that  
10 the petite cracks were opened up as a result of the  
11 sequence of the break-up of the airplane and did not in  
12 any way initiate the airplane's breaking up, or really  
13 their presence didn't even affect the break-up itself  
14 after it initiated.

15 You also asked about corrosion. I was  
16 surprised, frankly, at the lack of corrosion damage on  
17 the airplane considering that it had been in salt water  
18 for many times months. We looked at some of the  
19 fractures at high magnifications with a scanning  
20 electron microscope, and at that time you could see a  
21 very thin layer of corrosion that had started to build  
22 up on the fractures.

23 In general, I would say the airplane was  
24 remarkably free of corrosion damage that had occurred  
25 prior to the salt water emersion, and certainly found

1 not evidence of any corrosion to any extent that might  
2 have caused substantial weakening of any of the members  
3 inside the structure.

4 MR. LIDDELL: Thank you, sir. No further  
5 questions.

6 CHAIRMAN HALL: Thank you. Captain Young,  
7 Trans World Airlines, Inc.?

8 CAPTAIN YOUNG: Thank you, Mr. Chairman. At  
9 the present time Trans World Airlines has no questions  
10 of the witnesses.

11 CHAIRMAN HALL: Thank you, sir. The Federal  
12 Aviation Administration, Mr. Streeter?

13 MR. STREETER: Yes, Mr. Chairman. For Mr.  
14 Wildey, a couple of items here for clarification.  
15 Specifically out of the red area, were there any  
16 fuselage skins in that area that showed any type of  
17 hoop tension failure (inaudible) .

18 WITNESS WILDEY: Yes, we tried to document  
19 that and it is contained within our report. One of the  
20 figures that I used did show this hoop tension type of  
21 fracture. That occurred at the initial point of the  
22 fuselage fracture at stringer forty right.

23 There were also other areas where you could  
24 not see any evidence of a running fracture that we  
25 classified as -- basically, from pure hoop tension, but

1 on either side of these other areas the fracture was  
2 running into it and then out of it in the other  
3 direction.

4 so, the only real area that we saw was  
5 associated with stringer forty -- excuse me -- yes,  
6 forty right where the fuselage cracking initiated as it  
7 came down through the front spar.

8 MR. STREETER: The one other area that was  
9 mentioned in your testimony regarding span-wise beam 3  
10 failing in the forward direction, in Exhibit 18(a) you  
11 discussed where a portion of span-wise beam 2 was found  
12 in the red area.

13 Now, are there any inconsistencies of that,  
14 or is that related to the fuselage opening up? My  
15 concern is, would you have expected span-wise beam 2 to  
16 end up elsewhere?

17 WITNESS WILDEY: Well, I don't know if we had  
18 any expectations, or if you could really expect what  
19 would happen, because we just don't really know. But,  
20 there was a manufacturing access door from span-wise  
21 beam 2 just behind span-wise beam 3, and this door was  
22 found in the red zone and had no soot or fire damage on  
23 it consistent with very early departure and with its  
24 recovery position.

25 It clearly indicates that this door separated

1 as part of the initial event and was blown out as  
2 part -- as was span-wise beam 3 and the front spar, and  
3 came out through the same hole in the lower fuselage  
4 that was created in the belly skin just in front of the  
5 front spar.

6 CHAIRMAN HALL: What is a manufacturing  
7 access door? Can you describe that for us?

8 WITNESS WILDEY: It is a door that is  
9 provided in span-wise beam 2 for access during the  
10 manufacturing process. It is then rivetted up and you  
11 can't really get in there after that.

12 There are other doors that are maintenance  
13 access doors that can be disassembled and reassembled.  
14 This is a door that is rivetted back up during the  
15 manufacturing process and is not really there.

16 CHAIRMAN HALL: The approximate size of this  
17 piece?

18 WITNESS WILDEY: It is about two feet by  
19 three feet. It is an oval-shaped door.

20 CHAIRMAN HALL: Thank you.

21 WITNESS WILDEY: Did that answer your  
22 question, Mr. Streeter?

23 MR. STREETER: I think so. The main thing I  
24 am trying to get at is, again, with that piece in that  
25 position, your group didn't see any reason for that to

1 cause any concern as far as your break-up sequence  
2 design, is that correct?

3 WITNESS WILDEY? Well, our sequence does take  
4 into account how this door -- we list several possible  
5 ways for this door to have come off. I don't know that  
6 we reached an absolute firm conclusion as to exactly  
7 how that happened, but surely during the initial  
8 explosion or shortly thereafter this door was broken  
9 from its perimeter, and we see significant evidence  
10 that the door was pushed in the forward direction after  
11 part of it failed and, so, it came out while there was  
12 still pressure behind it to push it out, so it is part  
13 of the initial event.

14 We do not see any evidence of a bomb or any  
15 kind of explosion features right on the door, itself.  
16 so, it appears that part of the door perimeter was  
17 ripped apart and then the pressure behind the door  
18 pushed it in the forward direction. It hit the top of  
19 the tank and then got blown out into the earliest  
20 portion of the recovery field.

21 MR. STREETER: Okay, thank you very much,  
22 sir. No more questions.

23 CHAIRMAN HALL: Very well. The Boeing  
24 Commercial Airplane Group? Mr. Rodrigues?

25 MR. RODRIGUES: No questions from Boeing, Mr.

1 Chairman.

2 CHAIRMAN HALL: Okay, the Air Line Pilots  
3 Association? Captain?

4 CAPTAIN REKART: If I could, just one  
5 question. I think it is primarily for clarification of  
6 Mr. Wildey, and I believe that he said, Jim, that your  
7 sequencing report was done without respect to where the  
8 pieces were found on the bottom of the ocean, or how  
9 they got there, but rather totally independent and only  
10 based upon the metallurgy of the systems of the pieces  
11 that came apart?

12 WITNESS WILDEY: Yes. Would you like me to  
13 comment on that a little further?

14 CAPTAIN REKART: If you could, please.

15 WITNESS WILDEY: Well, that is a good  
16 question, and really I guess it does deserve more of an  
17 explanation.

18 First of all, it would be really naive to  
19 suggest that the Sequencing Group was not aware of the  
20 color coding of the parts and of the obvious  
21 significance or the suggestions that the color coding  
22 puts forth.

23 For example, the distinct ring of red  
24 color -- red zone parts around the fuselage in the  
25 earliest recovery field. I mean, it obviously suggests

1 that those were the first pieces to come out of the  
2 airplane. Our group was aware of that, and we could  
3 see that on the reconstructed and recovered portions of  
4 the airplane.

5 Our report, though -- and in fact if you look  
6 at the specific sequencing details which is Exhibit --  
7 it is Appendix B of our report, and I think that is in  
8 Exhibit 18(b) .

9 If you look at the specific sequencing  
10 details that are the basis for the sequencing report, I  
11 think there are only two references in there under  
12 "supporting data" that actually quotes the recovery  
13 zone. so, to that degree, our results are truly and  
14 actually based on the features that we could see on the  
15 actual parts, not the recovery position.

16 Now, they do correspond with one another, and  
17 in some cases we tried to develop rationale. For  
18 example, on the wing staying together and the aft part  
19 of the airplane staying together, we were aware that  
20 that had to make it all the way to the green zone.

21 so, we developed a rationale to try to  
22 explain the apparent fact that this structure made it  
23 to its recovery position, and I think we did that.  
24 But, the individual sequencing elements really would  
25 not be affected by the recovery positions. They

1 speak - the structure speaks for itself. Those  
2 features are on the airplane. They are still there to  
3 be observed.

4 I would like to say that as an example of  
5 what we do, or how we used the color coding, in the  
6 nose landing gear area -- and I mentioned that. This  
7 was brought to our attention, and the reason that we  
8 examined this was that three of the four nose landing  
9 doors had a red tag and were recovered from the  
10 earliest part of the debris field and, similarly,  
11 around the nose landing gear area there were some  
12 fuselage pieces that were recovered that had a red tag  
13 on it and were supposedly recovered from the red -- the  
14 red -- earliest debris field.

15 Of course it became a very distinct question,  
16 well, what happened up there, how did these pieces, the  
17 fuselage pieces in the doors get into the red zone?  
18 Well, our group took this as a task to look at. We  
19 made a report on it and we determined that, for  
20 example, on the doors themselves that, yes, those doors  
21 apparently did come off the airplane.

22 They had a lack of damage on them that was  
23 consistent with early departure. We developed some  
24 hypotheses and scenarios that could allow the doors to  
25 depart from the airplane very early in the sequence,

1 and it is consistent with the factual observations we  
2 have made.

3 so, for the doors we said, yes, it appears as  
4 though we have a sequence that could account for the  
5 doors to come off early, and we also examined the  
6 fuselage pieces right around there that had red tags on  
7 them, and we looked at all the features we could find,  
8 and for the fuselage pieces around there we said we  
9 find no physical evidence to suggest that those  
10 particular pieces actually departed the airplane early  
11 on in the sequence.

12 I think, if I remember our report, we said we  
13 believed that those particular pieces should be treated  
14 as yellow zone parts because we don't find any way that  
15 they could possibly have come off the airplane early in  
16 the sequence and actually have been found in the red  
17 debris field.

18 Just as a side note, I am aware that the tags  
19 on those particular fuselage pieces from around the  
20 nose area are the so-called 2,000 series tags, and that  
21 is not my area of expertise, but these are the -- these  
22 tags had some questions about their pedigree, if you  
23 will.

24 But, that is really not our concern. We are  
25 saying, and our group said that we don't believe those

1 are red zone parts and we would treat those as yellow  
2 zone parts for the purposes of analyzing the break-up  
3 sequence.

4 If in the rest of the airplane there had been  
5 similar parts that did not fit with the sequence, I  
6 have every confidence in the world that we would have  
7 said the same thing, that here is a piece that is  
8 tagged red, and I don't care if you have got side  
9 scanning sonar and divers' logs and lat logs, that if  
10 we didn't think that it fit with the sequence we would  
11 have said so in our report.

12 The fact of the matter is, I find generally  
13 very good agreement with the recovered positions of the  
14 red, yellow and green zone pieces and the sequence that  
15 we had developed, but I think these two items kind of  
16 stand, to a large degree, independent of each other,  
17 and frankly I think they kind of support each other.

18 CAPTAIN REKART. Thank you, Mr. Wildey. Mr.  
19 Hall, we have no more questions.

20 CHAIRMAN HALL: Thank you very much.  
21 Honeywell, Inc.?

22 MR. THOMAS: Honeywell has no questions, Mr.  
23 Chairman.

24 CHAIRMAN HALL: Crane Company Hydro-Aire, do  
25 you have any additional questions?

1                   MR. BOUSHIE: Crane Company has no questions,  
2 Mr. Chairman.

3                   CHAIRMAN HALL: Okay. Do any of the parties  
4 have additional questions for these witnesses?

5                   (No response. )

6                   If not, we will move to the Board of Inquiry.  
7 Mr. Sweedler?

8                   MR. CAMPBELL: Yes, Mr. Chairman. I just  
9 have one question of Mr. Bott, or Dr. Shabel, or both.  
10 You mentioned there was no evidence of a missile or a  
11 bomb, a missile striking the aircraft or a bomb. Is  
12 there evidence of anything else that could have  
13 possibly struck the airplane, like a meteorite?

14                  WITNESS SHABEL: I didn't feel that. I -- if  
15 a meteorite would have likely made a very high velocity  
16 penetration, then I really -- the ones that I saw  
17 showed no evidence of any unusual velocity penetration.

18                  I believe that meteorite type impacts are  
19 classified as very high velocity, and I didn't see  
20 anything that approached that type of damage that would  
21 have justified that.

22                  WITNESS BOTT: I would echo those same  
23 feelings. I have been involved in a number of FAT  
24 accident investigations, and in our line of business  
25 doing live fire testing on airplanes we typically don't

1 like to use good airplanes that the fleet can use. We  
2 will bring in components that have been previously  
3 crashed.

4 So, I have seen maybe thirty to fifty crashed  
5 aircraft over the years up there, and I didn't see  
6 anything on TWA 800 that was any different than post  
7 mishap ground or water impacts that we see on Navy  
8 aircraft.

9 MR. CAMPBELL: Thank you. That's all I have,  
10 Mr. Chairman. Thank you.

11 CHAIRMAN HALL: Dr. Ellingstad?

12 DR. ELLINGSTAD: Just a quick question for  
13 Mr. Wildey. Dr. Shabel has talked about his inspection  
14 for holes and penetrations, et cetera. There have  
15 been, I believe, a number of other investigations of  
16 that same issue. Could you summarize, you know, the  
17 other activities looking for this kind of evidence in  
18 the wreckage?

19 WITNESS WILDEY: Well, I guess you are  
20 referring to one of my reports, perhaps?

21 DR. ELLINGSTAD: Yes, Jim, I am.

22 WITNESS WILDEY: Well, I also had an  
23 opportunity to review the Boeing test plates and  
24 generate a report. It is one of the fifteen reports,  
25 fifteen exhibits -- fifteen series reports. I am not

1       sure which one it is, but I basically reached the same  
2       conclusions .

3               Certainly around the wing center section tank  
4       there were no holes that were of a higher velocity  
5       characteristics . Does that address your question?

6               DR. ELLINGSTAD: That is fine. Thank you.

7               DR. LOEB: Let me be, Jim, just a little bit  
8       more specific.

9               CHAIRMAN HALL: I assume Dr. Ellingstad is  
10       through?

11              DR. ELLINGSTAD: Yes, I am.

12              CHAIRMAN HALL: Dr. Loeb?

13              DR. LOEB: Let me be a little bit more  
14       specific. Both Dr. Shabel and Richard Bott have  
15       indicated that they see no damage on this airplane that  
16       is consistent with a bomb or a missile impact. Do you  
17       agree with that?

18              WITNESS WILDEY: Absolutely, yes.

19              DR. LOEB: Second of all, this discussion  
20       about parts being in the various zones that may be  
21       questionable, or we may not quite understand why or how  
22       they got there but we have some theories; if those  
23       theories are incorrect, does that in any way affect  
24       your sequencing report and your -- and your believe in  
25       how this airplane came apart?

1                   WITNESS WILDEY:   What theories are you  
2   referring to?

3                   DR. LOEB:   Well, no, some of the theories  
4   that we may have about how a part may have gotten to an  
5   area in which we are not certain how it got there, but  
6   we may have some thoughts about it; if our thoughts are  
7   incorrect on that, does it in any way change the fact  
8   that the sequencing report still stands?

9                   WITNESS WILDEY:   Well, that is a similar  
10   question that Captain Rekart asked. The sequencing  
11   report really is independent of that, and it really  
12   stands on its own, I believe.

13                  DR. LOEB:   Okay, so -- but, the specific  
14   question is, if we are incorrect and a part didn't get  
15   there the way we theorize, but it may have gotten there  
16   some other way, does that in any way affect our  
17   sequencing report?

18                  WITNESS WILDEY:   Well, I hate to say it  
19   doesn't affect it at all. I am not really sure -- I  
20   don't want to be argumentative, but I am not sure what  
21   theory you are talking about. Maybe if you can give me  
22   an example.

23                  DR. LOEB:   Any of the pieces that may have  
24   been flyers and therefore gotten there and may have  
25   gotten out in a way that does -- if we are incorrect,

1 if it wasn't a flyer and got there some other way, does  
2 it in any way affect the outcome of our sequencing  
3 report?

4 WITNESS WILDEY: I don't believe it does.  
5 The sequencing report is based on, again, the factual,  
6 observable features on the parts themselves, and if a  
7 specific part, you know, was dragged along the ocean  
8 bottom, or was a flyer, or shifted somehow, you know,  
9 it --

10 These things are going to happen, we know  
11 this and the report is going to be independent of that,  
12 and certainly in the sequence of events you can't take  
13 one part out of it and say that it didn't happen that  
14 way, because they kind of have to follow each other.

15 DR. LOEB: Thank you.

16 CHAIRMAN HALL: Mr. Wildey, this is one of  
17 those areas where we have sort of worked parallel with  
18 the FBI, and if we -- I want the public to understand  
19 that -- and I am sure that you and the group you worked  
20 with were aware of all the attention that was given in  
21 the news media to the possibility of a missile or a  
22 bomb.

23 If you all -- if you found any evidence of a  
24 missile or a bomb, am I correct in saying that you  
25 would have turned that over to the proper authorities?

1                   WITNESS WILDEY: Yes, it is. It would have  
2                   been very exciting news and unfortunately, or  
3                   fortunately we didn't find any characteristics at all  
4                   that really be attributed to such damage, and that has  
5                   been examined by not just myself, but other  
6                   metallurgists of the Safety Board, FBI specialists in  
7                   this area, and every pieces was sent through a filter  
8                   before it was actually part of the reconstruction on  
9                   the airplane and was examined by bomb technicians and  
10                  metallurgists .

11                  Every single piece was passed through this  
12                  filter individually -- not just as a basket of parts,  
13                  but individually. So, every part has been specifically  
14                  examined for those features and nothing has been found  
15                  so far to even indicate that there may be a possibility  
16                  that this occurred.

17                  CHAIRMAN HALL: How many years have you  
18                  worked for the Safety Board?

19                  WITNESS WILDEY: Twenty-two years.

20                  CHAIRMAN HALL: You have been paid by the  
21                  American people that whole time?

22                  WITNESS WILDEY: Yes, I think so.

23                  CHAIRMAN HALL: You are telling us the truth  
24                  on this?

25                  WITNESS WILDEY: To the best of my ability,

1       yes, sir.

2                   CHAIRMAN HALL: Well, I appreciate that very  
3 much, and I appreciate all the work of you and Deepak  
4 and others that have spent months up there in  
5 Calverton, and when you are six foot seven and a half,  
6 thinking of you on your hands and knees with a  
7 magnifying glass is something -- looking at the  
8 wreckage -- is something to see, and I know you did  
9 that.

10                   I know that people have been over every piece  
11 of that wreckage, and I want the American people to  
12 know that if there is anything in that wreckage that  
13 any of us at any time thought was of a nature that  
14 needed to be brought to the Federal Bureau of  
15 Investigation, we would do that.

16                   Mr. Bott, do you or the good doctor have  
17 anything you would want to contribute at the conclusion  
18 or offer to the Safety Board, or do you have a solution  
19 that you could offer us so we could end this hearing?

20                   WITNESS BOTT: No, sir.

21                   CHAIRMAN HALL: Doctor, we appreciate very  
22 much your assistance and hard work on this. I know you  
23 all spent a great deal of time. You have worked in a  
24 very cooperative fashion with both the criminal  
25 investigation and our accident investigation. We

1 appreciate your assistance and may need to continue  
2 with it. But, we want to thank you for your  
3 willingness to come here and testify this morning.

4 This concludes this panel. We will move  
5 after a break to the medical factors and cabin interior  
6 panel, which will be our last presentation for the day.  
7 We will take a break until fifteen minutes after the  
8 hour, 3:15 eastern standard time. We stand in recess.

9 (Whereupon, at 3:00 p.m. a brief recess was  
10 taken. )

11 CHAIRMAN HALL: We will reconvene this  
12 hearing of the National Transportation Safety Board  
13 looking into the matter of the TWA Flight 800 event.

14 The next item on our agenda is the Medical  
15 Factors and Cabin Interior Panel. This panel  
16 presentation the Board felt must be done in the  
17 interest of a complete investigation.

18 However, I must tell you that personally I  
19 wish it could be omitted from our presentations because  
20 it may be particularly painful to the family members  
21 here. So, I would want to be sure that any of the  
22 family members who wanted to absent themselves during  
23 this presentation certainly would take the opportunity  
24 to do so.

25 But, we will have a presentation at this time

1 on the medical factors, and I would ask Mr. Dickinson  
2 if he would swear the witnesses in.

3 MR. DICKINSON: Thank you, Mr. Chairman.  
4 Could I ask the two doctors, Dr. Wetli and Dr. Shanahan  
5 and Mr. Burt Simon and Mr. Hank Hughes to stand up and  
6 raise your right hand?

7 Whereupon,

8 DR. CHARLES WETLI, DR. DENNIS SHANAHAN,  
9 MR. BURT SIMON and MR. HANK HUGHES  
10 were called as a witnesses by and on behalf of the  
11 NTSB, and, after having been duly sworn, were examined  
12 and testified on their oath as follows.

13 MR. DICKINSON: Thank you. You may be  
14 seated. A brief biography -- all four biographies have  
15 been entered on our web page today.

16 Mr. Hank Hughes joined the NTSB in 1985. He  
17 is a Senior Survival Factors Investigator assigned to  
18 the Office of Aviation Safety. Mr. Hughes has an  
19 extensive background in forensics and over twenty-eight  
20 years experience as an investigator.

21 During his tenure at the NTSB, Mr. Hughes has  
22 participated in many survival factors group chairman  
23 investigations, including the 1991 crash of USAir 1493  
24 in Los Angeles, the crash of USAir 427 in Pittsburgh,  
25 Northwest Airlines DC-9, a Boeing 727 accident in

1 Detroit and several other major investigations.

2 Mr. Burt Simon has been with the Board for  
3 twelve years. He has fifteen years in Law Enforcement  
4 as a Criminal Investigator, Academy Instructor and  
5 Accident Investigator. He also holds a private pilot's  
6 license, and his education is in Law Enforcement,  
7 University of Maryland, and some education with the  
8 University of Southern California.

9 Dr. Charles Wetli is the Chief Medical  
10 Examiner for Suffolk County, New York, and as such has  
11 jurisdiction in the TWA 800 case. His office was  
12 responsible for the determination and manner and cause  
13 of death of the victims of TWA 800, as well as for the  
14 identification of the victims.

15 Dr. Dennis Shanahan, previously the  
16 Commanding Officer for the U.S. Army Aero-Medical  
17 Research Laboratory is an expert in determining the  
18 causes of injury using biomechanical analysis. He  
19 serves as the Safety Board's Chief Medical Consultant  
20 in the TWA 800 case, and has been involved in the  
21 investigation since the crash occurred.

22 I will now turn it over to - the microphone  
23 over to Mr. Hank Hughes.

24

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**DIRECT EXAMINATION**

1  
2 WITNESS HUGHES: Good afternoon, ladies and  
3 gentlemen. The Airplane Interior Documentation Group  
4 was formed on July 24th, 1996 at the Calverton, Long  
5 Island facility. Members of the Aircraft Interior  
6 Documentation Group represented the following parties  
7 to the investigation: The National Transportation  
8 Safety Board, Trans World Airlines, the International  
9 Association of Machinists and Aerospace Workers, the  
10 New York State Police, Federal Aviation Administration,  
11 Boeing Aircraft Company, the Bureau of Alcohol, Tobacco  
12 and Firearms and the Suffolk County Police Department.

13 The group is diverse in terms of specific  
14 skills. TWA and IAM personnel were assigned because of  
15 their intimate familiarity with the Boeing 747 cabin  
16 furnishings .

17 The New York State Police Investigators were  
18 selected because of their skill in processing evidence.  
19 A Boeing Engineer and an FAA Human Factors Specialist  
20 were assigned to document all modifications of the  
21 airplane cabin from the date of manufacture to the date  
22 of the accident and to provide technical support to the  
23 group during the reconstruction of the cabin interior.

24 Four Bureau of Alcohol, Tobacco and Firearms  
25 Special Agents with expertise in post-bomb blast

1 explosion investigation were assigned to assist in  
2 processing the wreckage and conducting forensic  
3 examination of parts for possible evidence of an  
4 explosive device or other criminal evidence.

5 The Suffolk County Police Department provided  
6 a Crime Analyst whose expertise in database creation  
7 and computer graphics were utilized to catalogue both  
8 the Interior Documentation Group and the Medic --  
9 Forensic Medical Group's database, and then combine the  
10 two databases for further analysis.

11 The group established three preliminary  
12 investigative objectives, the first of which was to  
13 examine, identify and document as many of the airplane  
14 interior components as possible. Second, to  
15 reconstruct as much as possible the airplane cabin  
16 interior using only those parts which could be replaced  
17 in a specific location from which they came. The third  
18 was to provide technical assistance to other NTSB  
19 groups and FBI investigative groups.

20 The group assumed the following  
21 responsibilities. First, to document modifications of  
22 the airplane cabin from delivery to the date of the  
23 accident. This was important. We needed to do this  
24 for a benchmark from which to identify parts and place  
25 them in the proper locations.

1                   We also examined crew and passenger seats,  
2                   the cabin floor and carpeting, side walls, overhead  
3                   bins, ceiling panels, lavatories and components,  
4                   galley and their components, stowage compartments,  
5                   duty free containers, airplane cabin emergency  
6                   equipment, as well as food storage containers.

7                   The group also created a one-to-one scale  
8                   airplane cabin interior, utilizing the reconstructive  
9                   components and the creation of the group's database  
10                  which was integrated later, as I said, into the  
11                  Forensic Medical Group's database.

12                  The group worked to completion in March of  
13                  1997. Completed tasks were as follows. Basically, we  
14                  were able to inventory all airplane parts received at  
15                  the Calverton facility, and we also completed the  
16                  reconstruction of the cabin interior with available  
17                  parts.

18                  All 21 of the crew seats and 398 of the 433  
19                  passenger seats were identified and partially  
20                  reconstructed, as well as all the galleys, lavatories,  
21                  storage areas and about twenty percent of the carpeting  
22                  from the floor.

23                  The crew and passenger seat database was  
24                  completed and the Airplane Interior Documentation  
25                  Group's factual report was developed and approved by

1 all group members. This information was also provided  
2 to the Medical Group for their work.

3 Basically, the interface between the Interior  
4 Documentation Group and the Forensic Medical Group was  
5 that the parts documentation was integrated into the  
6 Medical Group's work by way of comparative analysis.  
7 They looked at the seats, the seat structures, as well  
8 as the other interior components and gave them some  
9 weight with regard to their consideration and analysis  
10 of the injuries to the victims.

11 All members of the group discussed the need  
12 for standardized procedure for the process of  
13 processing the parts for the interior. The group  
14 established a standard procedure for receiving,  
15 examining and documenting all the parts for the  
16 reconstruction area.

17 The standard operating procedure included a  
18 quality control function whereby two teams  
19 independently examined and documented all parts, and a  
20 third team checked the work of the other two teams.  
21 All three teams rotated duties. In addition, upon  
22 completion of the reconstruction, the entire group met  
23 and reviewed all the work completed before it was  
24 approved for the group report.

25 The reconstruction of the airplane's interior

1 was completed in a separate hangar at the Calverton  
2 facility because of space requirements. A taped off  
3 grid was placed on the hangar floor and a one-to-one  
4 scale of the airplane cabin was developed.

5 After several weeks sufficient pieces were  
6 placed in the reconstruction area to permit reassembly  
7 of the seats, galleys and lavatories. This was  
8 accomplished by several thousand feet of wire and more  
9 than 16,000 board feet of lumber.

10 Rebuilding the interior components gave the  
11 group the opportunity to examine and document each  
12 reconstructive seat, galley, lavatory and other  
13 components in more detail and record the findings for  
14 out database. This database also was accompanied by  
15 digitized photographs of all of the evidence.

16 The process of reconstructing the crew and  
17 passenger seats was significantly simplified because  
18 TWA had numbered the individual rows of seats in the  
19 accident airplane, although there is no requirement to  
20 do so. About forty percent of the passenger seats had  
21 their row and seat numbers still affixed, which made  
22 the process of reconstructing the seats simpler.

23 Additionally, the passenger seats were  
24 manufactured by three different companies which  
25 assisted in the identification after cross-reference

1 with TW engineering records and placement of the seats.  
2 In many instances seats had numbers still affixed to  
3 them -- their arm rests, and they were associated later  
4 by way of fracture match, fire damage, or other bending  
5 or identifiable marks that allowed us to reconstruct  
6 the rows.

7 The process of reconstructing the seats was  
8 slow. On a good day we did twelve seats. On our worst  
9 day we did one. The same amount of effort was expended  
10 in both cases. The investigation marked the first  
11 complete interior reconstruction of a Boeing 747  
12 interior.

13 (Slide shown.)

14 You will see a seating diagram, and you will  
15 also note that there is basically five categories of  
16 damage. We established a standardized criteria. Given  
17 the fact that all of these parts were very severely  
18 damaged, we tried to put that aside and look at it and  
19 try to set up a classification system for parts.

20 You will see that on the top we have minimal  
21 damage that is indicated by light blue, and on the  
22 bottom, red, which indicates fragmented, or I should  
23 say highly fragmented pieces.

24 Minimally damaged seats, and there were a few  
25 of those, basically are seats that were almost

1 functional and didn't have major deformation. The  
2 fragmented seats are just what the term implies. They  
3 were highly fragmented in very small pieces. If you  
4 look at the overhead --

5 CHAIRMAN HALL: What's the story? I mean,  
6 I -- take us through each one of them, if you would.

7 WITNESS HUGHES: Okay, sir. I have the  
8 definitions that the group established on another  
9 overhead.

10 CHAIRMAN HALL: Oh, okay.

11 WITNESS HUGHES: I am sorry.

12 (Next slide shown.)

13 Excuse the delay, sir.

14 CHAIRMAN HALL: No problem.

15 WITNESS HUGHES: As I said, the seats were  
16 all, for all practical purposes, severely damaged. For  
17 the purpose of trying to classify the damage, as far as  
18 degrees of severity, the group agreed upon a  
19 standardized protocol that we would use to look at this  
20 damage and, basically, as I said, they ranged from  
21 minimal to fragmented.

22 Basically, the difference between a seat that  
23 is destroyed, which is indicated by yellow, and one  
24 that is fragmented -- and, again, the group decided on  
25 these titles and we discussed the definitions -- are

1 the size of the small parts.

2 CHAIRMAN HALL: Were you able to reconstruct  
3 destroyed seats, or frag --

4 WITNESS HUGHES: Yes.

5 CHAIRMAN HALL: But, not the fragmented?

6 WITNESS HUGHES: All --

7 CHAIRMAN HALL: Or, both?

8 WITNESS HUGHES: We were able to reconstruct  
9 some part of all the seats regardless of whether there  
10 were any of these five classifications. Again, it  
11 is - all of the seats, for all practical purposes -- I  
12 know you saw them and spent a lot of time in the hangar  
13 with us -- were destroyed.

14 In our mind it was an investigative tool that  
15 we used to try to look at how destroyed they were, if  
16 that is a way to categorize them. But, basically we  
17 looked at the degree of severity, and that is the  
18 benchmark that our group used.

19 CHAIRMAN HALL: Okay.

20 WITNESS HUGHES: You can see in the cockpit  
21 area would be the Captain or First Officer's seat along  
22 with the Flight Engineer, and the cockpit was equipped  
23 with two observer's seats. Further aft there is  
24 ninety-one and ninety-two in the upper deck, and then  
25 we will go down to the A-Zone in the main cabin of the

1 airplane.

2 Mr. Jackson, if you would zoom back to the C-  
3 Zone area and then END. Hold on there for a minute.

4 (Next slide shown.)

5 I might add that when you look at the  
6 diagram -- and in a minute Mr. Jackson is going to zoom  
7 back on the overall diagram -- you will note that the  
8 seats in the aft section of the airplane are highly  
9 fragmented.

10 I might add that I think it is significant to  
11 say that the construction, the design and the materials  
12 used for those seats was different from the seats  
13 further forward in the airplane. Another factor to  
14 consider is the structure of the airplane in that area.  
15 I only point that out as a distinction that we made  
16 when we looked at them.

17 Would you pull back to the overall?

18 (Next slide shown.)

19 Okay. There is a static display of that  
20 diagram. Again, the degree and severity damage to the  
21 seats and other cabin components throughout the length  
22 of the airplane were documented, and this is a  
23 pictorial way of noting those.

24 One area of great consideration was looking  
25 for fire damage. We talked about physical damage in

1 the other diagram or chart. This depicts the sixty-six  
2 seats which sustained thermal damage. I think it is  
3 important to note that some of those seats we know were  
4 on fire in the water, burning in pool fires subsequent  
5 to the break-up of the airplane.

6 so, it is not fair to draw an analogy that  
7 all those burnt -- seats that were burned were burned  
8 or the fire damage was incurred while the airplane was  
9 still intact, or in the air. Some of the damage we  
10 know did happen as a result of the pool fires on the  
11 water as the seats floated.

12 This tarp was a project that we did to study  
13 or look at the relationship of the airplane cabin with  
14 the top of the center fuel tank in the C-Zone area.  
15 With the assistance of the members of the Structures  
16 Group we got detailed information on the fracture  
17 pattern on the upper surface of the center fuel tank.

18 We translated that to a plastic tarp. We  
19 taped out those fracture matches, and then after taping  
20 those out to scale and verifying the accuracy of the  
21 measurements with the assistance of the Structures  
22 Group, we replaced the seats that had been recovered  
23 and rebuilt in the C-Zone area.

24 Again, this was done to look at the  
25 relationship of the fracture pattern on the top of the

1 center fuel tank, as well as the seats. We thought  
2 that information might be useful for the medical group  
3 and/or other groups involved in the investigation.

4 What you are looking at here, as in the case  
5 of the other one, is the C-Zone area from around row  
6 seventeen to row twenty-eight, or -- and to the bottom  
7 of the screen is the left side of the airplane. The  
8 top would be the right side, and the right side of the  
9 screen would be facing forward.

10 CHAIRMAN HALL: So, the nose of the plane is  
11 which way?

12 WITNESS HUGHES: To the right, sir.

13 CHAIRMAN HALL: To the right.

14 WITNESS HUGHES: Subsequent to the completion  
15 of our field notes our group met and developed our  
16 factual report, and after review of that report it was  
17 submitted as the group factual report.

18 We provided the information that we were able  
19 to collect to the Medical Group. As I said earlier,  
20 basically the interface between the Interior  
21 Documentation Group and the Medical Group was looking  
22 at the damage to the interior of the airplane, the  
23 parts, in a context of the victims to the airplane and  
24 passengers in the airplane.

25 Mr. Simon, Burt Simon of our staff, led the

1 Medical Group, and he has a presentation. Mr.  
2 Chairman, that completes my remarks.

3 CHAIRMAN HALL: Thank you. Mr. Simon, please  
4 proceed.

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**DIRECT EXAMINATION**

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2 WITNESS SIMON: Good afternoon, Mr. Chairman.  
3 The Forensic Medical Group consisted of four persons,  
4 primarily myself, Dr. Shanahan, from the Air Line  
5 Pilots Association Mr. Donald Foldy (sic), and from the  
6 Suffolk County Police Department, Department Officer  
7 Anthony Legalla, a computer specialist.

8 The objective of the Forensic Medical  
9 Investigative Group was to document and utilize medical  
10 and forensic data and biomechanical analysis to  
11 reconstruct injury events occurring during the  
12 explosion, break-up and water impact of TWA Flight 800.

13 Preliminary medical forensic data was used to  
14 aid in the initial determination of whether an  
15 explosive device detonated in close proximity to any  
16 passenger or crew member, and to elucidate burn and  
17 break-up patterns and sequences.

18 To accomplish this objective, all medical  
19 data contained in the records of the Suffolk County  
20 Medical Examiner were reviewed by a team of physicians  
21 and abstracted into a summary data sheet for each  
22 victim. The abstracted data were then entered into a  
23 computer database.

24 All data were subsequently reviewed by the  
25 Senior Medical Consultant, Dr. Shanahan, and a team of

1 pathologists from the Armed Forces Institute of  
2 Pathology to insure accuracy of the data contained in  
3 the database.

4 A seat assignment was available for each  
5 passenger aboard Flight 800, and for purposes of  
6 reconstruction the seat assignment was used to reflect  
7 actual seating location even though some passengers may  
8 have moved from their assigned seats during a ground  
9 delay prior to the departure of Flight 800.

10 A comparison of passenger seat assignments to  
11 the physical evidence of seat restraint use actually on  
12 the seats was conducted to provide an indication of the  
13 extent to which passengers may have moved from their  
14 assigned seats in the cabin.

15 A geographical information software was  
16 utilized to graphically depict the cabin seating  
17 arrangement and other interior features of the  
18 airplane. All passenger and flight attendant seats  
19 were geographically coded so that the medical data in  
20 the database could be searched for any injury or  
21 combination of injuries, and the results then could be  
22 projected onto a map of the cabin seating arrangement.

23 This software application allowed graphic  
24 presentation of the results of the medical  
25 investigation, enhancing the search for injury patterns

1 and the correlation of injuries with other physical  
2 evidence.

3 Those conclude my remarks, Mr. Chairman. I  
4 would like to question Dr. Charles Wetli, the Medical  
5 Examiner for Suffolk County.

6 CHAIRMAN HALL: Thank you, and I would like  
7 to thank Dr. Wetli for being here with us today.  
8 Welcome, Dr. Wetli.

9 WITNESS WETLI: Thank you.

10 CHAIRMAN HALL: Please proceed, Mr. Simon.

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**DIRECT EXAMINATION**

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BY MR. SIMON:

Q Good afternoon, Dr. Wetli.

A Good afternoon.

Q Could you please tell us your experience with mass casualty events prior to the TWA 800 tragedy in your jurisdiction?

A My experience as a forensic pathologist provides training almost at the outset for mass disaster. You know, handling management, evaluation and so forth. I suppose my first taste of it, if you will, first hand experience occurred in 1980 with the Dade County riots with a number of people, about eighteen people actually being killed in that particular incident.

Since then, there were numerous planning things, such as disaster manuals, creation of disaster response kits and so forth while I was a Medical Examiner in Miami, and then also the experience of Hurricane Andrew prior to my moving to Suffolk County in February of 1995.

Q Can you tell me, please, how you became aware of the crash of TWA Flight 800?

A Basically, simultaneously I heard it on the news and also from the -- my Chief Forensic

1 Investigator, Bob Gold, who called me at home  
2 indicating that there was perhaps a mass disaster, that  
3 they weren't sure what happened, but there was a  
4 possibility of an air -- commercial jetliner having  
5 gone down into the ocean off of the East Moriches.

6 Q Can you describe to us, please, the initial  
7 response of your office to that crash?

8 A To answer that, I could back up a little bit  
9 so it will make more sense, if you will.

10 (Tape change. )

11 These meetings were held monthly, looking at  
12 the type of disaster which would most likely happen and  
13 planning for it. During the preceding year and a half,  
14 for example, we had a disaster cage built in our  
15 basement stocked with about 250 body bags and numerous  
16 other equipment that would be needed for mass disaster.

17 We had tours, we had other people who would  
18 come over, such as Long Island Railroad, Suffolk County  
19 Police Department, Fire Rescue Emergency Services and  
20 others, so we all knew who each other were, what our  
21 individual needs and wants and so forth would be  
22 required in the event of a disaster actually taking  
23 place.

24 When we were therefore notified of an actual  
25 disaster, we simply activated the mass disaster plan.

1 That called for the response of the Chief Forensic  
2 Investigator to respond to the scene, in this case the  
3 Coast Guard Station at the East Moriches, and also our  
4 Deputy Chief of our Crime Laboratory.

5 At Suffolk County we are unique in that the  
6 Crime Laboratory is under the jurisdiction of the  
7 Medical Examiner. So, the Crime Laboratory responded  
8 as well as Suffolk County Police Department and the  
9 Suffolk County ID Section to form a temporary morgue  
10 and execute the duties that would be required at that  
11 time.

12 My Deputy Chief Medical Examiner was also  
13 dispatched to the scene. The other personnel who were  
14 required responded to the Medical Examiner's Office.  
15 This included our Supervisor of the Morgue who unlocked  
16 the disaster cage, arranged for refrigerated trucks and  
17 had the body bags delivered to the East Moriches.

18 The response at the temporary morgue was to  
19 photograph and inventory the bodies as they were  
20 brought ashore, and at that particular point to  
21 actually give them an accession number, place them into  
22 a color coded body bag, and then that body bag was  
23 locked with another tag containing that same number and  
24 then placed into the refrigerated truck.

25 By nine o'clock the following morning the

1 first ninety-nine bodies that had been recovered during  
2 the night were, in fact, at the Medical Examiner's  
3 Office, and that was essentially our initial response.

4 Many other things occurred simultaneously.  
5 Our pathologist went in very early to take care of  
6 additional cases, set up additional work stations, such  
7 as fingerprint stations and so forth.

8 As part of our planning we also had a dental  
9 team all ready assembled, consisting of actually  
10 unbelievable forty dentist that had all ready been  
11 working together for several years as a team, and they  
12 were ready and responding, as well.

13 Q Can you describe the interaction of your  
14 office with other emergency response agencies involved  
15 in this disaster?

16 A In general, I would say it was excellent  
17 response, an excellent relationship we had with both  
18 federal and local agencies. The U.S. Coast Guard in  
19 particular was extremely helpful to us at the scene.  
20 We had good relations with NTSB, FBI and other federal  
21 agencies, as well.

22 Expected jurisdictional squabbles did occur,  
23 but they didn't involve us in particular. As the  
24 Medical Examiner's Office, we are sometimes caught in  
25 the middle, but aside from that we had no real

1 problems.

2           The only agency problem, in a sense, I had  
3 was with the State Emergency Management Office. They  
4 provided us readily with equipment and so forth, but  
5 were less than well prepared to provide us with  
6 personnel in the sense that they were responsible,  
7 "well, we will have to see who calls in, " but  
8 nonetheless when I requested certain pathologists from  
9 New York State, they were able to get a hold of them  
10 and arrange for them to respond to our office. But,  
11 that was about the only problem I had, inter-agency  
12 problem.

13           Q     Did you experience any particular  
14 difficulties in handling large numbers of victims in  
15 this case?

16           A     The large numbers of victims did not propose  
17 a real problem to us because of our disaster plan.  
18 Ironically, our -- for purposes of planning, we were  
19 planning on the crash of a commercial jetliner killing  
20 250 people and, so, that is what we were pretty much  
21 geared for.

22                     so, we had the refrigerated trucks available  
23 and we knew how we were going to do this. I mentioned  
24 we had had tours of our planning. We even had a tour  
25 of our own morgue, saying if we have the situation, how

1 exactly will we be processing these bodies to acquire  
2 the data we need for identification purposes and so  
3 forth.

4 so, it was more a matter of long hours and  
5 setting up the stations initially. Once these were set  
6 up, then things began to work out pretty well. So, we  
7 really had no real difficulty in that sense.

8 I must also mention, our facility is a fairly  
9 large facility. We have five autopsy tables that were  
10 working eventually around the clock and staffed by  
11 pathologists and so forth. So, we had a fairly good  
12 physical facility to begin with.

13 Q During the early days of your response to  
14 this tragedy, did you experience difficulties with  
15 manpower?

16 A The only -- we didn't really experience much  
17 in the way of difficulties of manpower. Initially, we  
18 didn't request a lot of manpower because we first of  
19 all had to evaluate exactly what we were dealing with  
20 and early on had to make certain decisions. Such  
21 things, for example, do we autopsy all the victims; do  
22 we x-ray them and how much -- how extensive a  
23 radiologic examination do we do, and so forth.

24 After that was done, then we had no real  
25 problems obtaining individuals. People both within

1 government and the private sector and ordinary citizens  
2 readily volunteered for whatever they could. So, in  
3 that sense, we didn't have a real problem.

4 We were very fortunate, also, being able to  
5 have the resources of a number of excellent forensic  
6 pathologists that had responded, as well.

7 The only real problem we had was  
8 photographers, and particularly x-ray technicians. We  
9 requested the local clinics in Suffolk County to supply  
10 x-ray techs to us, and the problem they ran into is  
11 when they saw what they had to deal with, many of them  
12 could not take it.

13 They would last -- some just walked out, some  
14 lasted a half a day, others began to have problems like  
15 nightmares and so forth, and we are correcting that now  
16 by instituting a program of desensitization to identify  
17 these people ahead of time and avoid that type of  
18 problem in the future.

19 Q What was the focus of your efforts during the  
20 first few weeks of the tragedy?

21 A The focus of our effort were basically three  
22 fold. One was to identify and recover any foreign  
23 objects that might possibly indicate a bomb, missile,  
24 or something along those lines. So, that was one of  
25 the most important things we felt we had to do was

1 retrieve as much of the foreign material as possible.

2 Secondly, of course, identification of the  
3 victims, and because we were working this entire  
4 scenario, as everybody else was, as a potential  
5 terrorist attack and therefore 230 homicides, we had to  
6 be very, very sure of the identification.

7 so, therefore the decision was made early on  
8 that all identifications would have to be rock solid  
9 and not open to challenge in a court of law, either  
10 legal, or civil, or what have you. So, therefore, all  
11 identifications would have to be done on a scientific  
12 basis.

13 The next effort, of course, is to document  
14 all the entries. Of course, all these were efforts  
15 taking place simultaneously, understand, but to  
16 actually document the injury as best as possible, both  
17 photographically, diagrammatically and of course by the  
18 dictated and subsequently typed report for future  
19 correlations which Dr. Shanahan will be getting into  
20 later.

21 Finally, at least in the initial stage, was  
22 to identify any foreign objects or injury patterns  
23 which seem to be somewhat unusual that might give an  
24 early clue as to the cause of the crash.

25 For example, if we had one individual with

1 unusual metallic fragments and unusual injuries, we  
2 would bring this to the attention of one of the  
3 physician engineers from the federal government as the  
4 possibility that this might be something unusual that  
5 they should pay attention to.

6 Q During the initial phase of the  
7 investigation, did you encounter any unusual  
8 difficulties or pressures that may have affected your  
9 operation?

10 A The most severe interference with our  
11 investigation and operation was the isolation of the  
12 families and the Family Assistance Center about sixty  
13 miles away near the JFK airport.

14 This put a tremendous strain upon not only  
15 the Medical Examiner's staff, but upon rabbis, funeral  
16 directors, Suffolk County Police Department, mental  
17 health professionals, and the list goes on.

18 It made our job very difficult because we  
19 encountered things like jewelry and so forth from a few  
20 victims for which we could actually take a photograph,  
21 for which you could take a photograph to hopefully get  
22 a tentative identification.

23 We could not respond right away to the  
24 families with these. We had to wait until the evening  
25 when we could send our dispatch team to go by

1 helicopter, or by police escort, or a vehicle to the  
2 Ramada Inn near the JFK Airport.

3 I think it was a very tremendous disservice  
4 to the families, also, because from what we understand  
5 from mass disasters it is important for the families to  
6 be able to participate in the process, and this was  
7 very much taken away from them.

8 They were very much isolated out there while  
9 we were working to try and make the identification and  
10 so forth, and it created just a horrible atmosphere and  
11 a tremendous strain of resources for a lot of people.  
12 As I said before, it was very unfair, I think, for the  
13 families.

14 Q Have you made your determinations concerning  
15 the cause and manner of death of the individuals aboard  
16 TWA Flight 800?

17 A Well, the cause of death was the -- very  
18 simply, air plane crash, in a very broad  
19 categorization, without going into mechanisms of  
20 individual persons and so forth.

21 This is a fairly standard approach with most  
22 airplane crash investigations whether commercial, or  
23 private, or what have you. The manner of death is  
24 still pending further investigation until the actual  
25 cause of the crash is officially determined.

1           Q     During your investigation you used  
2 extensive -- or, you extensively used DNA to assist you  
3 in identification. Would you elaborate, please, on the  
4 utility of DNA in this regard and how it may have  
5 benefitted you.

6           A     DNA we found to be extremely useful in that  
7 at one point very early on, actually within a few days  
8 after the crash, we realized that if we were going to  
9 identify everybody in this particular crash that DNA  
10 would be absolutely crucial.

11                     Therefore, Dr. Jack Ballantine -- I basically  
12 dispatched him to set up whatever was needed to make  
13 DNA identifications, and he made a number of very  
14 important decisions, probably the most important of  
15 which is to obtain genetic histories and blood samples,  
16 or bubble or mouth scrapings from as many genetic  
17 relatives as possible to provide a database from which  
18 we could then compare to the bone fragments, body parts  
19 and what have you that were being recovered.

20                     That has to be done very early on, and I  
21 would recommend that be done early on for future  
22 investigations, as well. At least the bubble scrapings  
23 and at least fingertip -- finger stick samples of blood  
24 from genetic relatives, and if these are needed then  
25 they are available. If they are not needed later on,

1 they could be discarded. But, we have to get them  
2 immediately.

3 In this particular case we began the DNA  
4 typing, and on the one hand it was wonderful in that it  
5 enabled us to finally identify all 230 people aboard  
6 the airplane crash. Approximately September or October  
7 of last year we still had about 17 unidentified, which  
8 I had to hold an inquest so that families could be able  
9 to have death certificates so that they could go to  
10 probate court and get insurance claims and what have  
11 you. so, the DNA identification allowed the solid  
12 identification of the remainder of those victims.

13 The down side of the DNA was when Dr.  
14 Ballantine brought me a list of a number of body parts  
15 of individuals that had all ready been identified, but  
16 whose bodies had -- the bodies had all ready been  
17 released to the families, and this created a tremendous  
18 dilemma for us and a lot of dilemma for the families,  
19 and I think that it created a lot of problems that I  
20 think should be avoided in the future.

21 Although it is not going to be my decision, I  
22 think based on the experience of TWA, DNA testing  
23 should be done when conventional methods in fact are  
24 not at that point useful or cannot be -- if a person  
25 cannot be identified utilizing more conventional means

1 such as dental or fingerprint data.

2 Secondly, once the identification is made,  
3 then further identifications of body parts are not  
4 being -- simply just not be reported as such, and these  
5 individual body parts will, in fact, be separated, but  
6 probably remain in a common grave and, of course,  
7 interred after a descent, you know, ceremony, a proper  
8 ceremony and so forth.

9 The third particular aspect for DNA work  
10 would be for investigation, and that is one of the  
11 things we were looking at here, as well. For example,  
12 would we find a DNA profile on somebody who was not  
13 supposed to be aboard that airplane.

14 Then, finally, another phase in the  
15 investigation would be sometimes the -- another  
16 investigator from NTSB or FBI would want to know what  
17 body -- for example, a bone fragment was associated  
18 with a part of a plane, and we would be able to tell  
19 them who that belonged to.

20 Q During the early portion of the  
21 investigation, while your focus was in identifying the  
22 victims to the accident, did you have any difficulty  
23 with maintaining that -- or, having that focus, and did  
24 it affect in any way your autopsy protocols, or did the  
25 volume of bodies that were in your charge at that time

1 make it difficult to maintain a full autopsy protocol?

2 A No, we had a processing such that the body  
3 actually went from one station to another. Initially,  
4 another inventory was done. Jewelry and what not was  
5 examined, sometimes using high tech equipment which  
6 could magnify, say, the inscription of a ring and that  
7 type of thing.

8 From there they went to fingerprints and then  
9 to the dental team -- oh, I am sorry, to x-ray and then  
10 to the dental team. The dental team then utilized  
11 computerized dental radiographs to expedite the  
12 process, and sometimes coupled with the dental x-rays,  
13 and then finally they went to complete autopsy.

14 so, the various functions never interfered  
15 with each other, and we had tracking slips such that if  
16 the fingerprint station was being idle for a moment, we  
17 could take something - take one body out of sequence,  
18 bring it to the fingerprint station, or bring it to  
19 autopsy prior to dental, and that type of thing.

20 so, all these functions were really taking  
21 place simultaneously, and none every interfered with  
22 the other.

23 Q You mentioned some, but do you have any other  
24 recommendations that may be useful to other medical  
25 examiners and to agencies involved in response to mass

1       disasters such as this that -- lessons that you have  
2       learned in this case?

3             A       Yeah, I think there are several things that  
4       are important. One is -- one of the major problems we  
5       had early on which I only partially alluded to was  
6       there was an awful lot of vitriol commentary,  
7       particularly on the part of politicians who were very  
8       ill informed and raised a lot of impossible  
9       expectations amongst a lot of people.

10            This had a very negative impact morale-wise  
11       upon the disaster task force and people who were  
12       putting in long, hard hours and working very, very  
13       hard. This had a very significant morale problem, and  
14       the unnecessary pressure it created nearly resulted in  
15       some mis-identifications which fortunately were  
16       averted.

17            so, we became -- we were very sure of the  
18       identifications . But, initially the pressure was there  
19       that people were beginning to rush and you could see  
20       mistakes could have happened.

21            My other recommendations; first of all, I  
22       think that has to be -- that aspect has to be  
23       contained, and it is just not -- it wasn't unique to  
24       TWA . It has happened in other disasters such as the  
25       Chicago heat wave disaster and others, and so forth.

1           I think the biggest recommendation in general  
2           for any jurisdiction is to have monthly meetings and  
3           take them seriously and really work towards a cohesive  
4           plan of action. It is important that the people know  
5           who each other are when they are on the scene. You  
6           don't want to meet people for the very first time when  
7           you are on a mass disaster scene.

8           so, I think the monthly meetings are  
9           extremely important, and to have the ability to respond  
10          initially, and to incorporate as many agencies into  
11          that as possible.

12          Although we did not particularly run into the  
13          problem in the Medical Examiner's Office, per se, it  
14          was encountered in East Moriches, and that was where  
15          local agencies were very familiar with and wanted to  
16          implement what is known as the incident command system.

17          Apparently federal agencies were not willing  
18          to subscribe to that, and that created some problems,  
19          as well, and I think I can safely say that local  
20          agencies in general would like to see the federal  
21          agencies subscribe to the incident command system.

22          I think also it is important to remember that  
23          about five weeks after the incident you have to be sure  
24          of your own disaster team and make mandatory incident  
25          stress debriefings, particularly for volunteers and for

1 people who are not used to, as we call it -- we call  
2 them body handlers, people who do not see the things  
3 that Medical Examiners and morgue technicians see every  
4 day. These people can have a lot of problems and  
5 psychological counseling should be provided for them.

6 MR. SIMON: Dr. Wetli, I would like to say  
7 that having worked with you for so many months, I  
8 really appreciate your professionalism and your  
9 cooperation throughout, and I think that this  
10 experience with you has been a learning opportunity for  
11 all of us.

12 WITNESS WETLI: Thank you.

13 MR. SIMON: Mr. Chairman, I would like to at  
14 this time, if I may, question Dr. Shanahan.

15 CHAIRMAN HALL: Please proceed.  
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**DIRECT EXAMINATION**

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BY MR. SIMON:

Q Dr. Shanahan, just to get something out front so there is no misunderstanding as we discuss it down the road, would you please explain the term "biomechanical analysis"?

A Yes, I would be glad to. Biomechanical analysis is basically what we performed in our investigation. As Dr. Wetli has already described, he performed and his group performed the autopsies and provided the basic information of the injuries that each individual sustained during the crash of TWA 800.

What we did was carry that one step further. We looked at each injury trying to describe exactly what might have caused that injury, and to do so, as Mr. Hughes has alluded, we conceptually placed each individual into a seat and to the seat that he was assigned so that we could match up injuries to the seat, if you will, to injuries to the body, to look at these mechanisms of injury.

By biomechanical, what we are looking at is the engineering features of injury combined with the medical features so that we have a clearer understanding of precisely what occurred during the crash sequence.

1           Q     How did you first become aware of the crash  
2 of TWA Flight 800?

3           A     My first -- I was on a trip in Frederick,  
4 Maryland in a motel and saw it on the news. It was  
5 breaking news, and that was my first knowledge that it  
6 had occurred.

7           Q     At that time you were in the United States  
8 Military as a Colonel and Commanding Officer of what  
9 command?

10          A     I was Commanding Officer, Commander of the  
11 U.S. Army Air Medial Research Laboratory at Fort  
12 Rucker, Alabama, and we had our headquarters based in  
13 Frederick, Maryland.

14          Q     Your expertise in biomechanical analysis is  
15 somewhat unique. Can you give us some insights on the  
16 uniqueness of your specialty?

17          A     I don't know exactly of the uniqueness, but I  
18 can certainly describe the specialty. I think what I  
19 have brought forth to investigation of injury is an  
20 experience as a pilot, as a physician, a surgeon and  
21 also by trade more than anything else -- engineering.

22                    To combine all those aspects into describing  
23 how injuries occur in crashes, my background started in  
24 the Army. I spent twenty years in the Army -- twenty-  
25 six years in the Army, but twenty years of that was

1 spent in doing aircraft accident investigation and  
2 performing research, you know, within the laboratory to  
3 try to describe how people got injured and also to try  
4 to develop means of preventing injury in crashes.

5 We have a very strong program in the Army and  
6 indeed in the other services to provide what we call  
7 crash-worthy aircraft, or aircraft that can crash and  
8 still provide some degree of protection to the  
9 occupants of the aircraft.

10 Q Can you give us an example of the benefits of  
11 biomechanical analysis?

12 A Oh, absolutely. I think if you -- the  
13 devices that we have available both in aircraft and in  
14 automobiles today to protect you in a crash are the  
15 result of biomechanical analysis.

16 That goes with the seat belts, air bags, the  
17 seats themselves, even the structure of the car to  
18 absorb energy, or the airplane to absorb energy in the  
19 event of a crash. There are many specific examples of  
20 how this type of analysis has benefited the general  
21 public.

22 Q How, then, did you become involved in the  
23 investigation of this tragedy?

24 A Several days after the accident occurred I  
25 received a telephone call from Dr. Ellingstad asking me

1 if I could provide some support for the TWA crash.  
2 Since I had been assigned to the NTSB as an Army  
3 officer, I believe in 1989, I had maintained a  
4 consultant status both through myself and the  
5 laboratory which I commanded to provide support in  
6 biomechanical areas, or biomedical areas to the NTSB.

7 We had an agreement between the NTSB and our  
8 laboratory to provide this kind of support. So, when  
9 he called I went up to Long Island.

10 Q So, within a few days you were on site?

11 A Yes. I believe I received notification on  
12 the 20th or the 21st and was up there within twenty-  
13 four hours.

14 Q Where did you report once you arrived?

15 A I reported to the Command Center that was set  
16 up, I believe at that time at the airport -- I don't  
17 recall the name of the airport outside of East  
18 Moriches.

19 Q Where did you spend most of your time,  
20 Doctor?

21 A At Calverton and -- between Calverton and the  
22 Medical Examiner's Office. In the early days we had --  
23 our group was set up in the Suffolk County Medical  
24 Examiner's Office, and once all autopsies had been  
25 performed we moved the group out to -- with the rest of

1 the investigative group at Calverton.

2 Q During the time that the group was working at  
3 the Medical Examiner's Office, can you give us an  
4 overview of what actually took place there with respect  
5 to the functions of this group?

6 A With respect to the functions of the group,  
7 what we did initially was set up liaison with Dr. Wetli  
8 and his staff. We were very conscious of not  
9 interfering with the process that was going on, but  
10 also at the same time to monitor it.

11 It was important to observe what was going on  
12 and also to observe as many of the individual autopsies  
13 as possible, to review films as they were developed and  
14 generally to participate in the -- begin the analysis  
15 portion of what we were going to do in the future.

16 Of course, being a very small group and the  
17 Medical Examiner working around the clock, we certainly  
18 couldn't observe every autopsy. Plus, the group had  
19 assembled several days after the accident, so Dr. Wetli  
20 was well under way by the time we got to the Medical  
21 Examiner's Office.

22 Q Did the data that had been recorded and the  
23 photographs and radiographs and so on by Dr. Wetli's  
24 office prove useful in developing a database?

25 A Absolutely. Once the autopsies were

1 completed, we then -- it was our job to collect all the  
2 information that Dr. Wetli and his staff had generated  
3 which included the autopsy reports, the radiographs  
4 that were taken, photographs that were taken, any notes  
5 that were taken and diagram and collect all that data  
6 and collate it.

7           Whereas Dr. Wetli and his team were looking  
8 at individuals, it was our job to both compile the data  
9 on the individuals, but also to look at people  
10 collectively. I think what is not well understood  
11 about this process is that in a very basic sense we  
12 looked at bodies as another layer of engineering  
13 structure to the aircraft.

14           They can tell many stories in terms of what  
15 happened during the crash. They can help us elucidate  
16 by the mechanism of injury whether there was a bomb or  
17 other explosive device in the airplane, they can tell  
18 us something about the sequence of the break-up of the  
19 airplane, they can tell us many things about what  
20 happened at that time.

21           That is primarily what we do, is try to use  
22 bodies to tell us what occurred during that crash.

23           Q     The information taken then at autopsy and  
24 through the processing of the victims developed into a  
25 database, and that database was applied to, as I

1 described, a mapping program or a graphics program.

2           Would you please, using some of the graphics  
3 that were developed by the group, give us some insights  
4 into particular charts?

5           A     Yes, I would be glad to.

6                     (Slide shown.)

7           What you see here is a typical chart that we  
8 generated, and you have all ready seen from Mr. Hughes'  
9 presentation the type of thing that we did. Now, the  
10 reason I throw this chart up here initially is to give  
11 you some background information about the process that  
12 was involved.

13           Here you can see we are highlighting several  
14 things . One is the aircraft by zones, Zone-A being the  
15 first section, and moving on back B, C, D and E. Then  
16 we also have there the upper deck portrayed on the  
17 right, and above that the cockpit. So, that gives the  
18 layout of the aircraft.

19           Now, what we did was for every individual we  
20 used their assigned seating position, because it was  
21 the only information we had as to where any particular  
22 individual might have been located within the aircraft.

23           There is a warning, as you can see, on the  
24 written material and -- or, a caveat in the lower right  
25 hand corner that describes that we were well aware of

1 the fact that people might have moved into different  
2 areas, and I will talk about this a little bit later.

3 But, for the initial operating assumption, we  
4 would place the individuals in the seats to which they  
5 were assigned. So, that is why it is portrayed the way  
6 it is there.

7 Now, furthermore, this analysis that you see  
8 here does not include the fourteen flight attendants.  
9 The aircraft -- the Captain had all ready released the  
10 flight attendants from their stations, and they were  
11 presumably out of their seats and doing their duties  
12 within the cabin, and we had no way of estimating where  
13 any individual flight attendant might have been.

14 Furthermore, flight attendant assignments are  
15 apparently made by the crew themselves, and they are  
16 posted on paper within the aircraft, but it wouldn't  
17 have been on any other documentation, at least that we  
18 were able to find outside of the aircraft. So, we  
19 weren't able to determine the exact locations of flight  
20 attendants. So, you won't see that, and that is why  
21 the number of recovered victims there is 216.

22 Beyond that, what I am showing on this  
23 particular chart is the seat assignments which are  
24 indicated by the yellow dots, and the recovered seats  
25 by the black squares.

1           The utility of this program was such that we  
2 could with the database put all of the medical  
3 information into a database and then use that database  
4 projected on this graphic representation so that we  
5 could very quickly look at what-ifs, if you will, that  
6 if we wanted to know where all the people with burns  
7 were located, we could quickly project that and learn  
8 the kinds of patterns of injuries that were occurring  
9 within the aircraft, and in subsequent charts I will  
10 show you how these particular types of analyses might  
11 help us understand better what had occurred during the  
12 crash.

13           Oh, the other thing I would mention is Zone-C  
14 is -- you can see the lines that indicate the forward  
15 and aft edges of the wing itself, which were located --  
16 which were in Zone-C, and the fuel -- the center fuel  
17 tank was located within Zone-C, from about the fourth  
18 row of seats forward to all the way aft.

19           The next chart, please.

20           (Next slide shown.)

21           Now, this chart doesn't project real well,  
22 but one of the more important and early on drives of  
23 this investigation was trying to -- us trying to  
24 elucidate whether any of the occupants of the aircraft  
25 were exposed to a bomb or other explosive device.

1           One way of getting at this is to look at  
2 fragmentation of the bodies, and I won't go into a  
3 large description of that, but basically you can see  
4 that the degree of fragmentation ran from none to  
5 severe and, of course, for a certain number there they  
6 were unknown because of recovering skeletal remains  
7 late in the investigation.

8           But, by doing this, we can project the level  
9 of injury -- or, fragmentation, rather, onto the entire  
10 part of the aircraft and try to look for patterns that  
11 would show high degree of fragmentation, keeping in  
12 mind we had all ready looked at each individual and  
13 made the determination of each individual that we did  
14 not find evidence of an explosive device.

15           The next step to be thorough was to look if  
16 there was any pattern, and if you go into a long shot  
17 of that you can see in general that the degree of body  
18 fragmentation was quite random. There was one area  
19 where you might argue that there was a higher degree of  
20 body fragmentation, and that was in Zone-D, and you can  
21 see that cluster of individuals.

22           Now, two things to keep in mind, that, number  
23 one, as we went back and looked at each one of those  
24 very carefully to try to determine whether there might  
25 have been an explosive device and, secondly, the

1 clustering may be an effect of repositioning of  
2 individuals later on beyond what their assigned seats  
3 were.

4 But, in general we could not find any  
5 clustering or any indication that there was a bomb that  
6 went off in close proximity to anyone on board the  
7 aircraft.

8 Next slide, please.

9 (Next slide shown.)

10 Now, this is an example of the kind of  
11 sharing of information that went on between the Cabin  
12 Interior Group and the Medical Forensic Group. What we  
13 are showing you here is the chart of evidence of seat  
14 restraint use.

15 It was very important to us to try to perform  
16 this analysis in order to try to determine how many  
17 individuals aboard the flight might have changed their  
18 positions.

19 The first thing to note on the chart is that  
20 where we were able to make a definite determination of  
21 seat belt use -- in other words, yes, there was only  
22 twenty-three -- but combining with that likely was  
23 thirty-four. The total there would be fifty-seven  
24 individuals where we had a very high degree of  
25 certainty that a seat had been occupied.

1           But, still, based on that information we were  
2           able to calculate that approximately twelve percent of  
3           individual -- of seats that were -- we were relatively  
4           certain were occupied, were not assigned seats. So, we  
5           know that a significant percentage of people moved from  
6           their assigned seats.

7           The other thing that is probably a more  
8           personal bias and based upon observation of having  
9           spent many hours flying an aircraft, that generally  
10          people do not change -- when there is seating  
11          available, do not leave the cabin to which they are  
12          assigned.

13          You tend to see a lot of moving around, but  
14          it is usually in close proximity. That was a partial  
15          working assumption that we used in our subsequent  
16          analysis.

17          Next slide.

18          (Next slide shown.)

19          This is somewhat of a tender area, and I  
20          don't mean to put too much emphasis on it, but as Dr.  
21          Wetli had mentioned, ninety-nine individuals were found  
22          floating on the surface of the ocean, whereas the  
23          remainder of the individuals had to be recovered by  
24          divers, or the salvage operation.

25          Now, there is a significant difference

1 between these individuals in that the ones who were  
2 found floating were clearly at some point released from  
3 the aircraft and were able to float freely on the  
4 surface.

5 Most bodies will float, at least initially,  
6 and ninety-nine of them were free and found on the  
7 surface of the water. So, one of our analyses were to  
8 try to look at where the individuals who were found  
9 floating were assigned so that we could learn something  
10 more about break-up of the airplane, the assumption  
11 being that if the -- if they were able to be released  
12 from the interior of the aircraft, that that portion of  
13 the aircraft would have had to suffer significant  
14 break-up.

15 You can see from this chart that it  
16 correlates pretty well with the C-Zone. The majority  
17 of the individuals found free-floating were above the  
18 fuel tank. But, that does not necessarily mean that  
19 they -- and certainly we have seen data today that  
20 showed that there wasn't significant penetration of the  
21 cabin floor by that fuel tank, but certainly the break-  
22 up of the aircraft did begin just forward of the C-  
23 Zone.

24 Q So, with respect to your -- to a  
25 biomechanical analysis using this chart, what would be

1 the rationale for approaching it this way?

2 A I am sorry, could you clarify that?

3 Q Your rationale for the use of this chart in  
4 this type of analysis?

5 A Well, our rationale for doing that was, as I  
6 described, that if we saw significant clustering, that  
7 would tell us something about the break-up of the  
8 aircraft.

9 In fact, fifty-one percent of the victims  
10 found floating on the surface of the ocean were from  
11 Zone-C.

12 Q Thank you.

13 A Next slide.

14 (Next slide shown.)

15 Now, also, because there was a fire and  
16 explosion, and as you have seen that it was significant  
17 evidence of burn damage to the aircraft itself and to  
18 the seats, we also wanted to look at the individuals  
19 occupying the interior of the aircraft to see what burn  
20 patterns we could elucidate. That is good, just focus  
21 on Zones C and D there (indicating) .

22 We looked at -- there are several levels of  
23 looking at thermal burns. One was that there were a  
24 certain number that we were very certain of that had  
25 thermal burns. There were also a number that were not

1 certain. I believe the number for certain was eight,  
2 and we added an additional four possible.

3 Subsequent to death, and particularly after  
4 sudden death as occurred in this case, it can be  
5 somewhat difficult to determine definitively whether  
6 the individual had a thermal burn, or not.

7 But, between Dr. Wetli's team and my team  
8 from -- myself and forensic pathologists from the Armed  
9 Forces Institute of Pathology, we were able to come up  
10 with this particular number.

11 In looking at it, you can see that the red  
12 dots indicate the individuals and their assigned seats  
13 as to where -- as to who was burned, and you can see  
14 that we had all but one were concentrated in Zone-C.

15 Now, we also -- I need to check that number.

16 (Pause. )

17 That is correct, and so that it was  
18 correlated that we were able to correlate burns with  
19 that location. However, you will notice also that it  
20 correlates very highly with individuals who were found  
21 floating, and we had to deal with the question of did  
22 these burns arise from people being exposed to burning  
23 fuel on the surface of the water.

24 Looking carefully at the burn patterns as  
25 well as the seating locations, we felt pretty certain

1       that the burns that occurred within the interior of the  
2       aircraft, they were all very minor burns. They were  
3       flash-burns, and primarily to the front surfaces of the  
4       body, which indicates that a flash-fire -- they had  
5       been exposed to a flash-fire, but not to constant  
6       burning of the aircraft interior.

7               Next slide.

8               (Next slide shown.)

9               All right, well, as we looked at the  
10       relationship between burns and found floating on the  
11       ocean surface, we also tried to look for correlation  
12       between individuals who were burned and seat  
13       assignment, and you can see here that the correlation  
14       was not by any means complete. Nine out of twelve  
15       individuals, which is seventy-five percent, were  
16       assigned to burn seats.

17              What this tells us is one of two things;  
18       either those individuals were not sitting in their  
19       assigned seats, or it is also possible -- and there is  
20       other evidence to suggest -- that many individuals  
21       became separated from their seats at some point during  
22       the break-up sequence.

23              Q     Dr. Shanahan, I am sorry to --

24              A     Yes, sir.

25              Q     With respect to that last chart, can you help

1 us understand why so few individuals in the aircraft  
2 were burned?

3 A Why so few burned? Well, I have various  
4 theories on that, but I think, you know, working from  
5 the facts, we know that there was significant fire.  
6 The interior of the cabin was subjected to some degree  
7 of fire, but mostly externally.

8 so, what we then looked at were the  
9 individuals who were burned and their seating location  
10 and got some degree of correlation, but, as you will  
11 notice, where the burn was within the cabin did not  
12 necessarily correlate with individuals.

13 Now, the conclusions that we can draw from  
14 that and that I believe are probably correct is that  
15 many of these individuals had departed that part of the  
16 aircraft by the time the fire propagated, because we  
17 only had very rudimentary burns on individuals, very  
18 superficial burns.

19 The other thing you could argue is that the  
20 seating position had changed so significantly that very  
21 few people were sitting in that center cabin, which I  
22 think is highly unlikely.

23 (Tape change. )

24 This is a chart depicting trauma severity  
25 indexes, we ended up calling it. Again, in this

1 analysis what we wanted to determine was that although  
2 every individual had very, very serious traumatic  
3 injuries, we were dealing with everyone with fatal  
4 injuries. We tried to grade the degree of fatal injury  
5 which individuals sustained.

6 One of the ways of doing this was by looking  
7 at whether the injuries were sufficient to cause  
8 instantaneous death, or were not. What you see here is  
9 the grading of trauma severity index. What we said  
10 here was severe was a grade of absolutely in the mind  
11 of two pathologists and myself that the injuries were  
12 instantaneously fatal.

13 Moderate, for which there were fifteen  
14 individuals, was there was some question as to whether  
15 they were instantaneous, and then minimal would have  
16 been where we felt that the -- that death was not  
17 absolutely instantaneous.

18 Now, I really need to provide a caveat with  
19 this particular chart, and that is described in the  
20 written material, as well. That is that death is  
21 somewhat difficult to describe or to define and, as  
22 many of you know, we have gone through in the medical  
23 world a lot of rethinking about what death is.

24 But, I won't get into those philosophical  
25 meanings, but basically what we used for instantaneous

1 death was if there was brain injury that would not  
2 support life, or if there was significant enough organ  
3 injury such as rupture of the heart and aorta that  
4 death was essentially instantaneous, we believe that  
5 all these individuals were almost immediately  
6 incapacitated. Whether they were dead or not, it is  
7 highly unlikely they were conscious or aware. So that  
8 was the determination we had made.

9 But, now, the reason for doing that was to  
10 try to find areas of the cabin that might have been  
11 less damaged, and if less damaged it really gives us  
12 some information as to what the sequence of break-up  
13 was and the severity of that particular break-up.

14 As it turned out, the correlations were  
15 essentially negligible that the -- both body  
16 fragmentation and trauma severity index were pretty  
17 much randomly distributed throughout the cabin.

18 Q Doctor, do you have an opinion concerning the  
19 potential exposure of occupants of the airplane to  
20 explosive devices?

21 A Yes, absolutely I do. We focused most of our  
22 attention to looking very carefully at these remains to  
23 see if we could find any evidence of an explosive  
24 device. We found none whatsoever.

25 Q Thank you.

1 MR. SIMON: Mr. Chairman, I am finished.  
2 Thank you.

3 CHAIRMAN HALL: Are there other questions  
4 from the Technical Panel for the witnesses?

5 (No response. )

6 Mr. Hughes, none?

7 MR. HUGHES: No, sir.

8 CHAIRMAN HALL: Mr. Simon, none?

9 MR. SIMON: No.

10 CHAIRMAN HALL: Very well. We will move,  
11 then, to the parties in order now. It would be the --  
12 are there any questions from Trans World Airlines,  
13 Inc.? Captain Robert Young?

14 CAPTAIN YOUNG: Mr. Chairman, at this time  
15 TWA has no questions of the witnesses. Thank you.

16 CHAIRMAN HALL: Thank you. The Federal  
17 Aviation Administration? Mr. Streeter?

18 MR. STREETER: No questions, Mr. Chairman.

19 CHAIRMAN HALL: Boeing Commercial Airplane  
20 Group? Mr. Rodrigues?

21 MR. RODRIGUES: No questions, Mr. Chairman.

22 CHAIRMAN HALL: The Air Line Pilots  
23 Association? Captain?

24 CAPTAIN REKART: Yes, sir, and I would like  
25 to direct the question, I think, to Mr. Hughes, if I

1       could. Mr. Hughes and Mr. Simon and earlier Mr. Wildey  
2       have all referred to databases, and I was just  
3       wondering if these are multiple databases, or if it is  
4       a single database?

5                WITNESS HUGHES: Captain, the database I  
6       referred to basically is a consolidated database. It  
7       was a project that was undertaken by the Interior  
8       Documentation Group with consultation -- or, I should  
9       say complete support from the Medical Group. As a  
10      matter of fact, a member of the Medical Group, Officer  
11      Legalla from Suffolk County, was our computer person.

12               The process was combined for two reasons.  
13      Basically, the Interior Documentation Group looked at  
14      all of the interior parts, cataloged those parts in a  
15      database and then merged that information with the  
16      Medical Group that was doing similar projects,  
17      basically cataloging injuries from throughout the  
18      length of the airplane.

19               Those two databases were merged into one  
20      specifically for the purpose of examining trends -- or,  
21      looking for trends for damage in the aircraft cabin, as  
22      well as injury patterns for the victims.

23               CAPTAIN REKART: In your cabin documentation,  
24      the cabin documentation that occurred, what was the  
25      degree of coordination between the Cabin Documentation

1 Group, the Fire and Explosives Group and the Structures  
2 Group to assure that there was unifying criteria for  
3 fire damage and structural deformation to standardize  
4 the description for the factualls and the databases and  
5 the exhibits?

6 WITNESS HUGHES: Our work basically was  
7 reconstruction of the interior. We did that, which  
8 allowed or facilitated the Fire and Explosion Group  
9 and the Structures Group, as well as all NTSB groups  
10 and the FBI -- it gave them an opportunity to examine  
11 it.

12 Our job was primarily the nuts and bolts of  
13 reconstructing the airplane interior. The criteria  
14 that we used as far as damage was done specifically for  
15 our purpose for use in the Cabin Doc Group and the  
16 Medical Group, but we consulted on a daily basis at our  
17 team meetings. As you know, we had one every day and  
18 on an informal basis whenever anybody would have a  
19 question or come to the hangar.

20 MR. SIMON: If I may, I hope that you won't  
21 confuse this with any other databases that may exist in  
22 the investigation, such as the one done by the  
23 Sequencing Group.

24 This database, because it contains  
25 information generated by the Medical Examiner's Office

1 from autopsies and so on, is not a matter of public  
2 record. So, the databases with respect to the Medical  
3 Examiner's data and the cabin interior data were  
4 combined and generated the graphics that we have looked  
5 at, plus the additional twenty-two or so that are in  
6 the public record.

7 WITNESS HUGHES: I might add that the  
8 Interior Documentation Group's database is included in  
9 its entirety as an attachment, the series six of the  
10 factual report.

11 Our information was not sensitive and, as  
12 such, was published. It is available, as I said, in  
13 its entirety as an attachment. I believe it is  
14 Attachment 6(c) to the group report.

15 CAPTAIN REKART: Thank you, Chairman Hall. I  
16 have no other questions.

17 CHAIRMAN HALL: Honeywell?

18 MR. THOMAS: Honeywell has no questions, Mr.  
19 Chairman.

20 CHAIRMAN HALL: Crane Company, Hydro-Aire?

21 MR. BOUSHIE: Crane has no questions, Mr.  
22 Chairman.

23 CHAIRMAN HALL: International Association of  
24 Machinists and Aerospace Workers?

25 MR. LIDDELL: Yes, Mr. Chairman, just one

1 question for Dr. Shanahan. Could you qualify, or give  
2 me a further explanation when you say no explosive  
3 evidence was found?

4 WITNESS SHANAHAN: Yes. Without going into  
5 too many details, an explosion in close proximity to an  
6 individual leaves certain injury patterns. As I  
7 mentioned, one, which was fragmentation of the body,  
8 the way the body reacts to that in terms of you get  
9 tearing instead of lacerations.

10 You also, with very close proximity, would  
11 see powder, discoloration and other things of that  
12 nature. But, probably more importantly would be the  
13 nature of material that would be -- that would be found  
14 inside the body, that had penetrated the body.

15 so, those are the basic things we look at --  
16 looked at and couldn't find any correlation, or  
17 couldn't find any evidence, I should say, of an  
18 explosive device going off in close proximity to an  
19 individual .

20 Considering the distribution of people within  
21 the cabin, at least insofar as assigned seating, it  
22 would pretty well, without evidence from anybody, it  
23 would pretty much rule out any large device within the  
24 cabin itself.

25 Of course, I understand that that doesn't

1 apply to the aircraft as a whole, but as I mentioned in  
2 my earlier discussion was that we look at this as one  
3 particular layer of the investigation.

4 MR. LIDDELL: No further questions.

5 CHAIRMAN HALL: Thank you. Are there  
6 additional questions from any of the parties to these  
7 witnesses?

8 (No response. )

9 If not, we will move up to the Board of  
10 Inquiry. Mr. Sweedler?

11 MR. SWEEDLER: I have no questions, Mr.  
12 Chairman.

13 CHAIRMAN HALL: Dr. Ellingstad?

14 DR. ELLINGSTAD: I have no questions.

15 CHAIRMAN HALL: Dr. Loeb?

16 DR. LOEB: Just one question. Dr. Wetli, I  
17 just wanted to make certain. I don't think this  
18 question was asked directly. Did you see any evidence  
19 of an explosion or explosive device in the process of  
20 doing the autopsies and the medical examination?

21 DR. WETLI: No, we saw nothing that we could  
22 definitely say was an explosive device, but the -- many  
23 of the bodies in fact became, if you will, projectile  
24 traps, and there was a lot of shrapnel, rivets and  
25 metallic fragments which we had no idea what they were,

1       although we could assume they were in fact portions of  
2       the airplane.

3               When we encountered something that was  
4       different or unusual we did bring it to the attention  
5       of Dr. Shanahan or one of his people, and also to the  
6       attention of the FBI, and usually got a very quick  
7       turn-around answer that it was a piece of a certain  
8       part of the plane, or what have you.

9               The other things that Dr. Shanahan mentioned  
10       we also were looking for; evidence of powder or things  
11       that would not seem to fit an airplane part and so  
12       forth. We never encountered anything like that,  
13       either.

14              DR. LOEB: Thank you.

15              CHAIRMAN HALL: Well, I have a couple of  
16       questions, and I want to preface my questions with some  
17       comments, brief comments. Alluding back to what I said  
18       at the very beginning, this is -- this is a difficult  
19       area to discuss in a public setting and I wish that --  
20       I wish that we didn't have to do it, but we felt that  
21       it was necessary to do to be sure we had a complete  
22       discussion of the issues.

23              Let me say candidly that -- and I have a  
24       great appreciation for the work of both Dr. Shanahan  
25       and both Dr. Wetli -- and what Mr. Simon and Mr. Hughes

1 did. But, we have a situation here that needs  
2 improvement in future accidents in terms of the  
3 interrelationship between the Medical Examiner, the  
4 NTSB, the federal authorities and the families.

5 While I appreciate and understand Dr. Wetli's  
6 comments -- and then the Chairman always tries to  
7 encourage public officials to be responsible in their  
8 comments. There was feeling among the families that  
9 things could have been handled in a better fashion, and  
10 there were misunderstandings, and there were things  
11 that could be improved.

12 It is the National Transportation Safety  
13 Board's responsibility as the primary federal agency,  
14 and the Medical Examiner who is responsible to try to  
15 look at the job we did, and if there are ways to  
16 improve it since this accident -- and I mentioned this  
17 to the families in my remarks last evening.

18 As you know, President Clinton initiated the  
19 Gore Commission to look at a number of things,  
20 including how we handle the family matters. The  
21 Congress under the able leadership of Chairman Duncan,  
22 Chairman McKane have passed legislation now entrusting  
23 the NTSB with the responsibilities of better  
24 coordinating in the future some of these -- the  
25 handling of some of these issues which are very, very

1       difficult issues.

2               Here, because of the uncertainty of exactly  
3 what had caused this accident, there was the competing  
4 needs and interests of the families for identification  
5 of the remains, as well as the responsibility of the  
6 Medical Examiner and the criminal authorities to be  
7 sure that none of the remains provided evidence that  
8 might lead to criminal action.

9               But, there are a couple of concerns that had  
10 been expressed, and I wanted, Dr. Wetli, for you and I  
11 to explore just a little more the interaction with the  
12 Attorney General in regard to the autopsy reports and  
13 the death certificates that the families have received.

14              If you could, tell me exactly what that  
15 process is, and any suggestions you have on how that  
16 might be improved.

17              WITNESS WETLI:    I am not sure I quite  
18 understand your question.  Are you referring to the  
19 release of autopsy reports and autopsy findings to  
20 families as well as death certificates?

21              CHAIRMAN HALL:    Yes.

22              WITNESS WETLI:    How that takes place?

23              CHAIRMAN HALL:    Yes.

24              WITNESS WETLI:    Okay.  The death certificate;  
25 as soon as we have identified the person and -- as soon

1 as we have identified the person and performed the  
2 autopsy, then the death certificate is released right  
3 away.

4 In other words, we fill out the portion of  
5 the death certificate concerning the medical aspects of  
6 it, and then the death certificate is turned over to  
7 the funeral directors who fill out the rest of it, and  
8 we will then notify the family, and then the family can  
9 make arrangements with the funeral directors and so  
10 forth for the release of the remains for cremation, or  
11 what have you.

12 CHAIRMAN HALL: Do they have a final death  
13 certificate? You had mentioned in your earlier  
14 testimony that there was -- that you were awaiting the  
15 cause, or the probable cause of the accident for a  
16 final death certificate.

17 I think some of the families -- obviously, I  
18 would be if I had lost a family member -- would want to  
19 know where is - you know, when will that -- when can I  
20 put closure on that part of this process.

21 WITNESS WETLI: The closure can only come  
22 once we have, in a sense, a completed death certificate  
23 as far as manner is death is concerned, meaning natural  
24 accident, suicide, or homicide. That determination has  
25 to come with the identification of the cause of the

1 crash.

2 CHAIRMAN HALL: so, at the present moment the  
3 families -- the death certificates they have under the  
4 State of New York law are temporary death certificates?

5 WITNESS WETLI: Yes, they are pending further  
6 investigation. Once we have an official pronouncement  
7 as to the cause of the crash, the section on the manner  
8 of death and how the accident occurred, presumably when  
9 that is filled out then that will be the final death  
10 certificate.

11 CHAIRMAN HALL: You had some thoughts that  
12 we -- I had discussed and Secretary Slater and I had  
13 gotten into in some detail with the responsibilities we  
14 were given with the Task Force on Family Assistance,  
15 in regard to DNA testing did -- at what point in this  
16 investigation did we - did this -- in the process  
17 here, did we start to do DNA testing and was that  
18 decision made to start DNA testing?

19 WITNESS WETLI: The decision to start DNA  
20 testing was made very early on, probably that weekend  
21 of the crash. The crash occurred Thursday evening, and  
22 I would say Saturday or Sunday we made a definite  
23 decision that DNA testing was going to be needed  
24 because we realized the recovery effort was going to be  
25 probably relatively slow. We were not going to be

1 getting the remainder of the bodies, for example, the  
2 next week.

3 so, I then uniformly -- or, I contacted the  
4 Armed Forces Institute of Pathology by telephone and  
5 requested that they give us support with DNA testing as  
6 well as anthropology, forensic anthropology which I  
7 anticipated. I believe it was on July 22nd, and I sent  
8 a formal request to the AFIP asking for more formal  
9 assistance should we need it in the area of DNA.

10 We have a very good DNA laboratory in our  
11 office, so we were able to, with the assistance of the  
12 New York City EMS people, obtain material we needed and  
13 began the DNA testing right away in our office. Then,  
14 subsequently in January or February utilized resources  
15 of the Armed Forces Institute of Pathology, as well.

16 CHAIRMAN HALL: Well, we have -- in future --  
17 let me first paraphrase by saying I hope there is no  
18 future, but if there is a future accident of this  
19 magnitude we have initiated -- I must -- I would like  
20 to report that the National Association of Medical  
21 Examiners we have met with -- I went and spoke to your  
22 national convention.

23 There are resources available to the Federal  
24 Government Mortuary Teams that are part of the  
25 Department of Health and Human Services that can come

1 in and assist the local Medical Examiner at the -- at  
2 the beginning of a situation like this so that we can  
3 try to deal in a responsible fashion to those  
4 individuals who lost a loved one, who are very  
5 interested in the identification of that loved one and  
6 want that loved one back just as soon as they can get  
7 that loved one back with their family members for  
8 appropriate services.

9 The other; obviously, responsibilities we  
10 have in an accident or situation similar to TWA to  
11 the -- to the investigation in trying to find out the  
12 truth of what happened.

13 Dr. Shanahan, explain to me again, because I  
14 know that many of the American people may see the  
15 simulations that have been done by both the CIA and the  
16 NTSB that you have seen today, and see the fire  
17 depicted with the aircraft. Again, how does that match  
18 up with so few burn victims in what you found in terms  
19 of the medical, the forensic information?

20 WITNESS SHANAHAN: Well, of course it is  
21 difficult to determine within a real degree of  
22 certainty exactly what happened. I think to preface my  
23 answer, I think I need to explain that there were many  
24 what we call mechanisms of injury available in this  
25 particular sequence.

1           You have the break-up of the aircraft itself  
2           which imparts significant forces upon individuals; you  
3           have tumbling, potentially, of the aircraft sections  
4           themselves, and as they break up seats are coming out  
5           and other things are happening on board; and then  
6           impact with the water.

7           But, so it is difficult to look at any  
8           particular injury or set of injuries and say it  
9           happened at one particular time. That becomes very  
10          difficult because, unless you have some very salient  
11          characteristics to these injuries, you won't be able to  
12          determine at what point it occurred.

13          Fire is a little bit easier to determine in  
14          that respect because we know something about the  
15          propagation of the fire and the type of fire that  
16          occurred on board the aircraft. Again, it is somewhat  
17          in the area of speculation, but remember at least for  
18          the initial part of the break-up these -- the  
19          individuals were contained within the fuselage  
20          structure itself. There might have been some fire  
21          externally, but would not have penetrated the fuselage.

22          There was also the explosion of the tank  
23          which, as we mentioned, did not penetrate to a high  
24          degree within the cabin interior itself, although there  
25          may have been a flame front associated with that, and

1 that is one possibility of how some individuals got  
2 these flash type burns.

3 The other possibility is that shortly after  
4 the explosion of the fuel tank the aircraft started to  
5 fragment, and seats probably tore out and other things  
6 occurred. So, people could have been separated from  
7 the aircraft itself prior to the time that a  
8 significant amount of fire got within the aircraft  
9 cabin. We can't say with certainty that that occurred,  
10 but it is certainly one of the explanations for it.

11 CHAIRMAN HALL: Dr. Shanahan, are you aware,  
12 or have you participated in any type of reconstruction  
13 of this magnitude prior to your experience with TWA  
14 800?

15 WITNESS SHANAHAN: No, sir, not of this  
16 magnitude . This is certainly the largest I have ever  
17 been involved with. I have primarily been involved  
18 with military crashes, which are in general  
19 considerably smaller.

20 CHAIRMAN HALL: This, of course, as Mr.  
21 Hughes pointed out, is the first time that the Board  
22 did an interior reconstruction of the aircraft where  
23 you could actually walk into the aircraft through the  
24 aircraft seating as it was reconstructed.

25 We have had the families to Calverton for the

1 purpose of being able to see that and it was, of all  
2 the emotional moments this whole experience has  
3 provided, was the most emotional for me.

4 Well, are there any other comments that the  
5 Technical Panel has, questions, or the Board of  
6 Inquiry?

7 (No response. )

8 Gentleman, I appreciate your attendance here.  
9 Let me close by saying, though, that everyone worked  
10 very hard under very difficult circumstances and, Dr.  
11 Wetli, while I appreciate your appearance here today, I  
12 do hope that in future investigations that we will be  
13 able to do a better job in this area than we did,  
14 particularly as it was left in the mind of the family  
15 members. For all that, there is clearly -- you know,  
16 clearly room for improvement.

17 We are going to proceed tomorrow morning with  
18 the Fuel Tank Design Philosophy and Certification Panel  
19 Presentation promptly at 9:00 a.m., and we will  
20 therefore -- I will excuse these witnesses.

21 I thank the parties and the audience for  
22 their attention and courtesy that was extended today,  
23 and we will recess until 9:00 a.m. tomorrow morning.

24 (Whereupon, at 4:52 p.m. the hearing was  
25 adjourned, to reconvene at 9:00 a.m. the following day

in the same location.)

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