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

I N D E X

E X H I B I T S

P R O 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

TWA 800 never occurs again.

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

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

In the nine months of the recovery effort, there were 677 surface-supplied dives and 3,667 scuba dives, resulting in 1,773 hours of bottom time for the divers. That is the equivalent of 74 twenty-four hour days, and I hope all of you all can think with me and visualize the brave men and women who made those dives under those conditions to recover the loved ones and the wreckage. We all owe them a debt of gratitude.

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

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

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

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

While this effort was going on, the Safety Board participated in or conducted flight tests, explosion tests and laboratory examinations from airfields in England to California, and labs in Tennessee, New Mexico, California, Colorado, Ohio and Washington State. You will learn the results of all of those studies during this hearing.

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

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

The binders containing those letters are located behind me this morning. They include suggestions such as a smoker lit a cigarette in the lavatory and ignited fuel vapors; a mobile phone ignited gases in the air; if the crash was caused by weather events like a cyclone, lightning or wind shear; by bird strikes; by an exploding tire; by a cargo door opening; by a laser beam; by a bullet from a highpowered rifle; by a malfunctioning fuel pump or vent; by contaminated fuel; by mechanical problems like bad rivet holes or failures in the cabin pressurization system; by metal fatigue; or even that the plane was just too heavy to stay in the air.

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

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

All of this in an effort to reach the two goals of this investigation -- learning the ignition source that sparked the fuel tank explosion, and I believe even more importantly finding the best means of reducing the likelihood of explosive fuel/air vapors from accumulating in airliner fuel tanks. Because, in the final analysis, had the vapors in TWA Flight 800's fuel tank not been explosive, this accident would not have occurred, no matter what the ignition source.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Public hearings such as this are an exercise in accountability, accountability on the part of the Safety Board that is paid by public dollars, that it is conducting a thorough and fair investigation; accountability on the part of the Federal Aviation Administration that it is adequately regulating the industry; accountability on the part of the airline that it is operating safely; accountability on the part of the manufacturers as to the design and performance of their products; and accountability on the part of the work force, the pilots, the machinists and flight attendants, that they are performing up to the standards of professionalism expected of them.

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

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

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

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

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

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

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

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

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

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

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

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

Neither I nor any Safety Board personnel will attempt during this hearing to analyze the testimony received, nor will we at any time attempt to determine the probable cause of this accident. Such analysis and cause determination will be made by the full five-member Safety Board after consideration of all the evidence gathered during our investigation.

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

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

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

But, this is a public proceeding, and most of the 250 million Americans will rely on the media to learn what transpires here. I am going to ask the media, however, not to conduct any interviews here in this auditorium. This is for the business of the public hearing. All interviews should be conducted outside this room.

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

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

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

The Department of Transportation, Federal Aviation Administration?

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

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

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

The Airline Pilots Association?

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

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

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

Trans World Airlines, Inc.?

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

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

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

The Boeing Commercial Airplane Group?

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

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

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

The International Association of Machinists and Aerospace Workers?

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

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

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

CHAIRMAN HALL: Thank you very much. We appreciate the International Association of Machinist and Aerospace Workers' participation in this hearing.

Honeywell, Inc.?

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

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

CHAIRMAN HALL: Crane Company/Hydro-Aire?

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

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

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

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

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

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

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

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

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

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

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

Anyone wishing to purchase a transcript of this hearing, including the parties to this investigation, should contact the Court Reporter directly.

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

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

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

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

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

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

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

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

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

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

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

With all exhibits having been entered into the docket, and I will ask Mr. Al Dickinson, the Investigator-in-Charge of this investigation to present his opening statement. Mr. Dickinson?

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

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

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

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

The flight was scheduled to depart at 7:00 p.m. for Charles DeGaulle Airport in Paris. However, the flight was delayed due to a passenger/baggage mismatch and a disabled piece of ground equipment. Flight 800 took off from runway 22 right at 8:19 p.m. Visual meteorological conditions prevailed, and instrument flight rules flight plan was filed.

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

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

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

Upon arrival at Islip Airport we went

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

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

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

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

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

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

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

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

The recovery effort was an amazing feat, and all men and women who were part of that effort deserve our admiration and gratitude. Captain McCord will discuss the Navy operations shortly.

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

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

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

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

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

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

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

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

To better understand the accident, we built a three dimensional reconstruction, including the structure around the center wing tank from about fuselage station 520 to station 1640. The reconstruction, the largest in the world, took over two months to construct and contains over 876 pieces of wreckage, weighing over 60,000 pounds.

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

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

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

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

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

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

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

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

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

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

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

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

As I mentioned earlier, neither the CVR nor the FDR indicated any problems with the aircraft before the explosion. The FDR contained eighteen parameters and indicated that at the time the recording stopped the aircraft was in a wings level climb. The interruption in the recording was consistent with a sudden loss of electrical power to the recorder.

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

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

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

As part of both of these tests, we recorded the explosions on voice recorders in hopes of aiding our analysis of the sound spectrum from the cockpit voice recorder of TWA 800.

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

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

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

Nine flights were flown, including simulations of TWA Flight 800, for a total of forty-three hours of flight time. The results of these tests will be discussed this week.

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

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

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

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

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

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

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

Mr. Chairman, this concludes my statement.

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

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

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

(Witness approaches the witness stand.)

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

Whereupon,

CAPTAIN MCCORD,

was called as a witness by and on behalf of the NTSB, and, after having been duly sworn, was examined and testified on his oath as follows.

MR. DICKINSON: Thank you. Please be seated. Captain McCord, is the Director of Ocean Engineering, Supervisor of Salvage and Diving for the U.S. Navy a detailed description of Captain McCord's biography is on the NTSB web site today. Captain McCord served as the Coordinator for Salvage and Diving for many -- for the recovery of the wreckage of TWA 800.

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

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

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

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

DIRECT EXAMINATION

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

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

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

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

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

On the night of the 17th of July, the Navy was well aware of the problems with the TWA after the crash after we saw that on the TV that night. We were in contact with the NTSB the next day, and mobilized equipment to the site. What I would like to do in my presentation this morning is discuss how we conducted this operation.

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

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

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

I would like to point out that all three of these phases, although they are somewhat sequenced, continued out through the entire operation. I think you will appreciate from some of the slides I have this morning the importance of following a very disciplined approach in this search and recovery.

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

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

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

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

(Slide shown.)

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

(Pause.)

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

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

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

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

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

Again, we looked at this -- analyzed the data in conjunction with the NTSB to make sure that we were all on -- looking at the same information for the radars. On scene that night of the accident was the NOAA Ship Rude who had come out of Newport, Rhode Island to help in the assistance and possible recovery of victims, and also to -- wreckage that was floating on the surface that night. Rude had a small side scan sonar on her, and we were able to utilize her.

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

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

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

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

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

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

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

(Pause.)

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

(Next slide shown.)

In the lower left hand corner, mid way up is the -- is a 747 drawn to scale. This map is about three miles by three miles square. On this map are a series of dots, and I won't go into the color of the dots right now, but they were different stages of the investigation. The dots would change color as to whether we had investigated a sonar contact, or recovered it.

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

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

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

In the small box where a picture called USS Grapple is pointed to is where we discovered the cockpit and the first class section. In the upper right hand box of the major debris field where we have a line showing the USS Grapple is where the after part of the airplane from just forward of the wings to the tail ended up.

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

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

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

This method and this approach proved to be very beneficial for us, because Grasp was able to stay in that position for thirty-six days able to conduct diving and ROV operations around the clock for thirty-three of those thirty-six days.

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

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

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

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

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

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

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

It is very dangerous diving, and so what -- we used the Trenton and the Oak Hill to berth the divers when they were not on their shifts and, so, what -- we went to two twelve-hour shifts with about twenty divers on each ship.

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

(Next slide shown.)

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

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

Later on when we were starting to recover some of the large pieces of wreckage, the ROV would go down, the divers would look at the site before they would go down and they would know what tools and techniques that they were going to use when they got down on the bottom. The divers would then lift the big, heavy pieces straight up from the bottom to the ship with a boom. The smaller pieces would be put into a wire mesh.

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

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

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

We then use a couple of specifically military pieces of equipment in the recovery phase. On the small boats we had a hand-held military global positioning system, navigation system, GPS, that allowed -- that fixed the small boats' position to within about two to three yards.

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

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

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

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

(Next slide shown.)

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

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

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

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

To do this, it made much more sense to recover the wreckage. In the upper right-hand corner of the picture on this, you see a small wire mesh basket in the forefront. That was the type of basket that we used to put the smaller pieces in. The back shows larger pieces of fuselage that was rigged directly from the divers down on the bottom and picked up and put on the deck of the ship.

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

(Next slide shown.)

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

In addition to the two salvage ships, we had a small tug that we brought with us on board the USS Oak Hill and later on the Trenton. This allowed us to conduct recovery at remote sites from the salvage ships, but still needing a large lift capability, and this small tug had a ten ton capability to pick debris off the bottom.

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

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

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

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

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

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

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

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

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

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

(Next slide shown.)

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

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

In the trawling, we conducted 13,000 trawl lines for over 19,000 miles. To put this in perspective, if that trawling vessel was laying its nets down there, it would be sweeping one side of an interstate from Boston to Los Angeles and back seven times.

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

If I could run that video?

(Videotape shown.)

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

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

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

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

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

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

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

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

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

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

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

WITNESS McCORD: Yes, sir. We searched -- the initial search area was about a five by five mile box, twenty-five miles. We then conducted two other searches along the flight path going back towards the airport, about another twenty-five square miles back that way, and then another twenty-five miles further out -- twenty-five square miles further out. So, a total of about seventy-five square miles was our initial search box.

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

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

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

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

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

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

CHAIRMAN HALL: Thank you. In your opinion, do you have any idea how much of the wreckage was recovered and brought to the hangar at Calverton?

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

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

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

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

WITNESS McCORD: No, sir, trawling is not a normal recovery operation. This was not a normal operation. We do a lot of aircraft recovery, and normally we are in and out. We get something that the investigators can clue on very quickly.

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

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

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

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

WITNESS McCORD: Well, they didn't hamper the recovery, Mr. Chairman. The victim recovery was our number one priority. The members of the team, the divers, all the support people there were totally dedicated to recovering the victims throughout the entire operation; not just the Navy divers, the civilian divers, but even the trawling captains, too. That was our number one priority. It did not hamper us. It was just another aspect of the salvage operation that we had to conduct at that time.

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

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

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

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

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

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

WITNESS McCORD: Thank you, sir.

CHAIRMAN HALL: You are excused, Captain.

WITNESS McCORD: Thank you.

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

(Whereupon, a brief recess was taken.)

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

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

Mr. Mills has now got an ace bandage around his hand, and I guess you are the first casualty of this hearing. We hope we don't have anymore, Mr. Mills. We appreciate you exercising your responsibilities, and we appreciate the citizens of the great City of Baltimore for hosting this most important hearing.

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

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

Whereupon,

JOHN CLARK,

was called as a witness by and on behalf of the NTSB, and, after having been duly sworn, was examined and testified on his oath as follows.

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

DIRECT EXAMINATION

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

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

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

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

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

CHAIRMAN HALL: All right, very good.

WITNESS CLARK: So, we are okay.

(Slide shown.)

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

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

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

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

(Discussion off the record.)

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

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

(Slide shown.)

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

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

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

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

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

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

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

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

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

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

(Next slide shown.)

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

CHAIRMAN HALL: Could you identify those things as you describe them, or someone -- Charlie could on the screen, so --

WITNESS CLARK: Okay.

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

WITNESS CLARK: Certainly.

CHAIRMAN HALL: Okay.

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

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

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

(Next slide shown.)

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

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

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

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

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

The aft section of the airplane is tracked through the groups of primaries to its location in the water. We could identify several primaries that we believed to be that aft section. We can also track several primaries of the forward section to its location in the water.

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

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

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

CHAIRMAN HALL: Because of the speed?

WITNESS CLARK: Yes, the speed, yes.

(Pause.)

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

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

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

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

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

(Next slide shown.)

We conducted ballistic trajectory studies to help us understand how parts separated from the airplane and ended up in those debris fields. The ballistic trajectory is the path of a falling part that is affected only by gravity and friction -- to us that is drag -- and wind.

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

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

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

In the presence of a cross-wind heavy, low drag parts will tend to continue along the original flight path, but would drift slightly downwind. Light weight, high drag parts can drift long distances downwind as they settle to earth. Parts that have trajectory characteristics that are between engines and insulation would fall somewhere on that parabolic curve.

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

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

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

(Next slide shown.)

This graph shows ballistic trajectories of several parts that were separated at the time of the explosion. It is an overhead view looking down, so we were looking at the ground track. Again, the vertical axis is distance south of Islip radar and the horizontal axis is distance east of Islip radar.

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

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

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

In this graph most of the predicted separation points -- the ends of those tracks are positioned at the point where the part was found. For example, the pointer --

(Demonstrating.)

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

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

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

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

(Pause.)

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

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

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

There were numerous parts that continued to separate over the next several seconds up to the point noted for the fuselage section. Our calculations show that most of the big pieces of the airplane were in the water within fifty to ninety seconds of the explosion.

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

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

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

(Discussion off the record.)

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

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

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

(Pause.)

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

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

WITNESS CLARK: Yes, sir.

(Pause.)

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

This video is being played in real time.

(Video presentation.)

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

WITNESS CLARK: The green line is the aft section of the airplane. It includes the wings, the engines and the aft section. The yellow line is that seventy-foot forward section that separated, and the red lines are the several parts of various sizes and weights from in and around the center wing tank.

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

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

WITNESS CLARK: Yes, sir.

(Video presentation continued.)

I think we can cut the video and proceed ahead.

(Pause.)

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

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

Air traffic voice recordings record

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

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

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

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

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

(Next slide shown.)

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

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

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

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

(Next slide shown.)

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

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

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

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

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

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

No other unusual noise signatures have been found near the end of the CVR tape. Of significance, there were no signatures on the FDR that indicated to us that something was wrong until that last one-tenth of a second signature on the CVR. Thus, the very last signature of the CVR is to us undoubtedly the start of the structural break-up of the center wing tank.

(Next slide shown.)

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

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

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

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

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

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

(Next slide shown.)

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

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

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

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

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

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

(Next slide shown.)

The following animation --

CHAIRMAN HALL: Well, let's pause a moment, and if there are any of the family members or others of the audience that don't wish to view the upcoming video, please -- we will give you a moment to excuse yourself.

(Pause.)

Please proceed, Mr. Clark.

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

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

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

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

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

(Video presentation.)

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

(Video presentation continued.)

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

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

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

(Video presentation.)

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

That concludes my presentation.

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

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

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

(Pause.)

Mr. Crider?

MR. CRIDER: No, sir.

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

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

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

So, we will begin the questioning of this witness with Crane Company Hydro-Aire, and I would request if you could -- and I apologize for this, but evidently if you can remove the microphone and stand the cameras could see you and you could -- the viewing -- people who are viewing this event would have an opportunity to see the person answering the question.

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

Crane Company Hydro-Aire?

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

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

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

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

CAPTAIN YOUNG: Yes, sir, Captain Bob Young. One question for Mr. Clark. You mentioned it before, and I just want to re-verify. No radar data showed any altitude after the event occurred. In other words, we have no height finding radar, or any system that would show us the altitude of the parts of the airplane after the explosion. Is that correct?

WITNESS CLARK: That is correct.

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

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

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

CHAIRMAN HALL: Boeing Commercial Airplane Group?

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

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

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

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

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

CHAIRMAN HALL: Okay, that's fine.

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

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

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

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

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

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

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

CAPTAIN REKART: Thank you. There was another area on the descent of the aft section of the aircraft where it showed several green pieces that were split off from the main portion of the aircraft. Can you go into that a little bit, please?

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

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

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

CHAIRMAN HALL: Honeywell, Inc.?

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

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

(No response.)

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

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

CHAIRMAN HALL: Mr. Ellingstad? Dr.

Ellingstad, I apologize.

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

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

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

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

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

MR. ELLINGSTAD: Thank you, Mr. Clark.

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

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

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

DR. LOEB: Thank you.

CHAIRMAN HALL: Mr. Clark, I appreciate your presentation and the visual presentation that is easier, obviously, than the charts, graphs and columns of data in trying to understand the motion of the aircraft for the individuals who aren't specifically trained in that expertise.

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

(No response.)

WITNESS CLARK: No, sir.

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

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

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

Jim Cash is over at the visualizer, and Jim

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

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

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

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

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

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

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

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

A F T E R N O O N   S E S S I O N

(Time noted: 1:00 p.m.)

CHAIRMAN HALL: We will reconvene this hearing of the National Transportation Safety Board. It is convened for the discussion of the accident involving TWA Flight 800.

We are going to continue with the next agenda item, which is titled "Wreckage Examination and Sequence of Break-up." There will be a presentation by Mr. Jim Wildey of the National Transportation Safety Board staff, followed by a Panel presentation by two individuals who I will introduce as soon as Mr. Wildey concludes his presentation.

So, I would ask if Mr. Wildey could be sworn in, Mr. Dickinson?

MR. DICKINSON: Yes, sir, Mr. Chairman. Mr. Wildey, please stand.

(Witness complies.)

MR. DICKINSON: Raise your right hand, please.

Whereupon,

JAMES WILDEY,

was called as a witness by and on behalf of the NTSB, and, after having been duly sworn, was examined and testified on his oath as follows.

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

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

DIRECT EXAMINATION

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 catalogued the results with an enlarged set of notebooks and computer database.

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

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

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

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

The Fire and Explosion Group and the Structures Group also made several smaller scale three-dimensional mock-ups of the wing center section and the adjacent portions of the fuselage. These mock-ups that were constructed on scaffolding were small enough that the fractures were readily accessible and the various interactions between pieces could be explored.

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

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

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

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

CHAIRMAN HALL: Can we sharpen the focus on that at little.

(Slide shown.)

WITNESS WILDEY: Maybe not. Okay. For example, the station 520 there at the forward end is a point which would be about 520 inches from the nose of the airplane, and similarly on back through the rest of the labels there.

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

(Next slide shown.)

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

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

All the major parties to the investigation --

CHAIRMAN HALL: Are we going to give his

name?

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

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

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

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

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

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

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

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

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

For example, there is a large hole in the fuselage above the right wing, which is being pointed out there (demonstrating), and there is also a linear hole above the nose section window belt. The fuselage skin for both of these areas was contained on adjacent structure, but has been folded or deformed.

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

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

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

Initial examinations of the earlier mock-ups show that a portion of the aft fuselage and the nose section of the airplane remained relatively intact and impacted the water nearly flat, though the structure rotated somewhat to the right.

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

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

(Next slide shown.)

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

The pieces from the aft portion of the fuselage similarly were recovered from the green zone, and those pieces also have the same kind of upward crushing damage and indicates that this whole section of the airplane was intact when it hit the water.

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

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

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

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

WITNESS WILDEY: Well, a fracture propagation simply is the direction that a fracture, or a crack takes as going through a piece of metal, and we can look at the individual characteristics of the metal and of the fracture surface itself, and many times you can read the direction of propagation, or the running direction of the crack in this area.

CHAIRMAN HALL: Thank you.

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

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

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

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

WITNESS WILDEY: I am with you on that one. Stress analysis is basically number crunching to try to show with the expected loads on pieces what the stress is in the local and individual areas, and basically by knowing the material properties and the loads you can determine at what stress levels the individual parts would be failing.

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

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

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

CHAIRMAN HALL: Very well.

WITNESS WILDEY: The Sequencing Group determined that the break-up of the airplane was initiated from an explosion of the wing center section fuel tank.

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

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

(Next slide shown.)

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

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

CHAIRMAN HALL: You could stand in part of that?

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

CHAIRMAN HALL: No, well --

WITNESS WILDEY: Most people can.

(Laughter.)

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

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

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

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

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

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

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

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

WITNESS WILDEY: That's all right. The upper and lower skins of the wing center section are a thicker gage aluminum to carry the wing loads. The wing center section also contains a series of lateral or span-wise beams, and we will be referring to those. These beams connect the upper and lower skin to each other and provide stiffness.

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

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

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

WITNESS WILDEY: That is exactly correct. There is no bladder, or no can, or anything like that. It is actually physically located between the structural members that are sealed to keep the fuel inside.

CHAIRMAN HALL: Thank you.

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

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

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

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

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

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

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

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

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

CHAIRMAN HALL: Okay.

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

(Visual aid demonstration.)

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

(Visual aid demonstration.)

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

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

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

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

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

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

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

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

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

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

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

(Next slide shown.)

Also, upper pressure --

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

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

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

Here we tried to draw in the motion of span-wise beam three, which is the red arrows you see coming forward. That is the motion of the upper end of the end of span-wise beam three as it comes forward and hits the front spar.

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

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

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

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

As this photograph shows, the light arrows coming down indicate the fractures that are initiating in the front spar, and they are progressing from the top down. We didn't try to draw in all the damage, but there is significant other damage as span-wise beam three is hitting the front spar.

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

(Visual aid demonstration.)

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

(Next slide shown.)

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

Once the upper end of the front spar becomes totally separated from the upper skin, as is shown in the figure here, the over pressure within the wing center section could then force the lower skin of the center section and the forward end of the keel beam downward.

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

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

Did you point out the lower pressure bulkhead?

(Visual aid demonstration.)

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

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

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

CHAIRMAN HALL: What's a stringer?

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

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

One of the features we tried to explain was how did this fracturing initiate. We found that the stress analysis indicated that the downward motion of the keel beam by itself, as a result of the internal pressure from the explosion of the fuel tank would be enough to initiate cracking at stringer forty right. However, I should also emphasize this area is subjected to normal loads during typical airplane flights.

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

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

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

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

(Next slide shown.)

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

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

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

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

(Next slide shown.)

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

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

(Visual aid demonstration.)

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

Nearly symmetric pieces on each side of this hole then departed the airplane by motioning in an outward, upward and aft direction creating a curl of metal as the final corner pealed from the underlying structure.

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

(Next slide shown.)

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

(Visual aid demonstration.)

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

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

The window belts are stiffened structures.

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

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

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

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

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

At this point in time now, the red zone

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

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

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

Following some period of crippled flight after the explosion, the outboard ends of the left and right wings separated symmetrically in upward bending. Concurrently with or immediately after these wing tip separations, the weakened wing center section failed with the left wing separating away from the right wing and aft fuselage.

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

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

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

Also, the airplane itself was relatively lightly loaded to begin with, and the loss of the nose section would disrupt the lift from the inboard portion of the wings, thereby reducing the loads in the wing center section without affecting the loads further outboard where the wings initially fractured. We concluded that it is indeed possible for the wing tips to separate before the wing center section.

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

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

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

The break-up sequence ends as the wing tips, the left wing and the right wing with much of the wing center section and the fuselage aft of station 1480 then impacted the water separately, but relatively closely dispersed in the green area. The right wing was recovered mostly in one piece.

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

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

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

First of all, the conclusions reached by the Sequencing Group eliminated a large scale structural problem away from the wing center section fuel tank. Specific areas that were eliminated as factors include the section 4142 fuselage joint in the forward cargo door. A report on these subjects is contained in Exhibit 15(c).

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

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

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

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

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

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

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

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

The Sequencing Group concluded that the petite cracks did not cause or contribute to the explosion of the wing center section fuel tank, or even significantly alter or affect the manner in which the airplane broke apart.

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

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

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

(Video presentation.)

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

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

(Video presentation continued.)

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

(Video presentation continued.)

There is more.

(Video presentation continued.)

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

(Video presentation continued.)

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

(Video presentation continued.)

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

(Video presentation continued.)

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

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

(Video presentation continued.)

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

(Video presentation continued.)

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

(Video presentation continued.)

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

(Video presentation continued.)

We had almost all the inboard portions of the upper and lower surfaces of the wings to some degree. Rotating the model now shows that there are only very few or limited direct line entry points into the wing center section tank.

(Video presentation continued.)

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

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

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

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

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

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

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

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

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

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

Whereupon,

RICHARD BOTT and BARRY SHABEL,

were called as a witnesses by and on behalf of the NTSB, and, after having been duly sworn, were examined and testified on their oath as follows.

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

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

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

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

CHAIRMAN HALL: Please proceed with the

questioning.

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

DIRECT EXAMINATION

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

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

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

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

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

The second region of damage; slightly further away there will be numerous high velocity impact penetrations from the fragments on the warhead. I believe Dr. Shabel will go over the characteristics of high velocity and low velocity fragment impacts, but let me just quickly summarize some characteristics of high velocity impact.

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

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

So, I will give you some idea on shoulder launched missiles, how large those areas may be. Variables are numerous. It is difficult to say exactly, but if a warhead detonated somewhere near the surface of this aircraft there would be complete material removal -- region one of an area of, say, two to three feet in diameter.

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

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

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

However, the high velocity fragments, those typically occur at speeds -- again, it is dependent on materials -- in excess of, say, 4,000 feet per second. Those speeds are usually not encountered in post impact -- post-mishap ground impacts. I have never seen them in a mishap aircraft cause by anything other than an explosive event, either a bomb or a warhead.

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

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

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

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

A Well, the possibility that a missile -- shoulder launch missiles typically come with a self-destruct feature that will after a certain pre-set amount of time self destruct a missile if it doesn't impact its target and fuse, so you don't have live explosives laying around on the battle field.

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

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

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

In fact, if it was based on calculations, if you take one of these shoulder launch missile warheads and hang it out in space and put a 1,000 square foot target 100 feet away, which isn't too far, the number of large fragments coming off that warhead that will impact the 1,000 square foot target is only one or two.

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

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

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

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

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

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

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

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

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

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

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

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

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

Additionally, previous 747 mishaps have

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

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

Q Are you familiar with the --

CHAIRMAN HALL: Mr. Hilldrup?

MR. HILLDRUP: Yes, sir.

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

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

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

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

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

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

CHAIRMAN HALL: Thank you for that -- thank you.

BY MR. HILLDRUP: (Resuming.)

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

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

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

A Yes.

Q Okay.

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

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

A I have seen nothing.

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

CHAIRMAN HALL: I am trying to see something.

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

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

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

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

DIRECT EXAMINATION

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.

So, I could at least judge if the conditions and fractures and things that I was looking at were normal, if you will, as opposed to unusual and, again, my familiarity with the alloys and structures, microstructures and things of that sort that would be potentially relevant to the investigation.

BY MR. WILDEY: (Resuming.)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

So, in any event, we looked at the -- like I said, we had this background of comparative damage from the Boeing tests and some evidence from the literature on the kind of damages that one might see in penetrations and the nature of fracture surfaces. Then, also, the appearance of the spike type features.

We found in examining both the reconstructed portions of the aircraft, the fore and aft areas that you have seen pictures of there, and then also many of the parts on the hangar floor and in other areas at the Calverton hangar, we found about 117 or so spike type features.

Actually, most of the ones we found were on what we call the off reconstruction section. That is to say, they weren't all located in areas that comprised of forward reconstruction or near the central wing tank area, although there were spike features evident in those areas in some of the span-wise beam sections.

But, again, the spike features occurred in both the 2024 and 7075 type alloys in over a range of thicknesses in a variety of circumstances. So, from that type of evidence, I was led to in a sense to speculate or partly conclude that the spike feature was not as unique an indication of an explosion type of phenomenon as might have been inferred from some of those earlier papers which only tested the appearance and the presence of an explosion.

They may well be on a higher road to the higher strain rate kind of phenomenon that indicated that the fracture of the aircraft occurred quite rapidly after all. So, it certainly seems very likely that we would have a rapid -- what would be called a relatively high strain rate in this situation. But, again, as I said, the spikes were not as unique as we might have expected at the outset of my investigation.

In terms of the penetrations, we looked at a wide number of areas of the aircraft, in a sense as Richard did, almost -- many of the areas that were available to us, both the fore and aft constructions and the off construction areas on the hangar floor, cargo bed areas, there was some seat back areas that we looked at -- quite a range of samples. I think we had documented something like 1,400 instances that we looked at.

We really in no cases found -- again, by -- partly by some calibration in a sense with the Boeing test panels, we really found no evidence of the unusual high velocity or characteristic that we might have thought would have been apparent if a bomb or missile had occurred.

So, basically, I concluded from the extent of what I looked at that there was no evidence of a bomb or missile type of phenomenon.

Q Just as a point of clarification, you mentioned the spike tooth fractures. Did you examine the whole -- all the airplane structure for this type of feature?

A Yes, we did. We found -- well, we examined many pieces. We looked -- in all of the areas that I looked, we also did look for spike tooth for this spike fracture phenomenon. So, we did find some in the central wing tank area, but we found it -- in fact, most of the ones we found, I think 90 out of the 117 were actually found on just stray pieces off hangar and off reconstruction and elsewhere in a variety of locations.

So, we didn't see that these were unique to the central wing tank, or, you know, any particular area, in that sense. But, I didn't have locations on a lot of the individual parts that were on the Calverton floor, because those hadn't been located specifically with respect to the sites in the aircraft where they were.

Q So, just as another point of clarification, does the presence of these features throughout widely disbursed portions of the airplane, that is pretty much the largest factor in your conclusion that this is not a feature that can only be created by a high order explosion such as a bomb or a missile; is that correct?

A Yes, that would be -- I felt that the prevalence -- because, again, there were so many different parts, and then each of those parts then was in so many different locations around the aircraft that it didn't seem, you know, to fit with the hypothesis of a site being the focus of a -- of such an event.

Q Okay. Similarly, when you said -- you mentioned 1,400 penetrations. How many of those would you classify as small holes, or something like that, approximately?

A Well, in a way the bulk of them were small. I guess we characterized their sizes in at least an approximate way, and most of them were on the order of a quarter inch to less than a half an inch.

In one case where I did attempt, from the off reconstruction area parts that were lying on the floor of the hangar, there was one group of about 850, I believe, and the vast -- I would say most of them were under half a square inch in area.

So, quite a large number of them were probably less than a tenth of a square inch in area, which would correspond to diameters on the order of a quarter inch or perhaps a little bit larger. But, there were a number of larger holes, too, of course.

Q Okay, and just to complete this area, you found these holes, again, disbursed throughout the entire -- in all portions of the airplane structure; is that correct?

A Yes. We also -- we were looking at the fracture surfaces of the holes, and I should have added we also looked in some areas where we had what we called a missing area.

You had mentioned the reconstruction, but in some of the areas of the reconstruction, while some of the areas were -- where metal had curled back, as you had noted, Jim, actually there was no missing material, but in other cases there were just simply gaps, small gaps between located parts.

What we did was look at the fracture surfaces of the pieces we had which would have formed the perimeters of these missing areas. Again, all of the fracture surfaces that we looked at were quite consistent with normal -- or, what I would call normal velocity or normal mechanical testing deformation shaping types of processes in the metal.

They were not -- they were in typical kinds of failure surfaces that one sees in these aluminum alloys under normal conditions.

Q Were you able to reach a hypothesis or conclusion as to what was the cause of these holes, or penetrations if they were so widely disbursed?

A Well, I didn't really reach -- no, I can't say I reached a hypothesis as to the cause of the holes specifically, but they didn't have the features that we, you know, in a sense were looking for at least in terms of the possibility of a criminal activity, a bomb, or missile.

When I said that they looked like they could have been rivet hole -- you know, they were of a size that would be commensurate with a rivet flying through the metal, but I did not establish that as a cause by any means.

Q All right, thank you. Based on all of your examinations, can you give -- again, give us your conclusions that you could reach regarding the fractures and damage patterns found on the recovered portions of the airplane?

A Okay, my basic conclusion was that all of the fracture surfaces, penetrations and these -- and, you know, wide spread locations of the various spike features, led me to conclude that there was no specific evidence of a bomb or missile type of -- no bomb or missile type damage.

Q Thank you.

MR. WILDEY: That is all the questions I have.

CHAIRMAN HALL: Are there other questions from the Technical Panel for the witnesses? Mr. Hauter?

MR. HAUTER: For Jim Wildey, on the -- you were talking about the big holes that you could fill back in. About how big were the holes where you did not have material, would you say? Just, you know, you gave some estimate of the small ones, but the larger ones?

WITNESS WILDEY: Well, there were no large areas. If you are talking about something several feet, three or four feet in diameter, there were no holes like that where there was absolutely no missing structure.

I guess the possible exception might be internal to the tank where there was severe fire damage. I am thinking of span-wise beam 2. The left side of it had severe fire damage and it appeared that part of that had simply burned away.

As far as the fuselage and the skin of that, there were no large holes to the extent where you could say there is like a ten-foot hole, or anything like that. Everything could be filled in, certainly to a size less than ten feet, or so.

MR. HAUTER: To go any smaller than that, holes in the one, two foot diameter?

WITNESS WILDEY: Well, yes, there were areas where there were -- fuselage skin was missing, for example, over areas of about maybe a foot or so. Some maybe even larger than that.

There is one area on the left side down below the window belt in the red zone where the fuselage skin piece was not recovered. It may be five feet by two feet. But, fortunately in that particular area we recovered all the frames -- nearly all the frames and stringers that went right underneath the skin, and they showed no unusual patterns of any kind.

Then, of course, there were other areas, relatively small areas, that the fuselage skin itself wasn't recovered and many areas where the frames and stringers weren't identifiable because they didn't have any unique characteristics that you could take them back to their specific location.

MR. HAUTER: I guess I mentioned these holes are --

CHAIRMAN HALL: Mr. Hauter, you need to get closer to that microphone, as well, sir.

MR. HAUTER: Okay, on mentioning these holes that are one and two feet in diameter, did they show any penetrations where it went through one surface and then through another? Did you line any penetrations up?

MR. HAUTER: Well, I hate to give a one word answer, but if I were it would be no, we did not. The holes that I saw were typical of the structure breaking apart, and certainly in the red zone the holes are -- would be a part of the sequence and wouldn't be the initial point. They would be interpreted as identifiable by the surrounding fractures and things of that nature.

So, the bottom line on that is that the holes that are there seem to be part of the normal sequence, especially in the red zone pieces that you could identify.

MR. HAUTER: Thank you.

CHAIRMAN HALL: Okay. Any other questions from the Technical Panel?

(No response.)

Mr. Wildey, it is my understanding that you all -- you say you looked at all this wreckage and now all of our folks -- and we have had the folks from

China Lake and this gentleman look at the wreckage and you have examined all of it even down to -- with a magnifying glass?

WITNESS WILDEY: I can safely say that this is some of the most examined metal there is anywhere in the world, especially between the nose section and the aft section. Every -- literally, ever inch, every quarter inch of the fracture in the fuselage skin and the frames and the stringers and the center fuel tank in the wing center section, every inch of that structure has been examined in great detail.

Fracture directions have been mapped. We have looked at the surfaces for evidence of hot gas erosion and pitting and features that might be associated with bombs or missiles using excruciating detail on all these fractures on the whole airplane.

CHAIRMAN HALL: All that is in your report that has been submitted as part of the public record?

WITNESS WILDEY: Yes, it is.

CHAIRMAN HALL: Very well. We will move to the party tables now for your questions, and we will just proceed to give now the first opportunity to the International Association of Machinists and Aerospace Workers for their questions.

MR. LIDDELL: Thank you, Mr. Chairman. I

would like to ask Jim Wildey, was there any evidence of any pre-existing corrosion or failures in the wreckage found?

WITNESS WILDEY: Well, I will kind of divide that into two pieces. Pre-existing failures is the easy one, I think, and that answer is there is no evidence of any pre-existing failure.

Now, we do have the petite cracks that I mentioned on the airplane. Our group concluded that the petite cracks were opened up as a result of the sequence of the break-up of the airplane and did not in any way initiate the airplane's breaking up, or really their presence didn't even affect the break-up itself after it initiated.

You also asked about corrosion. I was surprised, frankly, at the lack of corrosion damage on the airplane considering that it had been in salt water for many times months. We looked at some of the fractures at high magnifications with a scanning electron microscope, and at that time you could see a very thin layer of corrosion that had started to build up on the fractures.

In general, I would say the airplane was remarkably free of corrosion damage that had occurred prior to the salt water emersion, and certainly found not evidence of any corrosion to any extent that might have caused substantial weakening of any of the members inside the structure.

MR. LIDDELL: Thank you, sir. No further questions.

CHAIRMAN HALL: Thank you. Captain Young, Trans World Airlines, Inc.?

CAPTAIN YOUNG: Thank you, Mr. Chairman. At the present time Trans World Airlines has no questions of the witnesses.

CHAIRMAN HALL: Thank you, sir. The Federal Aviation Administration, Mr. Streeter?

MR. STREETER: Yes, Mr. Chairman. For Mr. Wildey, a couple of items here for clarification. Specifically out of the red area, were there any fuselage skins in that area that showed any type of hoop tension failure (inaudible).

WITNESS WILDEY: Yes, we tried to document that and it is contained within our report. One of the figures that I used did show this hoop tension type of fracture. That occurred at the initial point of the fuselage fracture at stringer forty right.

There were also other areas where you could not see any evidence of a running fracture that we classified as -- basically, from pure hoop tension, but on either side of these other areas the fracture was running into it and then out of it in the other direction.

So, the only real area that we saw was associated with stringer forty -- excuse me -- yes, forty right where the fuselage cracking initiated as it came down through the front spar.

MR. STREETER: The one other area that was mentioned in your testimony regarding span-wise beam 3 failing in the forward direction, in Exhibit 18(a) you discussed where a portion of span-wise beam 2 was found in the red area.

Now, are there any inconsistencies of that, or is that related to the fuselage opening up? My concern is, would you have expected span-wise beam 2 to end up elsewhere?

WITNESS WILDEY: Well, I don't know if we had any expectations, or if you could really expect what would happen, because we just don't really know. But, there was a manufacturing access door from span-wise beam 2 just behind span-wise beam 3, and this door was found in the red zone and had no soot or fire damage on it consistent with very early departure and with its recovery position.

It clearly indicates that this door separated as part of the initial event and was blown out as part -- as was span-wise beam 3 and the front spar, and came out through the same hole in the lower fuselage that was created in the belly skin just in front of the front spar.

CHAIRMAN HALL: What is a manufacturing access door? Can you describe that for us?

WITNESS WILDEY: It is a door that is provided in span-wise beam 2 for access during the manufacturing process. It is then rivetted up and you can't really get in there after that.

There are other doors that are maintenance access doors that can be disassembled and reassembled. This is a door that is rivetted back up during the manufacturing process and is not really there.

CHAIRMAN HALL: The approximate size of this piece?

WITNESS WILDEY: It is about two feet by three feet. It is an oval-shaped door.

CHAIRMAN HALL: Thank you.

WITNESS WILDEY: Did that answer your question, Mr. Streeter?

MR. STREETER: I think so. The main thing I am trying to get at is, again, with that piece in that position, your group didn't see any reason for that to cause any concern as far as your break-up sequence design, is that correct?

WITNESS WILDEY? Well, our sequence does take into account how this door -- we list several possible ways for this door to have come off. I don't know that we reached an absolute firm conclusion as to exactly how that happened, but surely during the initial explosion or shortly thereafter this door was broken from its perimeter, and we see significant evidence that the door was pushed in the forward direction after part of it failed and, so, it came out while there was still pressure behind it to push it out, so it is part of the initial event.

We do not see any evidence of a bomb or any kind of explosion features right on the door, itself. So, it appears that part of the door perimeter was ripped apart and then the pressure behind the door pushed it in the forward direction. It hit the top of the tank and then got blown out into the earliest portion of the recovery field.

MR. STREETER: Okay, thank you very much, sir. No more questions.

CHAIRMAN HALL: Very well. The Boeing Commercial Airplane Group? Mr. Rodrigues?

MR. RODRIGUES: No questions from Boeing, Mr.

Chairman.

CHAIRMAN HALL: Okay, the Air Line Pilots Association? Captain?

CAPTAIN REKART: If I could, just one question. I think it is primarily for clarification of Mr. Wildey, and I believe that he said, Jim, that your sequencing report was done without respect to where the pieces were found on the bottom of the ocean, or how they got there, but rather totally independent and only based upon the metallurgy of the systems of the pieces that came apart?

WITNESS WILDEY: Yes. Would you like me to comment on that a little further?

CAPTAIN REKART: If you could, please.

WITNESS WILDEY: Well, that is a good question, and really I guess it does deserve more of an explanation.

First of all, it would be really naive to suggest that the Sequencing Group was not aware of the color coding of the parts and of the obvious significance or the suggestions that the color coding puts forth.

For example, the distinct ring of red color -- red zone parts around the fuselage in the earliest recovery field. I mean, it obviously suggests that those were the first pieces to come out of the airplane. Our group was aware of that, and we could see that on the reconstructed and recovered portions of the airplane.

Our report, though -- and in fact if you look at the specific sequencing details which is Exhibit -- it is Appendix B of our report, and I think that is in Exhibit 18(b).

If you look at the specific sequencing details that are the basis for the sequencing report, I think there are only two references in there under "supporting data" that actually quotes the recovery zone. So, to that degree, our results are truly and actually based on the features that we could see on the actual parts, not the recovery position.

Now, they do correspond with one another, and in some cases we tried to develop rationale. For example, on the wing staying together and the aft part of the airplane staying together, we were aware that that had to make it all the way to the green zone.

So, we developed a rationale to try to explain the apparent fact that this structure made it to its recovery position, and I think we did that. But, the individual sequencing elements really would not be affected by the recovery positions. They speak -- the structure speaks for itself. Those features are on the airplane. They are still there to be observed.

I would like to say that as an example of what we do, or how we used the color coding, in the nose landing gear area -- and I mentioned that. This was brought to our attention, and the reason that we examined this was that three of the four nose landing doors had a red tag and were recovered from the earliest part of the debris field and, similarly, around the nose landing gear area there were some fuselage pieces that were recovered that had a red tag on it and were supposedly recovered from the red -- the red -- earliest debris field.

Of course it became a very distinct question, well, what happened up there, how did these pieces, the fuselage pieces in the doors get into the red zone? Well, our group took this as a task to look at. We made a report on it and we determined that, for example, on the doors themselves that, yes, those doors apparently did come off the airplane.

They had a lack of damage on them that was consistent with early departure. We developed some hypotheses and scenarios that could allow the doors to depart from the airplane very early in the sequence, and it is consistent with the factual observations we have made.

So, for the doors we said, yes, it appears as though we have a sequence that could account for the doors to come off early, and we also examined the fuselage pieces right around there that had red tags on them, and we looked at all the features we could find, and for the fuselage pieces around there we said we find no physical evidence to suggest that those particular pieces actually departed the airplane early on in the sequence.

I think, if I remember our report, we said we believed that those particular pieces should be treated as yellow zone parts because we don't find any way that they could possibly have come off the airplane early in the sequence and actually have been found in the red debris field.

Just as a side note, I am aware that the tags on those particular fuselage pieces from around the nose area are the so-called 2,000 series tags, and that is not my area of expertise, but these are the -- these tags had some questions about their pedigree, if you will.

But, that is really not our concern. We are saying, and our group said that we don't believe those are red zone parts and we would treat those as yellow zone parts for the purposes of analyzing the break-up sequence.

If in the rest of the airplane there had been similar parts that did not fit with the sequence, I have every confidence in the world that we would have said the same thing, that here is a piece that is tagged red, and I don't care if you have got side scanning sonar and divers' logs and lat logs, that if we didn't think that it fit with the sequence we would have said so in our report.

The fact of the matter is, I find generally very good agreement with the recovered positions of the red, yellow and green zone pieces and the sequence that we had developed, but I think these two items kind of stand, to a large degree, independent of each other, and frankly I think they kind of support each other.

CAPTAIN REKART. Thank you, Mr. Wildey. Mr. Hall, we have no more questions.

CHAIRMAN HALL: Thank you very much. Honeywell, Inc.?

MR. THOMAS: Honeywell has no questions, Mr. Chairman.

CHAIRMAN HALL: Crane Company Hydro-Aire, do you have any additional questions?

MR. BOUSHIE: Crane Company has no questions, Mr. Chairman.

CHAIRMAN HALL: Okay. Do any of the parties have additional questions for these witnesses?

(No response.)

If not, we will move to the Board of Inquiry. Mr. Sweedler?

MR. CAMPBELL: Yes, Mr. Chairman. I just have one question of Mr. Bott, or Dr. Shabel, or both. You mentioned there was no evidence of a missile or a bomb, a missile striking the aircraft or a bomb. Is there evidence of anything else that could have possibly struck the airplane, like a meteorite?

WITNESS SHABEL: I didn't feel that. I -- if a meteorite would have likely made a very high velocity penetration, then I really -- the ones that I saw showed no evidence of any unusual velocity penetration.

I believe that meteorite type impacts are classified as very high velocity, and I didn't see anything that approached that type of damage that would have justified that.

WITNESS BOTT: I would echo those same feelings. I have been involved in a number of FAT accident investigations, and in our line of business doing live fire testing on airplanes we typically don't like to use good airplanes that the fleet can use. We will bring in components that have been previously crashed.

So, I have seen maybe thirty to fifty crashed aircraft over the years up there, and I didn't see anything on TWA 800 that was any different than post mishap ground or water impacts that we see on Navy aircraft.

MR. CAMPBELL: Thank you. That's all I have, Mr. Chairman. Thank you.

CHAIRMAN HALL: Dr. Ellingstad?

DR. ELLINGSTAD: Just a quick question for Mr. Wildey. Dr. Shabel has talked about his inspection for holes and penetrations, et cetera. There have been, I believe, a number of other investigations of that same issue. Could you summarize, you know, the other activities looking for this kind of evidence in the wreckage?

WITNESS WILDEY: Well, I guess you are referring to one of my reports, perhaps?

DR. ELLINGSTAD: Yes, Jim, I am.

WITNESS WILDEY: Well, I also had an opportunity to review the Boeing test plates and generate a report. It is one of the fifteen reports, fifteen exhibits -- fifteen series reports. I am not sure which one it is, but I basically reached the same conclusions.

Certainly around the wing center section tank there were no holes that were of a higher velocity characteristics. Does that address your question?

DR. ELLINGSTAD: That is fine. Thank you.

DR. LOEB: Let me be, Jim, just a little bit more specific.

CHAIRMAN HALL: I assume Dr. Ellingstad is through?

DR. ELLINGSTAD: Yes, I am.

CHAIRMAN HALL: Dr. Loeb?

DR. LOEB: Let me be a little bit more specific. Both Dr. Shabel and Richard Bott have indicated that they see no damage on this airplane that is consistent with a bomb or a missile impact. Do you agree with that?

WITNESS WILDEY: Absolutely, yes.

DR. LOEB: Second of all, this discussion about parts being in the various zones that may be questionable, or we may not quite understand why or how they got there but we have some theories; if those theories are incorrect, does that in any way affect your sequencing report and your -- and your believe in how this airplane came apart?

WITNESS WILDEY: What theories are you referring to?

DR. LOEB: Well, no, some of the theories that we may have about how a part may have gotten to an area in which we are not certain how it got there, but we may have some thoughts about it; if our thoughts are incorrect on that, does it in any way change the fact that the sequencing report still stands?

WITNESS WILDEY: Well, that is a similar question that Captain Rekart asked. The sequencing report really is independent of that, and it really stands on its own, I believe.

DR. LOEB: Okay, so -- but, the specific question is, if we are incorrect and a part didn't get there the way we theorize, but it may have gotten there some other way, does that in any way affect our sequencing report?

WITNESS WILDEY: Well, I hate to say it doesn't affect it at all. I am not really sure -- I don't want to be argumentative, but I am not sure what theory you are talking about. Maybe if you can give me an example.

DR. LOEB: Any of the pieces that may have been flyers and therefore gotten there and may have gotten out in a way that does -- if we are incorrect, if it wasn't a flyer and got there some other way, does it in any way affect the outcome of our sequencing report?

WITNESS WILDEY: I don't believe it does. The sequencing report is based on, again, the factual, observable features on the parts themselves, and if a specific part, you know, was dragged along the ocean bottom, or was a flyer, or shifted somehow, you know, it --

These things are going to happen, we know this and the report is going to be independent of that, and certainly in the sequence of events you can't take one part out of it and say that it didn't happen that way, because they kind of have to follow each other.

DR. LOEB: Thank you.

CHAIRMAN HALL: Mr. Wildey, this is one of those areas where we have sort of worked parallel with the FBI, and if we -- I want the public to understand that -- and I am sure that you and the group you worked with were aware of all the attention that was given in the news media to the possibility of a missile or a bomb.

If you all -- if you found any evidence of a missile or a bomb, am I correct in saying that you would have turned that over to the proper authorities?

WITNESS WILDEY: Yes, it is. It would have been very exciting news and unfortunately, or fortunately we didn't find any characteristics at all that really be attributed to such damage, and that has been examined by not just myself, but other metallurgists of the Safety Board, FBI specialists in this area, and every pieces was sent through a filter before it was actually part of the reconstruction on the airplane and was examined by bomb technicians and metallurgists.

Every single piece was passed through this filter individually -- not just as a basket of parts, but individually. So, every part has been specifically examined for those features and nothing has been found so far to even indicate that there may be a possibility that this occurred.

CHAIRMAN HALL: How many years have you worked for the Safety Board?

WITNESS WILDEY: Twenty-two years.

CHAIRMAN HALL: You have been paid by the American people that whole time?

WITNESS WILDEY: Yes, I think so.

CHAIRMAN HALL: You are telling us the truth on this?

WITNESS WILDEY: To the best of my ability, yes, sir.

CHAIRMAN HALL: Well, I appreciate that very much, and I appreciate all the work of you and Deepak and others that have spent months up there in Calverton, and when you are six foot seven and a half, thinking of you on your hands and knees with a magnifying glass is something -- looking at the wreckage -- is something to see, and I know you did that.

I know that people have been over every piece of that wreckage, and I want the American people to know that if there is anything in that wreckage that any of us at any time thought was of a nature that needed to be brought to the Federal Bureau of Investigation, we would do that.

Mr. Bott, do you or the good doctor have anything you would want to contribute at the conclusion or offer to the Safety Board, or do you have a solution that you could offer us so we could end this hearing?

WITNESS BOTT: No, sir.

CHAIRMAN HALL: Doctor, we appreciate very much your assistance and hard work on this. I know you all spent a great deal of time. You have worked in a very cooperative fashion with both the criminal investigation and our accident investigation. We appreciate your assistance and may need to continue with it. But, we want to thank you for your willingness to come here and testify this morning.

This concludes this panel. We will move after a break to the medical factors and cabin interior panel, which will be our last presentation for the day. We will take a break until fifteen minutes after the hour, 3:15 eastern standard time. We stand in recess.

(Whereupon, at 3:00 p.m. a brief recess was taken.)

CHAIRMAN HALL: We will reconvene this hearing of the National Transportation Safety Board looking into the matter of the TWA Flight 800 event.

The next item on our agenda is the Medical Factors and Cabin Interior Panel. This panel presentation the Board felt must be done in the interest of a complete investigation.

However, I must tell you that personally I wish it could be omitted from our presentations because it may be particularly painful to the family members here. So, I would want to be sure that any of the family members who wanted to absent themselves during this presentation certainly would take the opportunity to do so.

But, we will have a presentation at this time on the medical factors, and I would ask Mr. Dickinson if he would swear the witnesses in.

MR. DICKINSON: Thank you, Mr. Chairman. Could I ask the two doctors, Dr. Wetli and Dr. Shanahan and Mr. Burt Simon and Mr. Hank Hughes to stand up and raise your right hand?

Whereupon,

DR. CHARLES WETLI, DR. DENNIS SHANAHAN,
MR. BURT SIMON and MR. HANK HUGHES

were called as a witnesses by and on behalf of the NTSB, and, after having been duly sworn, were examined and testified on their oath as follows.

MR. DICKINSON: Thank you. You may be seated. A brief biography -- all four biographies have been entered on our web page today.

Mr. Hank Hughes joined the NTSB in 1985. He is a Senior Survival Factors Investigator assigned to the Office of Aviation Safety. Mr. Hughes has an extensive background in forensics and over twenty-eight years experience as an investigator.

During his tenure at the NTSB, Mr. Hughes has participated in many survival factors group chairman investigations, including the 1991 crash of USAir 1493 in Los Angeles, the crash of USAir 427 in Pittsburgh, Northwest Airlines DC-9, a Boeing 727 accident in

Detroit and several other major investigations.

Mr. Burt Simon has been with the Board for twelve years. He has fifteen years in Law Enforcement as a Criminal Investigator, Academy Instructor and Accident Investigator. He also holds a private pilot's license, and his education is in Law Enforcement, University of Maryland, and some education with the University of Southern California.

Dr. Charles Wetli is the Chief Medical Examiner for Suffolk County, New York, and as such has jurisdiction in the TWA 800 case. His office was responsible for the determination and manner and cause of death of the victims of TWA 800, as well as for the identification of the victims.

Dr. Dennis Shanahan, previously the Commanding Officer for the U.S. Army Aero-Medical Research Laboratory is an expert in determining the causes of injury using biomechanical analysis. He serves as the Safety Board's Chief Medical Consultant in the TWA 800 case, and has been involved in the investigation since the crash occurred.

I will now turn it over to -- the microphone over to Mr. Hank Hughes.

DIRECT EXAMINATION

WITNESS HUGHES: Good afternoon, ladies and gentlemen. The Airplane Interior Documentation Group was formed on July 24th, 1996 at the Calverton, Long Island facility. Members of the Aircraft Interior Documentation Group represented the following parties to the investigation: The National Transportation Safety Board, Trans World Airlines, the International Association of Machinists and Aerospace Workers, the New York State Police, Federal Aviation Administration, Boeing Aircraft Company, the Bureau of Alcohol, Tobacco and Firearms and the Suffolk County Police Department.

The group is diverse in terms of specific skills. TWA and IAM personnel were assigned because of their intimate familiarity with the Boeing 747 cabin furnishings.

The New York State Police Investigators were selected because of their skill in processing evidence. A Boeing Engineer and an FAA Human Factors Specialist were assigned to document all modifications of the airplane cabin from the date of manufacture to the date of the accident and to provide technical support to the group during the reconstruction of the cabin interior.

Four Bureau of Alcohol, Tobacco and Firearms Special Agents with expertise in post-bomb blast explosion investigation were assigned to assist in processing the wreckage and conducting forensic examination of parts for possible evidence of an explosive device or other criminal evidence.

The Suffolk County Police Department provided a Crime Analyst whose expertise in database creation and computer graphics were utilized to catalogue both the Interior Documentation Group and the Medic -- Forensic Medical Group's database, and then combine the two databases for further analysis.

The group established three preliminary investigative objectives, the first of which was to examine, identify and document as many of the airplane interior components as possible. Second, to reconstruct as much as possible the airplane cabin interior using only those parts which could be replaced in a specific location from which they came. The third was to provide technical assistance to other NTSB groups and FBI investigative groups.

The group assumed the following responsibilities. First, to document modifications of the airplane cabin from delivery to the date of the accident. This was important. We needed to do this for a benchmark from which to identify parts and place them in the proper locations.

We also examined crew and passenger seats, the cabin floor and carpeting, side walls, overhead bins, ceiling panels, lavatories and components, galleys and their components, stowage compartments, duty free containers, airplane cabin emergency equipment, as well as food storage containers.

The group also created a one-to-one scale airplane cabin interior, utilizing the reconstructive components and the creation of the group's database which was integrated later, as I said, into the Forensic Medical Group's database.

The group worked to completion in March of 1997. Completed tasks were as follows. Basically, we were able to inventory all airplane parts received at the Calverton facility, and we also completed the reconstruction of the cabin interior with available parts.

All 21 of the crew seats and 398 of the 433 passenger seats were identified and partially reconstructed, as well as all the galleys, lavatories, storage areas and about twenty percent of the carpeting from the floor.

The crew and passenger seat database was completed and the Airplane Interior Documentation Group's factual report was developed and approved by all group members. This information was also provided to the Medical Group for their work.

Basically, the interface between the Interior Documentation Group and the Forensic Medical Group was that the parts documentation was integrated into the Medical Group's work by way of comparative analysis. They looked at the seats, the seat structures, as well as the other interior components and gave them some weight with regard to their consideration and analysis of the injuries to the victims.

All members of the group discussed the need for standardized procedure for the process of processing the parts for the interior. The group established a standard procedure for receiving, examining and documenting all the parts for the reconstruction area.

The standard operating procedure included a quality control function whereby two teams independently examined and documented all parts, and a third team checked the work of the other two teams. All three teams rotated duties. In addition, upon completion of the reconstruction, the entire group met and reviewed all the work completed before it was approved for the group report.

The reconstruction of the airplane's interior was completed in a separate hangar at the Calverton facility because of space requirements. A taped off grid was placed on the hangar floor and a one-to-one scale of the airplane cabin was developed.

After several weeks sufficient pieces were placed in the reconstruction area to permit reassembly of the seats, galleys and lavatories. This was accomplished by several thousand feet of wire and more than 16,000 board feet of lumber.

Rebuilding the interior components gave the group the opportunity to examine and document each reconstructive seat, galley, lavatory and other components in more detail and record the findings for out database. This database also was accompanied by digitized photographs of all of the evidence.

The process of reconstructing the crew and passenger seats was significantly simplified because TWA had numbered the individual rows of seats in the accident airplane, although there is no requirement to do so. About forty percent of the passenger seats had their row and seat numbers still affixed, which made the process of reconstructing the seats simpler.

Additionally, the passenger seats were manufactured by three different companies which assisted in the identification after cross-reference with TW engineering records and placement of the seats. In many instances seats had numbers still affixed to them -- their arm rests, and they were associated later by way of fracture match, fire damage, or other bending or identifiable marks that allowed us to reconstruct the rows.

The process of reconstructing the seats was slow. On a good day we did twelve seats. On our worst day we did one. The same amount of effort was expended in both cases. The investigation marked the first complete interior reconstruction of a Boeing 747 interior.

(Slide shown.)

You will see a seating diagram, and you will also note that there is basically five categories of damage. We established a standardized criteria. Given the fact that all of these parts were very severely damaged, we tried to put that aside and look at it and try to set up a classification system for parts.

You will see that on the top we have minimal damage that is indicated by light blue, and on the bottom, red, which indicates fragmented, or I should say highly fragmented pieces.

Minimally damaged seats, and there were a few of those, basically are seats that were almost functional and didn't have major deformation. The fragmented seats are just what the term implies. They were highly fragmented in very small pieces. If you look at the overhead --

CHAIRMAN HALL: What's the story? I mean, I -- take us through each one of them, if you would.

WITNESS HUGHES: Okay, sir. I have the definitions that the group established on another overhead.

CHAIRMAN HALL: Oh, okay.

WITNESS HUGHES: I am sorry.

(Next slide shown.)

Excuse the delay, sir.

CHAIRMAN HALL: No problem.

WITNESS HUGHES: As I said, the seats were all, for all practical purposes, severely damaged. For the purpose of trying to classify the damage, as far as degrees of severity, the group agreed upon a standardized protocol that we would use to look at this damage and, basically, as I said, they ranged from minimal to fragmented.

Basically, the difference between a seat that is destroyed, which is indicated by yellow, and one that is fragmented -- and, again, the group decided on these titles and we discussed the definitions -- are the size of the small parts.

CHAIRMAN HALL: Were you able to reconstruct destroyed seats, or frag --

WITNESS HUGHES: Yes.

CHAIRMAN HALL: But, not the fragmented?

WITNESS HUGHES: All --

CHAIRMAN HALL: Or, both?

WITNESS HUGHES: We were able to reconstruct some part of all the seats regardless of whether there were any of these five classifications. Again, it is -- all of the seats, for all practical purposes -- I know you saw them and spent a lot of time in the hangar with us -- were destroyed.

In our mind it was an investigative tool that we used to try to look at how destroyed they were, if that is a way to categorize them. But, basically we looked at the degree of severity, and that is the benchmark that our group used.

CHAIRMAN HALL: Okay.

WITNESS HUGHES: You can see in the cockpit area would be the Captain or First Officer's seat along with the Flight Engineer, and the cockpit was equipped with two observer's seats. Further aft there is ninety-one and ninety-two in the upper deck, and then we will go down to the A-Zone in the main cabin of the airplane.

Mr. Jackson, if you would zoom back to the C-Zone area and then END. Hold on there for a minute.

(Next slide shown.)

I might add that when you look at the diagram -- and in a minute Mr. Jackson is going to zoom back on the overall diagram -- you will note that the seats in the aft section of the airplane are highly fragmented.

I might add that I think it is significant to say that the construction, the design and the materials used for those seats was different from the seats further forward in the airplane. Another factor to consider is the structure of the airplane in that area. I only point that out as a distinction that we made when we looked at them.

Would you pull back to the overall?

(Next slide shown.)

Okay. There is a static display of that diagram. Again, the degree and severity damage to the seats and other cabin components throughout the length of the airplane were documented, and this is a pictorial way of noting those.

One area of great consideration was looking for fire damage. We talked about physical damage in the other diagram or chart. This depicts the sixty-six seats which sustained thermal damage. I think it is important to note that some of those seats we know were on fire in the water, burning in pool fires subsequent to the break-up of the airplane.

So, it is not fair to draw an analogy that all those burnt -- seats that were burned were burned or the fire damage was incurred while the airplane was still intact, or in the air. Some of the damage we know did happen as a result of the pool fires on the water as the seats floated.

This tarp was a project that we did to study or look at the relationship of the airplane cabin with the top of the center fuel tank in the C-Zone area. With the assistance of the members of the Structures Group we got detailed information on the fracture pattern on the upper surface of the center fuel tank.

We translated that to a plastic tarp. We taped out those fracture matches, and then after taping those out to scale and verifying the accuracy of the measurements with the assistance of the Structures Group, we replaced the seats that had been recovered and rebuilt in the C-Zone area.

Again, this was done to look at the relationship of the fracture pattern on the top of the center fuel tank, as well as the seats. We thought that information might be useful for the medical group and/or other groups involved in the investigation.

What you are looking at here, as in the case of the other one, is the C-Zone area from around row seventeen to row twenty-eight, or -- and to the bottom of the screen is the left side of the airplane. The top would be the right side, and the right side of the screen would be facing forward.

CHAIRMAN HALL: So, the nose of the plane is which way?

WITNESS HUGHES: To the right, sir.

CHAIRMAN HALL: To the right.

WITNESS HUGHES: Subsequent to the completion of our field notes our group met and developed our factual report, and after review of that report it was submitted as the group factual report.

We provided the information that we were able to collect to the Medical Group. As I said earlier, basically the interface between the Interior Documentation Group and the Medical Group was looking at the damage to the interior of the airplane, the parts, in a context of the victims to the airplane and passengers in the airplane.

Mr. Simon, Burt Simon of our staff, led the

Medical Group, and he has a presentation. Mr. Chairman, that completes my remarks.

CHAIRMAN HALL: Thank you. Mr. Simon, please proceed.

DIRECT EXAMINATION

WITNESS SIMON: Good afternoon, Mr. Chairman. The Forensic Medical Group consisted of four persons, primarily myself, Dr. Shanahan, from the Air Line Pilots Association Mr. Donald Foldy (sic), and from the Suffolk County Police Department, Department Officer Anthony Legalla, a computer specialist.

The objective of the Forensic Medical Investigative Group was to document and utilize medical and forensic data and biomechanical analysis to reconstruct injury events occurring during the explosion, break-up and water impact of TWA Flight 800.

Preliminary medical forensic data was used to aid in the initial determination of whether an explosive device detonated in close proximity to any passenger or crew member, and to elucidate burn and break-up patterns and sequences.

To accomplish this objective, all medical data contained in the records of the Suffolk County Medical Examiner were reviewed by a team of physicians and abstracted into a summary data sheet for each victim. The abstracted data were then entered into a computer database.

All data were subsequently reviewed by the Senior Medical Consultant, Dr. Shanahan, and a team of pathologists from the Armed Forces Institute of Pathology to insure accuracy of the data contained in the database.

A seat assignment was available for each passenger aboard Flight 800, and for purposes of reconstruction the seat assignment was used to reflect actual seating location even though some passengers may have moved from their assigned seats during a ground delay prior to the departure of Flight 800.

A comparison of passenger seat assignments to the physical evidence of seat restraint use actually on the seats was conducted to provide an indication of the extent to which passengers may have moved from their assigned seats in the cabin.

A geographical information software was utilized to graphically depict the cabin seating arrangement and other interior features of the airplane. All passenger and flight attendant seats were geographically coded so that the medical data in the database could be searched for any injury or combination of injuries, and the results then could be projected onto a map of the cabin seating arrangement.

This software application allowed graphic presentation of the results of the medical investigation, enhancing the search for injury patterns and the correlation of injuries with other physical evidence.

Those conclude my remarks, Mr. Chairman. I would like to question Dr. Charles Wetli, the Medical Examiner for Suffolk County.

CHAIRMAN HALL: Thank you, and I would like to thank Dr. Wetli for being here with us today. Welcome, Dr. Wetli.

WITNESS WETLI: Thank you.

CHAIRMAN HALL: Please proceed, Mr. Simon.

DIRECT EXAMINATION

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

Investigator, Bob Gold, who called me at home indicating that there was perhaps a mass disaster, that they weren't sure what happened, but there was a possibility of an air -- commercial jetliner having gone down into the ocean off of the East Moriches.

Q Can you describe to us, please, the initial response of your office to that crash?

A To answer that, I could back up a little bit so it will make more sense, if you will.

(Tape change.)

These meetings were held monthly, looking at the type of disaster which would most likely happen and planning for it. During the preceding year and a half, for example, we had a disaster cage built in our basement stocked with about 250 body bags and numerous other equipment that would be needed for mass disaster.

We had tours, we had other people who would come over, such as Long Island Railroad, Suffolk County Police Department, Fire Rescue Emergency Services and others, so we all knew who each other were, what our individual needs and wants and so forth would be required in the event of a disaster actually taking place.

When we were therefore notified of an actual disaster, we simply activated the mass disaster plan.

That called for the response of the Chief Forensic Investigator to respond to the scene, in this case the Coast Guard Station at the East Moriches, and also our Deputy Chief of our Crime Laboratory.

At Suffolk County we are unique in that the Crime Laboratory is under the jurisdiction of the Medical Examiner. So, the Crime Laboratory responded as well as Suffolk County Police Department and the Suffolk County ID Section to form a temporary morgue and execute the duties that would be required at that time.

My Deputy Chief Medical Examiner was also dispatched to the scene. The other personnel who were required responded to the Medical Examiner's Office. This included our Supervisor of the Morgue who unlocked the disaster cage, arranged for refrigerated trucks and had the body bags delivered to the East Moriches.

The response at the temporary morgue was to photograph and inventory the bodies as they were brought ashore, and at that particular point to actually give them an accession number, place them into a color coded body bag, and then that body bag was locked with another tag containing that same number and then placed into the refrigerated truck.

By nine o'clock the following morning the first ninety-nine bodies that had been recovered during the night were, in fact, at the Medical Examiner's Office, and that was essentially our initial response.

Many other things occurred simultaneously. Our pathologist went in very early to take care of additional cases, set up additional work stations, such as fingerprint stations and so forth.

As part of our planning we also had a dental team all ready assembled, consisting of actually unbelievable forty dentist that had all ready been working together for several years as a team, and they were ready and responding, as well.

Q Can you describe the interaction of your office with other emergency response agencies involved in this disaster?

A In general, I would say it was excellent response, an excellent relationship we had with both federal and local agencies. The U.S. Coast Guard in particular was extremely helpful to us at the scene. We had good relations with NTSB, FBI and other federal agencies, as well.

Expected jurisdictional squabbles did occur, but they didn't involve us in particular. As the Medical Examiner's Office, we are sometimes caught in the middle, but aside from that we had no real problems.

The only agency problem, in a sense, I had was with the State Emergency Management Office. They provided us readily with equipment and so forth, but were less than well prepared to provide us with personnel in the sense that they were responsible, "well, we will have to see who calls in," but nonetheless when I requested certain pathologists from New York State, they were able to get a hold of them and arrange for them to respond to our office. But, that was about the only problem I had, inter-agency problem.

Q Did you experience any particular difficulties in handling large numbers of victims in this case?

A The large numbers of victims did not propose a real problem to us because of our disaster plan. Ironically, our -- for purposes of planning, we were planning on the crash of a commercial jetliner killing 250 people and, so, that is what we were pretty much geared for.

So, we had the refrigerated trucks available and we knew how we were going to do this. I mentioned we had had tours of our planning. We even had a tour of our own morgue, saying if we have the situation, how exactly will we be processing these bodies to acquire the data we need for identification purposes and so forth.

So, it was more a matter of long hours and setting up the stations initially. Once these were set up, then things began to work out pretty well. So, we really had no real difficulty in that sense.

I must also mention, our facility is a fairly large facility. We have five autopsy tables that were working eventually around the clock and staffed by pathologists and so forth. So, we had a fairly good physical facility to begin with.

Q During the early days of your response to this tragedy, did you experience difficulties with manpower?

A The only -- we didn't really experience much in the way of difficulties of manpower. Initially, we didn't request a lot of manpower because we first of all had to evaluate exactly what we were dealing with and early on had to make certain decisions. Such things, for example, do we autopsy all the victims; do we x-ray them and how much -- how extensive a radiologic examination do we do, and so forth.

After that was done, then we had no real problems obtaining individuals. People both within government and the private sector and ordinary citizens readily volunteered for whatever they could. So, in that sense, we didn't have a real problem.

We were very fortunate, also, being able to have the resources of a number of excellent forensic pathologists that had responded, as well.

The only real problem we had was photographers, and particularly x-ray technicians. We requested the local clinics in Suffolk County to supply x-ray techs to us, and the problem they ran into is when they saw what they had to deal with, many of them could not take it.

They would last -- some just walked out, some lasted a half a day, others began to have problems like nightmares and so forth, and we are correcting that now by instituting a program of desensitization to identify these people ahead of time and avoid that type of problem in the future.

Q What was the focus of your efforts during the first few weeks of the tragedy?

A The focus of our effort were basically three fold. One was to identify and recover any foreign objects that might possibly indicate a bomb, missile, or something along those lines. So, that was one of the most important things we felt we had to do was retrieve as much of the foreign material as possible.

Secondly, of course, identification of the victims, and because we were working this entire scenario, as everybody else was, as a potential terrorist attack and therefore 230 homicides, we had to be very, very sure of the identification.

So, therefore the decision was made early on that all identifications would have to be rock solid and not open to challenge in a court of law, either legal, or civil, or what have you. So, therefore, all identifications would have to be done on a scientific basis.

The next effort, of course, is to document all the entries. Of course, all these were efforts taking place simultaneously, understand, but to actually document the injury as best as possible, both photographically, diagrammatically and of course by the dictated and subsequently typed report for future correlations which Dr. Shanahan will be getting into later.

Finally, at least in the initial stage, was to identify any foreign objects or injury patterns which seem to be somewhat unusual that might give an early clue as to the cause of the crash.

For example, if we had one individual with unusual metallic fragments and unusual injuries, we would bring this to the attention of one of the physician engineers from the federal government as the possibility that this might be something unusual that they should pay attention to.

Q During the initial phase of the investigation, did you encounter any unusual difficulties or pressures that may have affected your operation?

A The most severe interference with our investigation and operation was the isolation of the families and the Family Assistance Center about sixty miles away near the JFK airport.

This put a tremendous strain upon not only the Medical Examiner's staff, but upon rabbis, funeral directors, Suffolk County Police Department, mental health professionals, and the list goes on.

It made our job very difficult because we encountered things like jewelry and so forth from a few victims for which we could actually take a photograph, for which you could take a photograph to hopefully get a tentative identification.

We could not respond right away to the families with these. We had to wait until the evening when we could send our dispatch team to go by helicopter, or by police escort, or a vehicle to the Ramada Inn near the JFK Airport.

I think it was a very tremendous disservice to the families, also, because from what we understand from mass disasters it is important for the families to be able to participate in the process, and this was very much taken away from them.

They were very much isolated out there while we were working to try and make the identification and so forth, and it created just a horrible atmosphere and a tremendous strain of resources for a lot of people. As I said before, it was very unfair, I think, for the families.

Q Have you made your determinations concerning the cause and manner of death of the individuals aboard TWA Flight 800?

A Well, the cause of death was the -- very simply, air plane crash, in a very broad categorization, without going into mechanisms of individual persons and so forth.

This is a fairly standard approach with most airplane crash investigations whether commercial, or private, or what have you. The manner of death is still pending further investigation until the actual cause of the crash is officially determined.

Q During your investigation you used extensive -- or, you extensively used DNA to assist you in identification. Would you elaborate, please, on the utility of DNA in this regard and how it may have benefitted you.

A DNA we found to be extremely useful in that at one point very early on, actually within a few days after the crash, we realized that if we were going to identify everybody in this particular crash that DNA would be absolutely crucial.

Therefore, Dr. Jack Ballantine -- I basically dispatched him to set up whatever was needed to make DNA identifications, and he made a number of very important decisions, probably the most important of which is to obtain genetic histories and blood samples, or bubble or mouth scrapings from as many genetic relatives as possible to provide a database from which we could then compare to the bone fragments, body parts and what have you that were being recovered.

That has to be done very early on, and I would recommend that be done early on for future investigations, as well. At least the bubble scrapings and at least fingertip -- finger stick samples of blood from genetic relatives, and if these are needed then they are available. If they are not needed later on, they could be discarded. But, we have to get them immediately.

In this particular case we began the DNA typing, and on the one hand it was wonderful in that it enabled us to finally identify all 230 people aboard the airplane crash. Approximately September or October of last year we still had about 17 unidentified, which I had to hold an inquest so that families could be able to have death certificates so that they could go to probate court and get insurance claims and what have you. So, the DNA identification allowed the solid identification of the remainder of those victims.

The down side of the DNA was when Dr. Ballantine brought me a list of a number of body parts of individuals that had all ready been identified, but whose bodies had -- the bodies had all ready been released to the families, and this created a tremendous dilemma for us and a lot of dilemma for the families, and I think that it created a lot of problems that I think should be avoided in the future.

Although it is not going to be my decision, I think based on the experience of TWA, DNA testing should be done when conventional methods in fact are not at that point useful or cannot be -- if a person cannot be identified utilizing more conventional means such as dental or fingerprint data.

Secondly, once the identification is made, then further identifications of body parts are not being -- simply just not be reported as such, and these individual body parts will, in fact, be separated, but probably remain in a common grave and, of course, interred after a descent, you know, ceremony, a proper ceremony and so forth.

The third particular aspect for DNA work would be for investigation, and that is one of the things we were looking at here, as well. For example, would we find a DNA profile on somebody who was not supposed to be aboard that airplane.

Then, finally, another phase in the investigation would be sometimes the -- another investigator from NTSB or FBI would want to know what body -- for example, a bone fragment was associated with a part of a plane, and we would be able to tell them who that belonged to.

Q During the early portion of the investigation, while your focus was in identifying the victims to the accident, did you have any difficulty with maintaining that -- or, having that focus, and did it affect in any way your autopsy protocols, or did the volume of bodies that were in your charge at that time make it difficult to maintain a full autopsy protocol?

A No, we had a processing such that the body actually went from one station to another. Initially, another inventory was done. Jewelry and what not was examined, sometimes using high tech equipment which could magnify, say, the inscription of a ring and that type of thing.

From there they went to fingerprints and then to the dental team -- oh, I am sorry, to x-ray and then to the dental team. The dental team then utilized computerized dental radiographs to expedite the process, and sometimes coupled with the dental x-rays, and then finally they went to complete autopsy.

So, the various functions never interfered with each other, and we had tracking slips such that if the fingerprint station was being idle for a moment, we could take something -- take one body out of sequence, bring it to the fingerprint station, or bring it to autopsy prior to dental, and that type of thing.

So, all these functions were really taking place simultaneously, and none every interfered with the other.

Q You mentioned some, but do you have any other recommendations that may be useful to other medical examiners and to agencies involved in response to mass disasters such as this that -- lessons that you have learned in this case?

A Yeah, I think there are several things that are important. One is -- one of the major problems we had early on which I only partially alluded to was there was an awful lot of vitriol commentary, particularly on the part of politicians who were very ill informed and raised a lot of impossible expectations amongst a lot of people.

This had a very negative impact morale-wise upon the disaster task force and people who were putting in long, hard hours and working very, very hard. This had a very significant morale problem, and the unnecessary pressure it created nearly resulted in some mis-identifications which fortunately were averted.

So, we became -- we were very sure of the identifications. But, initially the pressure was there that people were beginning to rush and you could see mistakes could have happened.

My other recommendations; first of all, I think that has to be -- that aspect has to be contained, and it is just not -- it wasn't unique to TWA. It has happened in other disasters such as the Chicago heat wave disaster and others, and so forth.

I think the biggest recommendation in general for any jurisdiction is to have monthly meetings and take them seriously and really work towards a cohesive plan of action. It is important that the people know who each other are when they are on the scene. You don't want to meet people for the very first time when you are on a mass disaster scene.

So, I think the monthly meetings are extremely important, and to have the ability to respond initially, and to incorporate as many agencies into that as possible.

Although we did not particularly run into the problem in the Medical Examiner's Office, per se, it was encountered in East Moriches, and that was where local agencies were very familiar with and wanted to implement what is known as the incident command system.

Apparently federal agencies were not willing to subscribe to that, and that created some problems, as well, and I think I can safely say that local agencies in general would like to see the federal agencies subscribe to the incident command system.

I think also it is important to remember that about five weeks after the incident you have to be sure of your own disaster team and make mandatory incident stress debriefings, particularly for volunteers and for people who are not used to, as we call it -- we call them body handlers, people who do not see the things that Medical Examiners and morgue technicians see every day. These people can have a lot of problems and psychological counseling should be provided for them.

MR. SIMON: Dr. Wetli, I would like to say that having worked with you for so many months, I really appreciate your professionalism and your cooperation throughout, and I think that this experience with you has been a learning opportunity for all of us.

WITNESS WETLI: Thank you.

MR. SIMON: Mr. Chairman, I would like to at this time, if I may, question Dr. Shanahan.

CHAIRMAN HALL: Please proceed.

DIRECT EXAMINATION

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.

Q How did you first become aware of the crash of TWA Flight 800?

A My first -- I was on a trip in Frederick, Maryland in a motel and saw it on the news. It was breaking news, and that was my first knowledge that it had occurred.

Q At that time you were in the United States Military as a Colonel and Commanding Officer of what command?

A I was Commanding Officer, Commander of the U.S. Army Air Medial Research Laboratory at Fort Rucker, Alabama, and we had our headquarters based in Frederick, Maryland.

Q Your expertise in biomechanical analysis is somewhat unique. Can you give us some insights on the uniqueness of your specialty?

A I don't know exactly of the uniqueness, but I can certainly describe the specialty. I think what I have brought forth to investigation of injury is an experience as a pilot, as a physician, a surgeon and also by trade more than anything else -- engineering.

To combine all those aspects into describing how injuries occur in crashes, my background started in the Army. I spent twenty years in the Army -- twenty-six years in the Army, but twenty years of that was spent in doing aircraft accident investigation and performing research, you know, within the laboratory to try to describe how people got injured and also to try to develop means of preventing injury in crashes.

We have a very strong program in the Army and indeed in the other services to provide what we call crash-worthy aircraft, or aircraft that can crash and still provide some degree of protection to the occupants of the aircraft.

Q Can you give us an example of the benefits of biomechanical analysis?

A Oh, absolutely. I think if you -- the devices that we have available both in aircraft and in automobiles today to protect you in a crash are the result of biomechanical analysis.

That goes with the seat belts, air bags, the seats themselves, even the structure of the car to absorb energy, or the airplane to absorb energy in the event of a crash. There are many specific examples of how this type of analysis has benefited the general public.

Q How, then, did you become involved in the investigation of this tragedy?

A Several days after the accident occurred I received a telephone call from Dr. Ellingstad asking me if I could provide some support for the TWA crash. Since I had been assigned to the NTSB as an Army officer, I believe in 1989, I had maintained a consultant status both through myself and the laboratory which I commanded to provide support in biomechanical areas, or biomedical areas to the NTSB.

We had an agreement between the NTSB and our laboratory to provide this kind of support. So, when he called I went up to Long Island.

Q So, within a few days you were on site?

A Yes. I believe I received notification on the 20th or the 21st and was up there within twenty-four hours.

Q Where did you report once you arrived?

A I reported to the Command Center that was set up, I believe at that time at the airport -- I don't recall the name of the airport outside of East Moriches.

Q Where did you spend most of your time, Doctor?

A At Calverton and -- between Calverton and the Medical Examiner's Office. In the early days we had -- our group was set up in the Suffolk County Medical Examiner's Office, and once all autopsies had been performed we moved the group out to -- with the rest of the investigative group at Calverton.

Q During the time that the group was working at the Medical Examiner's Office, can you give us an overview of what actually took place there with respect to the functions of this group?

A With respect to the functions of the group, what we did initially was set up liaison with Dr. Wetli and his staff. We were very conscious of not interfering with the process that was going on, but also at the same time to monitor it.

It was important to observe what was going on and also to observe as many of the individual autopsies as possible, to review films as they were developed and generally to participate in the -- begin the analysis portion of what we were going to do in the future.

Of course, being a very small group and the Medical Examiner working around the clock, we certainly couldn't observe every autopsy. Plus, the group had assembled several days after the accident, so Dr. Wetli was well under way by the time we got to the Medical Examiner's Office.

Q Did the data that had been recorded and the photographs and radiographs and so on by Dr. Wetli's office prove useful in developing a database?

A Absolutely. Once the autopsies were

completed, we then -- it was our job to collect all the information that Dr. Wetli and his staff had generated which included the autopsy reports, the radiographs that were taken, photographs that were taken, any notes that were taken and diagram and collect all that data and collate it.

Whereas Dr. Wetli and his team were looking at individuals, it was our job to both compile the data on the individuals, but also to look at people collectively. I think what is not well understood about this process is that in a very basic sense we looked at bodies as another layer of engineering structure to the aircraft.

They can tell many stories in terms of what happened during the crash. They can help us elucidate by the mechanism of injury whether there was a bomb or other explosive device in the airplane, they can tell us something about the sequence of the break-up of the airplane, they can tell us many things about what happened at that time.

That is primarily what we do, is try to use bodies to tell us what occurred during that crash.

Q The information taken then at autopsy and through the processing of the victims developed into a database, and that database was applied to, as I described, a mapping program or a graphics program.

Would you please, using some of the graphics that were developed by the group, give us some insights into particular charts?

A Yes, I would be glad to.

(Slide shown.)

What you see here is a typical chart that we generated, and you have all ready seen from Mr. Hughes' presentation the type of thing that we did. Now, the reason I throw this chart up here initially is to give you some background information about the process that was involved.

Here you can see we are highlighting several things. One is the aircraft by zones, Zone-A being the first section, and moving on back B, C, D and E. Then we also have there the upper deck portrayed on the right, and above that the cockpit. So, that gives the layout of the aircraft.

Now, what we did was for every individual we used their assigned seating position, because it was the only information we had as to where any particular individual might have been located within the aircraft.

There is a warning, as you can see, on the written material and -- or, a caveat in the lower right hand corner that describes that we were well aware of the fact that people might have moved into different areas, and I will talk about this a little bit later.

But, for the initial operating assumption, we would place the individuals in the seats to which they were assigned. So, that is why it is portrayed the way it is there.

Now, furthermore, this analysis that you see here does not include the fourteen flight attendants. The aircraft -- the Captain had all ready released the flight attendants from their stations, and they were presumably out of their seats and doing their duties within the cabin, and we had no way of estimating where any individual flight attendant might have been.

Furthermore, flight attendant assignments are apparently made by the crew themselves, and they are posted on paper within the aircraft, but it wouldn't have been on any other documentation, at least that we were able to find outside of the aircraft. So, we weren't able to determine the exact locations of flight attendants. So, you won't see that, and that is why the number of recovered victims there is 216.

Beyond that, what I am showing on this particular chart is the seat assignments which are indicated by the yellow dots, and the recovered seats by the black squares.

The utility of this program was such that we could with the database put all of the medical information into a database and then use that database projected on this graphic representation so that we could very quickly look at what-ifs, if you will, that if we wanted to know where all the people with burns were located, we could quickly project that and learn the kinds of patterns of injuries that were occurring within the aircraft, and in subsequent charts I will show you how these particular types of analyses might help us understand better what had occurred during the crash.

Oh, the other thing I would mention is Zone-C is -- you can see the lines that indicate the forward and aft edges of the wing itself, which were located -- which were in Zone-C, and the fuel -- the center fuel tank was located within Zone-C, from about the fourth row of seats forward to all the way aft.

The next chart, please.

(Next slide shown.)

Now, this chart doesn't project real well, but one of the more important and early on drives of this investigation was trying to -- us trying to elucidate whether any of the occupants of the aircraft were exposed to a bomb or other explosive device.

One way of getting at this is to look at fragmentation of the bodies, and I won't go into a large description of that, but basically you can see that the degree of fragmentation ran from none to severe and, of course, for a certain number there they were unknown because of recovering skeletal remains late in the investigation.

But, by doing this, we can project the level of injury -- or, fragmentation, rather, onto the entire part of the aircraft and try to look for patterns that would show high degree of fragmentation, keeping in mind we had all ready looked at each individual and made the determination of each individual that we did not find evidence of an explosive device.

The next step to be thorough was to look if there was any pattern, and if you go into a long shot of that you can see in general that the degree of body fragmentation was quite random. There was one area where you might argue that there was a higher degree of body fragmentation, and that was in Zone-D, and you can see that cluster of individuals.

Now, two things to keep in mind, that, number one, as we went back and looked at each one of those very carefully to try to determine whether there might have been an explosive device and, secondly, the clustering may be an effect of repositioning of individuals later on beyond what their assigned seats were.

But, in general we could not find any clustering or any indication that there was a bomb that went off in close proximity to anyone on board the aircraft.

Next slide, please.

(Next slide shown.)

Now, this is an example of the kind of sharing of information that went on between the Cabin Interior Group and the Medical Forensic Group. What we are showing you here is the chart of evidence of seat restraint use.

It was very important to us to try to perform this analysis in order to try to determine how many individuals aboard the flight might have changed their positions.

The first thing to note on the chart is that where we were able to make a definite determination of seat belt use -- in other words, yes, there was only twenty-three -- but combining with that likely was thirty-four. The total there would be fifty-seven individuals where we had a very high degree of certainty that a seat had been occupied.

But, still, based on that information we were able to calculate that approximately twelve percent of individual -- of seats that were -- we were relatively certain were occupied, were not assigned seats. So, we know that a significant percentage of people moved from their assigned seats.

The other thing that is probably a more personal bias and based upon observation of having spent many hours flying an aircraft, that generally people do not change -- when there is seating available, do not leave the cabin to which they are assigned.

You tend to see a lot of moving around, but it is usually in close proximity. That was a partial working assumption that we used in our subsequent analysis.

Next slide.

(Next slide shown.)

This is somewhat of a tender area, and I don't mean to put too much emphasis on it, but as Dr. Wetli had mentioned, ninety-nine individuals were found floating on the surface of the ocean, whereas the remainder of the individuals had to be recovered by divers, or the salvage operation.

Now, there is a significant difference

between these individuals in that the ones who were found floating were clearly at some point released from the aircraft and were able to float freely on the surface.

Most bodies will float, at least initially, and ninety-nine of them were free and found on the surface of the water. So, one of our analyses were to try to look at where the individuals who were found floating were assigned so that we could learn something more about break-up of the airplane, the assumption being that if the -- if they were able to be released from the interior of the aircraft, that that portion of the aircraft would have had to suffer significant break-up.

You can see from this chart that it correlates pretty well with the C-Zone. The majority of the individuals found free-floating were above the fuel tank. But, that does not necessarily mean that they -- and certainly we have seen data today that showed that there wasn't significant penetration of the cabin floor by that fuel tank, but certainly the break-up of the aircraft did begin just forward of the C-Zone.

Q So, with respect to your -- to a biomechanical analysis using this chart, what would be the rationale for approaching it this way?

A I am sorry, could you clarify that?

Q Your rationale for the use of this chart in this type of analysis?

A Well, our rationale for doing that was, as I described, that if we saw significant clustering, that would tell us something about the break-up of the aircraft.

In fact, fifty-one percent of the victims found floating on the surface of the ocean were from Zone-C.

Q Thank you.

A Next slide.

(Next slide shown.)

Now, also, because there was a fire and explosion, and as you have seen that it was significant evidence of burn damage to the aircraft itself and to the seats, we also wanted to look at the individuals occupying the interior of the aircraft to see what burn patterns we could elucidate. That is good, just focus on Zones C and D there (indicating).

We looked at -- there are several levels of looking at thermal burns. One was that there were a certain number that we were very certain of that had thermal burns. There were also a number that were not certain. I believe the number for certain was eight, and we added an additional four possible.

Subsequent to death, and particularly after sudden death as occurred in this case, it can be somewhat difficult to determine definitively whether the individual had a thermal burn, or not.

But, between Dr. Wetli's team and my team from -- myself and forensic pathologists from the Armed Forces Institute of Pathology, we were able to come up with this particular number.

In looking at it, you can see that the red dots indicate the individuals and their assigned seats as to where -- as to who was burned, and you can see that we had all but one were concentrated in Zone-C.

Now, we also -- I need to check that number.

(Pause.)

That is correct, and so that it was correlated that we were able to correlate burns with that location. However, you will notice also that it correlates very highly with individuals who were found floating, and we had to deal with the question of did these burns arise from people being exposed to burning fuel on the surface of the water.

Looking carefully at the burn patterns as well as the seating locations, we felt pretty certain that the burns that occurred within the interior of the aircraft, they were all very minor burns. They were flash-burns, and primarily to the front surfaces of the body, which indicates that a flash-fire -- they had been exposed to a flash-fire, but not to constant burning of the aircraft interior.

Next slide.

(Next slide shown.)

All right, well, as we looked at the relationship between burns and found floating on the ocean surface, we also tried to look for correlation between individuals who were burned and seat assignment, and you can see here that the correlation was not by any means complete. Nine out of twelve individuals, which is seventy-five percent, were assigned to burn seats.

What this tells us is one of two things; either those individuals were not sitting in their assigned seats, or it is also possible -- and there is other evidence to suggest -- that many individuals became separated from their seats at some point during the break-up sequence.

Q Dr. Shanahan, I am sorry to --

A Yes, sir.

Q With respect to that last chart, can you help us understand why so few individuals in the aircraft were burned?

A Why so few burned? Well, I have various theories on that, but I think, you know, working from the facts, we know that there was significant fire. The interior of the cabin was subjected to some degree of fire, but mostly externally.

So, what we then looked at were the individuals who were burned and their seating location and got some degree of correlation, but, as you will notice, where the burn was within the cabin did not necessarily correlate with individuals.

Now, the conclusions that we can draw from that and that I believe are probably correct is that many of these individuals had departed that part of the aircraft by the time the fire propagated, because we only had very rudimentary burns on individuals, very superficial burns.

The other thing you could argue is that the seating position had changed so significantly that very few people were sitting in that center cabin, which I think is highly unlikely.

(Tape change.)

This is a chart depicting trauma severity indexes, we ended up calling it. Again, in this analysis what we wanted to determine was that although every individual had very, very serious traumatic injuries, we were dealing with everyone with fatal injuries. We tried to grade the degree of fatal injury which individuals sustained.

One of the ways of doing this was by looking at whether the injuries were sufficient to cause instantaneous death, or were not. What you see here is the grading of trauma severity index. What we said here was severe was a grade of absolutely in the mind of two pathologists and myself that the injuries were instantaneously fatal.

Moderate, for which there were fifteen individuals, was there was some question as to whether they were instantaneous, and then minimal would have been where we felt that the -- that death was not absolutely instantaneous.

Now, I really need to provide a caveat with this particular chart, and that is described in the written material, as well. That is that death is somewhat difficult to describe or to define and, as many of you know, we have gone through in the medical world a lot of rethinking about what death is.

But, I won't get into those philosophical meanings, but basically what we used for instantaneous death was if there was brain injury that would not support life, or if there was significant enough organ injury such as rupture of the heart and aorta that death was essentially instantaneous, we believe that all these individuals were almost immediately incapacitated. Whether they were dead or not, it is highly unlikely they were conscious or aware. So that was the determination we had made.

But, now, the reason for doing that was to try to find areas of the cabin that might have been less damaged, and if less damaged it really gives us some information as to what the sequence of break-up was and the severity of that particular break-up.

As it turned out, the correlations were essentially negligible that the -- both body fragmentation and trauma severity index were pretty much randomly distributed throughout the cabin.

Q Doctor, do you have an opinion concerning the potential exposure of occupants of the airplane to explosive devices?

A Yes, absolutely I do. We focused most of our attention to looking very carefully at these remains to see if we could find any evidence of an explosive device. We found none whatsoever.

Q Thank you.

MR. SIMON: Mr. Chairman, I am finished. Thank you.

CHAIRMAN HALL: Are there other questions from the Technical Panel for the witnesses?

(No response.)

Mr. Hughes, none?

MR. HUGHES: No, sir.

CHAIRMAN HALL: Mr. Simon, none?

MR. SIMON: No.

CHAIRMAN HALL: Very well. We will move, then, to the parties in order now. It would be the -- are there any questions from Trans World Airlines, Inc.? Captain Robert Young?

CAPTAIN YOUNG: Mr. Chairman, at this time TWA has no questions of the witnesses. Thank you.

CHAIRMAN HALL: Thank you. The Federal Aviation Administration? Mr. Streeter?

MR. STREETER: No questions, Mr. Chairman.

CHAIRMAN HALL: Boeing Commercial Airplane Group? Mr. Rodrigues?

MR. RODRIGUES: No questions, Mr. Chairman.

CHAIRMAN HALL: The Air Line Pilots Association? Captain?

CAPTAIN REKART: Yes, sir, and I would like to direct the question, I think, to Mr. Hughes, if I could. Mr. Hughes and Mr. Simon and earlier Mr. Wildey have all referred to databases, and I was just wondering if these are multiple databases, or if it is a single database?

WITNESS HUGHES: Captain, the database I referred to basically is a consolidated database. It was a project that was undertaken by the Interior Documentation Group with consultation -- or, I should say complete support from the Medical Group. As a matter of fact, a member of the Medical Group, Officer Legalla from Suffolk County, was our computer person.

The process was combined for two reasons. Basically, the Interior Documentation Group looked at all of the interior parts, catalogued those parts in a database and then merged that information with the Medical Group that was doing similar projects, basically cataloguing injuries from throughout the length of the airplane.

Those two databases were merged into one specifically for the purpose of examining trends -- or, looking for trends for damage in the aircraft cabin, as well as injury patterns for the victims.

CAPTAIN REKART: In your cabin documentation, the cabin documentation that occurred, what was the degree of coordination between the Cabin Documentation

Group, the Fire and Explosives Group and the Structures Group to assure that there was unifying criteria for fire damage and structural deformation to standardize the description for the factuals and the databases and the exhibits?

WITNESS HUGHES: Our work basically was reconstruction of the interior. We did that, which allowed or facilitated the Fire and Explosion Group and the Structures Group, as well as all NTSB groups and the FBI -- it gave them an opportunity to examine it.

Our job was primarily the nuts and bolts of reconstructing the airplane interior. The criteria that we used as far as damage was done specifically for our purpose for use in the Cabin Doc Group and the Medical Group, but we consulted on a daily basis at our team meetings. As you know, we had one every day and on an informal basis whenever anybody would have a question or come to the hangar.

MR. SIMON: If I may, I hope that you won't confuse this with any other databases that may exist in the investigation, such as the one done by the Sequencing Group.

This database, because it contains information generated by the Medical Examiner's Office from autopsies and so on, is not a matter of public record. So, the databases with respect to the Medical Examiner's data and the cabin interior data were combined and generated the graphics that we have looked at, plus the additional twenty-two or so that are in the public record.

WITNESS HUGHES: I might add that the Interior Documentation Group's database is included in its entirety as an attachment, the series six of the factual report.

Our information was not sensitive and, as such, was published. It is available, as I said, in its entirety as an attachment. I believe it is Attachment 6(c) to the group report.

CAPTAIN REKART: Thank you, Chairman Hall. I have no other questions.

CHAIRMAN HALL: Honeywell?

MR. THOMAS: Honeywell has no questions, Mr. Chairman.

CHAIRMAN HALL: Crane Company, Hydro-Aire?

MR. BOUSHIE: Crane has no questions, Mr. Chairman.

CHAIRMAN HALL: International Association of Machinists and Aerospace Workers?

MR. LIDDELL: Yes, Mr. Chairman, just one question for Dr. Shanahan. Could you qualify, or give me a further explanation when you say no explosive evidence was found?

WITNESS SHANAHAN: Yes. Without going into too many details, an explosion in close proximity to an individual leaves certain injury patterns. As I mentioned, one, which was fragmentation of the body, the way the body reacts to that in terms of you get tearing instead of lacerations.

You also, with very close proximity, would see powder, discoloration and other things of that nature. But, probably more importantly would be the nature of material that would be -- that would be found inside the body, that had penetrated the body.

So, those are the basic things we look at -- looked at and couldn't find any correlation, or couldn't find any evidence, I should say, of an explosive device going off in close proximity to an individual.

Considering the distribution of people within the cabin, at least insofar as assigned seating, it would pretty well, without evidence from anybody, it would pretty much rule out any large device within the cabin itself.

Of course, I understand that that doesn't apply to the aircraft as a whole, but as I mentioned in my earlier discussion was that we look at this as one particular layer of the investigation.

MR. LIDDELL: No further questions.

CHAIRMAN HALL: Thank you. Are there additional questions from any of the parties to these witnesses?

(No response.)

If not, we will move up to the Board of Inquiry. Mr. Sweedler?

MR. SWEEDLER: I have no questions, Mr. Chairman.

CHAIRMAN HALL: Dr. Ellingstad?

DR. ELLINGSTAD: I have no questions.

CHAIRMAN HALL: Dr. Loeb?

DR. LOEB: Just one question. Dr. Wetli, I just wanted to make certain. I don't think this question was asked directly. Did you see any evidence of an explosion or explosive device in the process of doing the autopsies and the medical examination?

DR. WETLI: No, we saw nothing that we could definitely say was an explosive device, but the -- many of the bodies in fact became, if you will, projectile traps, and there was a lot of shrapnel, rivets and metallic fragments which we had no idea what they were, although we could assume they were in fact portions of the airplane.

When we encountered something that was different or unusual we did bring it to the attention of Dr. Shanahan or one of his people, and also to the attention of the FBI, and usually got a very quick turn-around answer that it was a piece of a certain part of the plane, or what have you.

The other things that Dr. Shanahan mentioned we also were looking for; evidence of powder or things that would not seem to fit an airplane part and so forth. We never encountered anything like that, either.

DR. LOEB: Thank you.

CHAIRMAN HALL: Well, I have a couple of questions, and I want to preface my questions with some comments, brief comments. Alluding back to what I said at the very beginning, this is -- this is a difficult area to discuss in a public setting and I wish that -- I wish that we didn't have to do it, but we felt that it was necessary to do to be sure we had a complete discussion of the issues.

Let me say candidly that -- and I have a great appreciation for the work of both Dr. Shanahan and both Dr. Wetli -- and what Mr. Simon and Mr. Hughes did. But, we have a situation here that needs improvement in future accidents in terms of the interrelationship between the Medical Examiner, the NTSB, the federal authorities and the families.

While I appreciate and understand Dr. Wetli's comments -- and then the Chairman always tries to encourage public officials to be responsible in their comments. There was feeling among the families that things could have been handled in a better fashion, and there were misunderstandings, and there were things that could be improved.

It is the National Transportation Safety Board's responsibility as the primary federal agency, and the Medical Examiner who is responsible to try to look at the job we did, and if there are ways to improve it since this accident -- and I mentioned this to the families in my remarks last evening.

As you know, President Clinton initiated the Gore Commission to look at a number of things, including how we handle the family matters. The Congress under the able leadership of Chairman Duncan, Chairman McKane have passed legislation now entrusting the NTSB with the responsibilities of better coordinating in the future some of these -- the handling of some of these issues which are very, very difficult issues.

Here, because of the uncertainty of exactly what had caused this accident, there was the competing needs and interests of the families for identification of the remains, as well as the responsibility of the Medical Examiner and the criminal authorities to be sure that none of the remains provided evidence that might lead to criminal action.

But, there are a couple of concerns that had been expressed, and I wanted, Dr. Wetli, for you and I to explore just a little more the interaction with the Attorney General in regard to the autopsy reports and the death certificates that the families have received.

If you could, tell me exactly what that process is, and any suggestions you have on how that might be improved.

WITNESS WETLI: I am not sure I quite understand your question. Are you referring to the release of autopsy reports and autopsy findings to families as well as death certificates?

CHAIRMAN HALL: Yes.

WITNESS WETLI: How that takes place?

CHAIRMAN HALL: Yes.

WITNESS WETLI: Okay. The death certificate; as soon as we have identified the person and -- as soon as we have identified the person and performed the autopsy, then the death certificate is released right away.

In other words, we fill out the portion of the death certificate concerning the medical aspects of it, and then the death certificate is turned over to the funeral directors who fill out the rest of it, and we will then notify the family, and then the family can make arrangements with the funeral directors and so forth for the release of the remains for cremation, or what have you.

CHAIRMAN HALL: Do they have a final death certificate? You had mentioned in your earlier testimony that there was -- that you were awaiting the cause, or the probable cause of the accident for a final death certificate.

I think some of the families -- obviously, I would be if I had lost a family member -- would want to know where is -- you know, when will that -- when can I put closure on that part of this process.

WITNESS WETLI: The closure can only come once we have, in a sense, a completed death certificate as far as manner is death is concerned, meaning natural accident, suicide, or homicide. That determination has to come with the identification of the cause of the crash.

CHAIRMAN HALL: So, at the present moment the families -- the death certificates they have under the State of New York law are temporary death certificates?

WITNESS WETLI: Yes, they are pending further investigation. Once we have an official pronouncement as to the cause of the crash, the section on the manner of death and how the accident occurred, presumably when that is filled out then that will be the final death certificate.

CHAIRMAN HALL: You had some thoughts that we -- I had discussed and Secretary Slater and I had gotten into in some detail with the responsibilities we were given with the Task Force on Family Assistance, in regard to DNA testing did -- at what point in this investigation did we -- did this -- in the process here, did we start to do DNA testing and was that decision made to start DNA testing?

WITNESS WETLI: The decision to start DNA testing was made very early on, probably that weekend of the crash. The crash occurred Thursday evening, and I would say Saturday or Sunday we made a definite decision that DNA testing was going to be needed because we realized the recovery effort was going to be probably relatively slow. We were not going to be getting the remainder of the bodies, for example, the next week.

So, I then uniformly -- or, I contacted the Armed Forces Institute of Pathology by telephone and requested that they give us support with DNA testing as well as anthropology, forensic anthropology which I anticipated. I believe it was on July 22nd, and I sent a formal request to the AFIP asking for more formal assistance should we need it in the area of DNA.

We have a very good DNA laboratory in our office, so we were able to, with the assistance of the New York City EMS people, obtain material we needed and began the DNA testing right away in our office. Then, subsequently in January or February utilized resources of the Armed Forces Institute of Pathology, as well.

CHAIRMAN HALL: Well, we have -- in future -- let me first paraphrase by saying I hope there is no future, but if there is a future accident of this magnitude we have initiated -- I must -- I would like to report that the National Association of Medical Examiners we have met with -- I went and spoke to your national convention.

There are resources available to the Federal Government Mortuary Teams that are part of the Department of Health and Human Services that can come in and assist the local Medical Examiner at the -- at the beginning of a situation like this so that we can try to deal in a responsible fashion to those individuals who lost a loved one, who are very interested in the idenfication of that loved one and want that loved one back just as soon as they can get that loved one back with their family members for appropriate services.

The other; obviously, responsibilities we have in an accident or situation similar to TWA to the -- to the investigation in trying to find out the truth of what happened.

Dr. Shanahan, explain to me again, because I know that many of the American people may see the simulations that have been done by both the CIA and the NTSB that you have seen today, and see the fire depicted with the aircraft. Again, how does that match up with so few burn victims in what you found in terms of the medical, the forensic information?

WITNESS SHANAHAN: Well, of course it is difficult to determine within a real degree of certainty exactly what happened. I think to preface my answer, I think I need to explain that there were many what we call mechanisms of injury available in this particular sequence.

You have the break-up of the aircraft itself which imparts significant forces upon individuals; you have tumbling, potentially, of the aircraft sections themselves, and as they break up seats are coming out and other things are happening on board; and then impact with the water.

But, so it is difficult to look at any particular injury or set of injuries and say it happened at one particular time. That becomes very difficult because, unless you have some very salient characteristics to these injuries, you won't be able to determine at what point it occurred.

Fire is a little bit easier to determine in that respect because we know something about the propagation of the fire and the type of fire that occurred on board the aircraft. Again, it is somewhat in the area of speculation, but remember at least for the initial part of the break-up these -- the individuals were contained within the fuselage structure itself. There might have been some fire externally, but would not have penetrated the fuselage.

There was also the explosion of the tank which, as we mentioned, did not penetrate to a high degree within the cabin interior itself, although there may have been a flame front associated with that, and that is one possibility of how some individuals got these flash type burns.

The other possibility is that shortly after the explosion of the fuel tank the aircraft started to fragment, and seats probably tore out and other things occurred. So, people could have been separated from the aircraft itself prior to the time that a significant amount of fire got within the aircraft cabin. We can't say with certainty that that occurred, but it is certainly one of the explanations for it.

CHAIRMAN HALL: Dr. Shanahan, are you aware, or have you participated in any type of reconstruction of this magnitude prior to your experience with TWA 800?

WITNESS SHANAHAN: No, sir, not of this magnitude. This is certainly the largest I have ever been involved with. I have primarily been involved with military crashes, which are in general considerably smaller.

CHAIRMAN HALL: This, of course, as Mr. Hughes pointed out, is the first time that the Board did an interior reconstruction of the aircraft where you could actually walk into the aircraft through the aircraft seating as it was reconstructed.

We have had the families to Calverton for the purpose of being able to see that and it was, of all the emotional moments this whole experience has provided, was the most emotional for me.

Well, are there any other comments that the Technical Panel has, questions, or the Board of Inquiry?

(No response.)

Gentleman, I appreciate your attendance here. Let me close by saying, though, that everyone worked very hard under very difficult circumstances and, Dr. Wetli, while I appreciate your appearance here today, I do hope that in future investigations that we will be able to do a better job in this area than we did, particularly as it was left in the mind of the family members. For all that, there is clearly -- you know, clearly room for improvement.

We are going to proceed tomorrow morning with the Fuel Tank Design Philosophy and Certification Panel Presentation promptly at 9:00 a.m., and we will therefore -- I will excuse these witnesses.

I thank the parties and the audience for their attention and courtesy that was extended today, and we will recess until 9:00 a.m. tomorrow morning.

(Whereupon, at 4:52 p.m. the hearing was adjourned, to reconvene at 9:00 a.m. the following day in the same location.)

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