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**NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.**

**MEDICAL/FORENSIC
GROUP CHAIRMAN'S FACTUAL
REPORT OF INVESTIGATION**

NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF AVIATION SAFETY
WASHINGTON, DC 20594

October 17, 1997

MEDICAL/FORENSIC GROUP CHAIRMAN'S FACTUAL REPORT OF
INVESTIGATION

A. ACCIDENT DCA-96-MA-070

LOCATION: The Atlantic Ocean at 72:37.46 North Latitude, 40:39.52 West
 Longitude, near East Moriches, New York
EQUIPMENT: Boeing 747-131, N93 119
OPERATOR: Trans World Airlines, Inc.
DATE: July 17, 1996
TIME: 2031 Eastern Daylight Time (EDT)

B. MEDICAL/FORENSIC INVESTIGATIVE GROUP

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C. SUMMARY

On July 17, 1996, at 2031 EDT a Boeing 747-131, registration number N93 119, operated by Trans World Airlines, Inc. (TWA) as TWA Flight 800 was en route from John F. Kennedy International Airport (JFK), New York, NY, to Charles DeGaulle International Airport, Paris, France. Shortly after departure from JFK and while climbing near the southern coast of Long Island, NY, the aircraft exploded and broke-up in flight and crashed into the Atlantic Ocean near East Moriches, NY.

Flight 800 was a scheduled air carrier flight, operated and conducted under Title 14, Code of Federal Regulations (CFR), Part 121. Visual meteorological conditions prevailed at the time and an Instrument Flight Rules (IFR) plan had been filed.

The 18 crewmembers and 212 passengers aboard Flight 800 were fatally injured and the airplane was destroyed.

D. DETAILS OF THE INVESTIGATION

1. VICTIM RECOVERY, EXAMINATION, AND IDENTIFICATION

The remains of all of the 230 victims aboard the airplane were recovered and identified. The remains were recovered at sea and brought to a temporary morgue at the Coast Guard station at East Moriches, NY. The first 99 bodies were found floating on the surface of the ocean and were recovered by various civilian, military, and police vessels during the night of July 17, 1996, and throughout the day of July 18, 1996. The majority of the remaining victims were recovered by U. S. Navy divers and local police divers during the next 96 days. Contract trawling operations were subsequently utilized for the recovery of additional wreckage and remains until April 30, 1997. The last remains that were identified were recovered by a fishing trawler on May 22, 1997.

Victims were placed in body bags and transported by boat to a temporary morgue at East Moriches, NY, which was staffed by personnel from the Suffolk County Medical Examiner's Office and the Suffolk County Police Department. Victims were assigned a medical examiner accession number, photographed, and their clothing and possessions were cataloged. Pertinent data on the location victims were found, when available, and the circumstances of the recoveries of the victims were also recorded. The remains were then placed in a refrigerated trailer and transported to the Suffolk County Medical Examiner's Office (ME) in Hauppauge, NY.

At the Medical Examiner's Office, the remains of the victims were (1) photographed with and without clothing, (2) radiographed, (3) fingerprinted if possible, (4) dentition was photographed and x-rayed, and (4) clothing and other personal effects were cataloged. All victims were then autopsied by a forensic pathologist from either the ME or a pathologist temporarily assigned to the ME by the State of New York or a neighboring jurisdiction. The ME had 5 autopsy tables available and during the early recovery efforts, all tables were utilized.

In most cases identification was accomplished through fingerprinting by an FBI team temporarily assigned to the ME, or by forensic odontology. In rare cases, the ME utilized DNA or forensic anthropology as the primary means of identification. In most cases, identification was based on more than one method. Body parts recovered separately and containing soft tissue were identified by DNA alone. Nineteen victims were identified solely by DNA either by the ME or the Armed Forces Institute of Pathology (AFIP).

The thoroughness of the forensic post-mortem examinations was highly variable depending primarily upon the pathologist who performed the autopsy and upon case flow. The primary objective of the ME was to identify all remains, and the ME was under constant and considerable pressure to do so with minimal delay. Consequently, a high priority was not placed on performing a detailed forensic autopsy directed toward elucidating mechanisms of injury. An effort was not made to relate damage to clothing with wounds on the body. Foreign material removed from the bodies was immediately released to an FBI technician, but autopsy reports did not record whether the material was found loosely within the body bag, in open wounds, or whether the foreign body had penetrated the skin and was found lodged in tissue. Trajectory information was not recorded. No record of the condition of the tympanic membranes of the victims was made.

2. OBJECTIVES AND CONDUCT OF THE INVESTIGATION

The objective of the Medical/Forensic 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 crewmember and to elucidate burn and break-up patterns and sequences.

To accomplish this objective, all medical data contained in the records of the ME were reviewed by a team of physicians and abstracted onto a summary data sheet for each victim. The records that were reviewed for each victim included the dictated autopsy protocol, photographs, radiographs, and various documents related to the recovery and identification of the individual. A single physician was responsible for the initial review and summarization of each case. The senior medical consultant then reviewed each case, comparing the abstracted data to the autopsy protocol to ensure accuracy and consistency of the data. The abstracted data were entered into a computer database. All data were subsequently reviewed by the Senior Medical Consultant and a team of pathologists from the AFIP to ensure accuracy of the data contained in the database.

Microsoft Access, Version 7.0, was used for the medical database. Demographic information, injury data pertinent recovery data and assigned seating location were recorded for each victim. Data fields were restricted to those potentially useful for elucidation of injury mechanisms in order to focus on the primary objective and not expend valuable investigative time on more academic pursuits.

Consideration was given in the design of the database to the development of a tool that could also be used by investigators for future investigations. Consequently, all data fields were kept simple and injury data fields were restricted to plain text. Development of a coding scheme was considered but rejected since this method would have increased the time required by investigators in the field to enter essential data and would have made data interpretation more difficult.

The many ways of describing a particular injury makes searching data base text fields very difficult. Therefore, each injury was entered into one of three data fields (external injuries, internal injuries, or fractures) using a carefully defined format. The format required that information follow a consistent sequence: aspect, object, a single word description of the injury, and other descriptors, i.e., left femur, fracture, transverse; right lung, laceration, extensive; etc. The Senior Medical Consultant completed and reviewed input of all records which helped to ensure compliance with the format and standardization of the data.

Most of the victims had extensive injuries and a listing of each injury would not have been productive in meeting the objectives of the investigation. Such a process would have required more valuable investigative time than was warranted. Consequently, Medical/Forensic Group members determined which injuries were important for developing mechanisms of injury and elucidating primary force vectors. At least two physicians reviewed each case and abstracted only the most significant injuries. Hard copies of the autopsy protocol, body diagrams, photographs, and radiographs for each case remain archived at the Medical Examiner's Office.

Seat assignment was available for each passenger aboard Flight 800 and, for purposes of reconstruction, the seat assigned 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 was conducted to provide an indication of the extent to which passengers moved from their assigned seats in the cabin.

The Cockpit Voice Recorder (CVR) revealed that the Captain had not turned off the “Fasten Seat Belt” sign at the time of the explosion, therefore passengers should have been seated with their seat belts fastened. The CVR also indicated that the Captain had released the 14 flight attendants to begin cabin service prior to the explosion.

3. TOXICOLOGICAL EXAMINATIONS OF VICTIMS

The Medical Examiner collected specimens for toxicological examination from the Captain, the Flight Engineer, and the Check Flight Engineer. Duplicate specimens were submitted to the Federal Aviation Administration (FAA) Civil Aeromedical Institute (CAMI) at Oklahoma City, OK, for examination. Suitable toxicological specimens were not available for examination from the remains of the First Officer. Refer to the attachments to this report the reports of the analyses completed by both laboratories. The ME also conducted toxicological examinations of other occupants of the airplane when biological material was available.

4. DATA MAPPING

A geographical information system (GIS) (MapInfo Professional, Version 4. 1) 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 could be searched for any injury or combination of injuries and the results projected onto a map of the cabin seating arrangement. This innovative 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.

The 14 on-duty flight attendants were excluded from this process since they had been released from their seats by the Captain and their location within the cabin could not be determined. Actual cabin service assignment documents were aboard the aircraft and were not recovered. Flight attendant seating assignments could not otherwise be determined.

The explanations of mapping of various data are presented below to accompany the charts included in the attachment to this report.

4.1 Assigned Seats

The chart depicts the seat assignment for each passenger according to the TWA manifest for Flight 800. Passengers may not have been occupying their assigned seats at the time of the incident since the aircraft was only half-full and passengers may have changed seats during the hour the aircraft was delayed at the gate prior to departure. Cockpit crewmembers are shown according to their assigned positions. The fourteen non-duty flight attendants are not depicted since their service assignments and positions in the cabin at the time of the incident were not known.

4.2 Assigned Seats with Recovered Victims

4.3 Assigned Seats with Unrecovered Victims

These charts were deleted since remains of all victims were recovered and identified.

4.4 Victims with Recovered Seats

4.5 Victims with Seats not Recovered

The charts show the assigned seating position of victims in relation to seats that were recovered or not recovered from the aircraft. The purpose of these charts was to determine if there was a particular pattern to unrecovered seats and victims and to test how well unrecovered victims correlated with unrecovered seats. Thirty-three of 455 seats were not recovered. Remains of all of the occupants of the airplane were eventually recovered.

4.6 Recovered Seats and Fire Damaged Seats

The chart shows the location of seats that were recovered from the wreckage and the location of fire damaged seats (67). Forty-eight fire-damaged seats were located in Zone C that is above the center fuel tank and in an area where there was evidence of burning of the fuselage.

4.7 Body Fragmentation

Bodies were coded according to degree of fragmentation or loss of extremities as follows:

- 0 (green): Body intact.
- 1 (yellow): Crushed head or loss of one extremity.
- 2 (blue): Loss of 2 extremities with or without crushed head.
- 3 (red): Loss of 3 or more extremities or complete transection of body.

This chart shows the degree of fragmentation of victims according to the seat assigned. Percentages displayed adjacent to each cabin zone indicate the proportion of victims with a specified degree of fragmentation.

The chart is potentially useful for determining if any victims were in close proximity to an explosion since individuals exposed to an explosion are usually badly fragmented by the force of the explosion. Explosions do not cause incised wounds; blast wounds are usually ragged and frequently result in a high degree of body fragmentation. In-flight break-up and impact into water can also cause body fragmentation.

4.8 Seat Damage

The Cabin Interior Documentation Group established a set of general guidelines with which the airplane's passenger and crew seats were evaluated. The criteria represent the overall condition of the recovered seat units and individual seats. (Additional seat unit and seat damage documentation was compiled for all of the recovered seats which is included in the separate Cabin Interior Documentation Group Factual Report.)

Minimal (light blue): Overall condition of seat unit or seat to include: seat legs, seat pan, seat back, armrest, and safety belt restraint system is intact.

Moderate (dark blue): Overall condition of seat unit or seat is intact with minor deformation to one or more components including seat legs, seat pan, seat back, armrest, safety belt restraint system.

Severe (green): Overall condition of seat unit or seat include fractures or deformation of the seat legs, seat pan, seat back, armrest, safety belt restraint system.

Destroyed (yellow): Overall condition of seat unit or seat is such that at least 2 of 5 component parts (seat legs, seat pan, seat back, armrest, safety belt restraint system) are fractured or missing.

Fragmented (red): Overall condition of seat unit or seat is such that more than 3 component parts (seat legs, seat pan, seat back, armrest, safety belt restraint system) are fractured or missing.

The chart shows the degree of seat damage by cabin zone.

4.9 Body Fragmentation and Seat Damage

The chart combines the data contained in the preceding two charts to depict the correlation between the degree of body fragmentation and the extent of seat damage. A high degree of correlation could suggest that the occupants remained in their seats throughout the crash sequence. Conversely, a low degree of correlation could suggest that the occupants were ejected from their seats sometime during the crash sequence.

4.10 Evidence of Seat Restraint Use

In order to help resolve which seats were occupied at the time of the crash, all recovered seats were examined for evidence of restraint usage. The following criteria were established by the Cabin Interior Documentation Group to evaluate and determine probable seat occupancy and seat restraint use:

Yes: Seat was assigned and physical evidence, such as belt loading, occupant related deformation, belt cut, belt anchor or anchor with portion of belt was missing.

Likely: Physical evidence, such as belt loading, occupant related deformation, and fastened belt.

Possible: Physical evidence of occupant related deformation, belt loading.

Unknown: No physical evidence of occupancy or restraint use.

Of a possible 422 seats recovered, 57 (14%) were classified as occupied or likely to have been occupied during the crash. Seven (12%) of the seats classified as occupied or likely to have been occupied were unassigned seats.

4.11 Victims with Foreign Bodies

The chart correlates assigned seats with passengers who were determined to have foreign material associated with their remains by radiography. It is unknown whether foreign bodies detected on radiographs had actually penetrated the body and lodged in tissue. Most victims had only single-plane radiographs which cannot distinguish between objects on the surface of the body and those that penetrated the body. Also, autopsy reports generally did not include information about the location of foreign bodies or trajectory, whether there were penetrations of the skin, or whether clothing defects correlated with skin penetrations.

Foreign material penetrating the bodies of passengers is common in in-flight break-ups, severe impacts, and explosions. Discriminating between various mechanisms for material to penetrate a body requires examining the type and density of material imbedded in the body, determining the trajectory of these objects, and looking for other injuries suggestive of explosion such as focal burns and avulsive injuries.

This chart depicts victims with associated foreign bodies. Percentages adjacent to cabin zones indicate the proportion of individuals within each zone that had foreign bodies associated with their remains.

4.12 Floating Victims/Assigned Seats

The chart depicts all assigned seats and the assigned seating locations of all individuals who were found floating on the surface of the ocean. There were a total of 99 victims who were found floating on the surface, 88 of which were passengers and are shown on this chart. These individuals were all located within the first 24 hours after the crash. Most bodies will float for a period of time if they are not secured to a non-floating object or not confined in an enclosed space. Free-floating victims were separated from their seats and the aircraft cabin at some time during the crash or after the wreckage came to rest on the bottom of the ocean.

The significance of floating victims is that their seating locations may indicate where the cabin was severely fragmented either during break-up or upon water impact, since they could not be ejected unless they were separated from their seats or their seats were torn loose and the surrounding cabin structure was severely compromised.

Fifty-one percent of floating victims were assigned to Zone C which is located above the center wing fuel tank.

4.13 Thermal Burns/Floating Victims and Assigned Seats

The chart simultaneously depicts all floating victims, all victims with thermal burns, and all assigned seats. The purpose of this depiction is to correlate victims with thermal burns with their seating location and recovery location (ocean surface vs. ocean floor).

All 8 burn victims were recovered from the surface of the ocean. None of them had severe burns - most of the burns consisted of singed hair and first or second degree burns primarily over their faces, upper arms, and chest. Of the 8 victims with thermal burns, 7 were assigned to Zone C, The remaining victim was assigned to the first row of Zone D, immediately behind Zone C.

4.14 Thermal Burns (including possible)/Floating Victims and Assigned Seats

Postmortem determination of the presence of thermal burns can be very difficult, particularly when the victims are recovered days or weeks after death. Consequently, some victims were classified as possibly burned. This chart combines all passengers with confirmed thermal burns (8) and those with possible thermal burns (4).

Ninety-two percent of burn victims were assigned to Zone C located above the center wing fuel tank. All of the burn victims were recovered from the surface of the ocean.

4.15 Thermal Injuries, Fire Damaged Seats, with Assigned Seats

The purpose of this chart was to determine the degree of correlation between passengers with thermal injuries and seats with evidence of burn damage. A high degree of correlation would indicate burn victims received their burns from the same source as the seats to which they were assigned. A lack of correlation would suggest that the burns to seats and victims were independent events or that passengers were not sitting in their assigned seats. Six (75%) of the burn victims were assigned to seats that were also burned.

4.16 Thermal Injuries (Including Possible), Fire Damaged Seats, with Assigned Seats

When confirmed burn victims are combined with possible burn victims, 9 of 12 burn victims (75%) were assigned to burned seats. This is the same percentage as the previous chart.

4.17 Chemical Burns/Floating Victims and Assigned Seats

This chart depicts the assigned seats for all individuals who had chemical burns and those suspected of having chemical burns. It was developed to look for a correlation between chemical burns and being recovered from the surface of the ocean. A high level of correlation would support the premise that chemical burns were caused by exposure to the fuel slick on the surface of the water and not from some other source inside the cabin. Floating victims had a greater potential for exposure to fuel than passengers who remained with wreckage and sank to the ocean floor. All victims with confirmed or suspected chemical burns were recovered from the surface of the ocean. Fifty-six percent of these victims were assigned to Zone C.

4.18 Injury Predominance: Right vs. Left

Passengers are depicted as to whether there was a predominance of injuries on the right or left side of their bodies when it was possible to make such a determination. Thirty-five percent (75) of occupants displayed lateralizing injuries. Fifty-seven percent of these had predominantly right-sided injuries while 43 percent had predominantly left sided injuries. The chart further depicts lateralizing injury percentages by cabin zone.

4.19 Injury Predominance: Right vs. Left with Floating Victims

The chart is a simultaneous projection of injury predominance and floating victims to determine the correlation between floating and lack of injury predominance. Thirty-three of the 88 floating victims (38%) exhibited lateralizing injuries and 33% of non-floating victims exhibited lateralizing injuries. The chart further depicts lateralizing injury percentages by cabin zone.

4.20 Seat Deformation: Right vs. Left

This chart is similar to chart 4.17 except that it depicts the direction of seat deformation (right vs. left), not injury predominance. Seat information was obtained from the Cabin Interior Documentation Group.

Forty-five percent of the seats recovered displayed right deformation, and 36% of those recovered were deformed to the left. Seat deformation varied throughout all zones in the cabin, except for the upper deck, which is to the right for all 7 seats recovered (78% of the 9 seats installed).

4.21 Right vs. Left Injury Predominance and Seat Deformation

The chart was constructed to test the correlation between injury predominance and seat deformation. A high degree of correlation would suggest that passengers remained in their seats throughout most of the crash sequence. A poor correlation would indicate that either passengers were not in their assigned seats or they became separated from their seats fairly early in the sequence.

Injury predominance is indicated by green or yellow solid circles for those victims who exhibited predominance of injuries to either side of their body. A solid red square indicates seat deformation to the right; a solid blue square indicates seat deformation to the left. Black squares show assigned seats. Absence of a colored circle or square indicates that injury predominance or seat deformation was indeterminate or the seat was not recovered.

4.22 Injury Predominance: Anterior vs. Posterior

This depiction considers predominance of anterior or posterior injuries. The premise is that forward motion of the airplane with respect to occupant seating and the protective effect of the seat at the occupant's back, would cause a seat occupant to have predominantly anterior injuries unless he was separated from the seat. The chart further depicts injury percentages by cabin zone.

One hundred sixteen victims exhibited anterior or posterior predominance of injuries. Eighty-two percent had predominant y anterior injuries and 18 percent exhibited primarily posterior injuries.

4.23 Posterior Injuries/Floating Victims

In the current chart, passengers with predominantly posterior injuries are plotted simultaneously with floating victims in order to determine degree of correlation. The forward motion of the airplane with respect to occupant seating and the protective effect of the seat at the occupant's back, would cause a seat occupant to have predominantly anterior injuries unless he was separated from the seat.

Of the 21 victims with predominantly posterior injuries, 71 percent were recovered from the surface of the ocean. The chart further depicts injury percentages by cabin zone.

4.24 Seat Deformation: Fore vs. Aft

This map depicts the major deformation of each seat in the fore and aft plane. In crashes with forward velocity, forward facing seats are deformed in the forward direction. In in-flight break-ups, this pattern may not occur since major portions of the airplane may have tumbled prior to ground or water impact.

Of the 422 seats recovered, 322 (76%) showed detectable deformation in the fore-aft plane. Of those, 59% were deformed in the forward direction.

4.25 Seat Deformation: Up vs. Down

This chart depicts seat deformation in the vertical plane. Occupied seats that remain upright until surface impact would show downward deflection of the seat pan.

Forty-nine percent of the seats with observable bending in the vertical plane were deformed downward.

4.26 Trauma Severity

All victims of the crash were classified according to severity of trauma where sufficient remains were recovered to make the determination. All victims received fatal injuries and the scoring system applied to this crash attempted to classify degrees of fatal injury according to whether death was determined to be instantaneous. In an injury investigation of a non-survivable crash, it is particularly useful to study those individuals who exhibited the least amount of traumatic injury. Such an investigation can provide information about:

- a. dynamic conditions in a particular portion of the airplane.
- b. break-up patterns and sequences.
- c. identification of zones in the aircraft possibly subjected to less severe trauma.

The trauma severity index used in this investigation was as follows:

Severe:	instantaneously fatal injuries.
Moderate:	questionable whether injuries were instantaneously fatal.
Minimal:	fatal injuries present, but not considered instantaneously fatal.

Sufficient remains were recovered from 202 victims to determine the trauma severity index. The trauma severity index is displayed simultaneously with floating victims to determine correlation between trauma severity and bodies recovered from the surface of the ocean.

One-hundred-eighty-three individuals received a trauma severity score of severe; 15 were scored as moderate and 4 as minimal. Individuals with a minimal severity score were all assigned to seats in Zone C. Half of these individuals were recovered from the surface of the ocean. Forty percent of victims classified as moderate were recovered from the surface; 45% of individuals scored as severe were recovered from the surface.

4.27 Tibia/Fibula Fractures

Tibia and fibula fractures were explored to detect a potential correlation between the explosion of the center wing fuel tank and lower extremity injuries. Only long bone (tibia or fibula) fractures of the lower leg were included, since it would take more force to fracture the long bones and because most occupants of the airplane had at least one fracture of the foot or dislocation of one ankle.

Tibia or fibula fractures occurred in 65% of occupants. The percentage of passengers with tibia or fibula fractures is shown by cabin zone.

4.28 Mid-Shaft Femur Fractures and Forward Horizontal Seat Frame Damage

The forward transverse seat frame member can create shearing forces across the femur as the upper leg contacts the seat frame in crashes with a significant vertical force vector. Mid-shaft femur fractures were correlated with evidence of downward loading to the horizontal seat frame in this crash.

There were 39 passengers with mid-shaft femur fractures and 45 seats with evidence of downward loading of the anterior horizontal seat frame. Fifteen percent of victims with mid-shaft femur fractures were assigned to seats with evidence of downward loading.

4.29 Seat Damage and Floating Victims

To be recovered from the surface of the ocean required that victims be discharged from their seats and the aircraft wreckage during the crash sequence. To test the hypothesis that victims found floating were released from their seats, floating victims were compared to seat damage. Of the 81 victims recovered from the surface that were assigned to seats with known damage, 63 (78%) were assigned to seats that were categorized as destroyed or fragmented. Twelve victims (15%) were assigned to seats with minimal or moderate damage. The remainder were assigned to seats with severe damage.

4.30 Area of Recovery and Assigned Seats

During the early victim recovery efforts, accurate locations of the recovery of individual remains were not obtained. As body recovery and the investigation progressed, Global Positioning System (GPS) positioning data was obtained and recorded in the Medical/Forensic database. This chart reflects recovery location for victims for which that data was recorded according to green, yellow, and red areas as described in the separate Data Management Study.

The red area was the first recovery zone along the direction of the flight path of TWA Flight 800. This was followed by the yellow and green zones. Sixteen bodies were recovered from the red zone, 7 from the yellow zone and 36 from the green zone.

5. BODY RECOVERY LOCATIONS

Body recovery locations, correlated to assigned seat, were geographically plotted. Refer to the attached Body Location by Medical Case Number chart depicting this information.

A handwritten signature in black ink, appearing to read "B. H. Simon", with a long horizontal flourish extending to the right.

Burton H. Simon
Group Chairman