National Transportation Safety Board

Office of Aviation Safety
Office of Research and Engineering
Washington, D.C. 20594

February 9, 2000

WITNESS GROUP STUDY REPORT

DCA96MA070

A. Accident

Location: East Moriches, New York

Date: July 17, 1996

Time: 2031 Eastern Daylight Time (EDT)

Airplane: Boeing 747-131, N93119
Operated as Trans World Airlines (TWA) flight 800

B. Witness group

David L. Mayer Chairman	National Transportation Safety Board Washington, D.C.
Douglass P. Brazy	National Transportation Safety Board Washington, D.C.
Heather Knapp	National Transportation Safety Board Washington, D.C.
Dana Sanzo	National Transportation Safety Board Washington, D.C.
Jim Walters	Air Line Pilots Association Herndon, Virginia
Dennis Rodrigues	Boeing Commercial Airplane Group Seattle, Washington
Joe Manno	Federal Aviation Administration Washington, D.C.

Fred Liddell	International Association of Machinists and Aerospace Workers Kansas City, Missouri
Bob Young	Trans World Airlines St. Louis, Missouri

C. Summary

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

Table of contents

List of appendices

Overview

A previous report, the *Witness Group Chairman's Factual Report*, explained how the witness group organized and prepared the Federal Bureau of Investigation (FBI) witness documents for study. This document describes the activities conducted by the witness group to study the witness accounts of the TWA flight 800 accident. As noted on page 21 of the *Witness Group Chairman's Factual Report*, the group agreed that a witness is:

> Anyone who reported hearing a sound and/or seeing an event or object or objects (including smoke or fire) in the sky in the general vicinity of the accident site, on July 17, 1996, at the approximate time of the TWA flight 800 crash. It must be likely that the sound or object observed was related to the crash, and the report must not be a secondhand account.

National Transportation Safety Board (NTSB) investigators assigned witness numbers to 755 potential witnesses. The document readers and group members read the accounts of these 755 potential witnesses and determined that 736 of these were witnesses. Of these, 670 witnesses reported seeing something that the witness group judged was probably related to the accident, and almost 250 reported hearing something that the witness group judged was probably related to the accident. The group determined that 258 witnesses reported seeing something that fits its definition of a streak of light travelling in the sky, and that 210 of these witnesses reported seeing both the streak of light and a fireball. In total, 599 witnesses reported seeing a fireball. Of these 599, 200 reported that the fireball split into two fireballs as it fell.

This report sets forth the definitions and procedures for systematically extracting factual information from the witness documents, and it evaluates the suitability of the documents for purposes of the accident investigation. Descriptive information about the witnesses is discussed. The report also includes information about a line of sight study that was conducted as part of the FBI's criminal investigation, and the report includes a summary of a sound propagation study conducted at the Safety Board's request by scientists at the NASA Langley Research Center. The report ends with several conclusions reached by the witness group.

Document reading project

The goal of the document reading project was to efficiently and objectively reduce the more than 1,500 pages of witness accounts to a manageable and quantifiable set of data. The witness group developed a set of procedures and definitions for the project in November 1998. Essentially, the group agreed to recruit and train a staff of document readers to read and extract information in a consistent manner from the witness documents. These procedures were implemented by NTSB investigators, and the resulting data were

subjected to an extensive series of quality checks by the witness group and by Safety Board staff. This section describes the document reading project in detail.

Purpose and method

By November 1998, each of the witness group members had reviewed the witness documents in some detail, and had become sufficiently familiar with them to know what kind of information was present in them, and thus, what items that they could reasonably expect a group of document readers to extract. From November 2, 1998, through November 5, 1998, the witness group met to list these items, and decide which ones would be most useful for evaluation. The group developed a worksheet for the document readers to follow when working with the witness documents, and it agreed on a set of procedures and definitions for the document reading project. This material appears as Appendix A to this report.

The worksheet listed each item to be extracted from the witness accounts, and it provided a specific definition for each item to provide guidance to the document readers as they evaluated each witness account. Examples include:

- When was the interview conducted (item 3)?
- Is this a witness account (item 2)?
- Did this witness observe a streak of light (item 11)?
- Did this witness observe a fireball (item 31)?

The group attempted to make the worksheet items as flexible and as all encompassing as possible, while still keeping it practical and objective. A worksheet that covered every possible observation or scenario would be much too long and difficult to work with. Similarly, a worksheet that was too brief would unduly limit the study. The agreed upon worksheet required a significant amount of time to develop and implement, but the end result was a useable worksheet that the group believed balanced these two extremes. Group members confirmed this by testing it on a small subset of witness documents during the November meetings.

Reading and extracting information

At the direction of the Safety Board, a contractor (Marasco Newton Group, Ltd., Arlington, Virginia) developed data entry software to create an electronic version of the worksheet. Nine document readers were recruited from diverse educational backgrounds and employment responsibilities. Three of the readers were NTSB staff, three were Federal government employees of other agencies who were recruited from interagency exchange programs (the Women's Executive Leadership Program and the Executive Placement Program), and three were provided by the contractor that developed the data entry software.

A training session for the document readers was held on January 7, 1999. Safety Board investigators provided an overview of the project and its purpose, explained the use of the worksheet, and discussed each item in the worksheet in detail. Safety board staff explained the importance of consistency when applying the item definitions, and provided a variety of guidelines for interpreting the witness accounts. The readers were told that one worksheet was to be completed for each witness, regardless of the number of witness documents pertaining to that witness. Readers were instructed to use all available information for each witness to complete each worksheet. They were told that if conflicting information was found in two or more documents pertaining to a given witness, to rely upon information contained in the initial interview, unless it appeared that information provided during a subsequent interview was specifically intended to correct information provided earlier.

Each of the readers read the same set of several witness accounts and completed a worksheet for each one as a training exercise. This exercise was designed to give the document readers practice using the worksheet and applying the definitions. Investigators included a variety of witness accounts in this set: some were rather brief and straightforward, but others were more complicated or definitive, and required more judgment on the part of the readers. When each reader had finished, investigators led a discussion on the classification of each witness to provide further guidance concerning the definitions and their application.

At the conclusion of the training session, groups of witnesses were assigned to each reader by witness number. Each reader reviewed his or her assigned witness accounts using the worksheet and the definitions. Worksheet entries were captured using the data entry software. The document readers were permitted to ask questions as they completed their work, and Safety board staff answered these questions by reviewing and explaining the relevant items and their definitions, not by supplying "correct answers" to the readers.

None of the document readers was required to read more than a few hundred witness accounts, but each of the witness accounts was read and evaluated independently by at least two different readers.[1] Once each witness had been evaluated by two readers, worksheet responses made by the readers for each witness were compared. When differences were found on key items, a third reader was assigned to read and evaluate the witness account.[2] Differences on key items were found for 361 of the 755 potential

[1] This is true for multiple choice and fill-in-the-blank items on the worksheet; however, some worksheet items called for the readers to quote text directly from the witness accounts. Other than determining what text to quote, these "text extraction" items required no other judgment or interpretation on the part of the readers. To facilitate efficient work, for any given witness, the second reader (and the third reader, if applicable) could freely view and edit the text extractions of the previous document reader.

[2] The key items were items 2, 5, 6, 11, 12, 13, 14, 31, and 35. These items and their definitions appear in Appendix A to this report.

witnesses. Differences were resolved by using the value chosen by two out of the three of the readers.

On January 13, 1999, a witness group teleconference was held to brief group members on the progress of the document reading project. Safety Board staff discussed the training of the readers and the progress to date, and plans were made for the group to meet once the document reading was complete.

Quality checking the work

Document reading required approximately three weeks. Upon completion, the work of the document readers was extensively quality checked to ensure consistent application of the worksheet definitions. NTSB staff initially made a cursory review of the worksheet data to correct any gross errors, and the witness group met from February 1, 1999, through February 10, 1999, to perform more comprehensive quality control checks of worksheet data for witnesses who had been identified by the document readers as having observed a "streak of light" (item 11). Specifically, the group decided to evaluate the judgments of the document readers on worksheet items 12 through 17, 21, and 23 for these witnesses. There were several reasons for choosing these particular witnesses and items for review by the group. First, witness reports of a streak of light are the ones most suggestive of missile involvement. Second, a streak of light was one of the earliest events reported by many witnesses, so it was reasonable to assume that witnesses who reported seeing a streak of light were likely to have observed a larger portion of the accident sequence than witnesses who did not report seeing such a streak. And finally, during the document reading task it became apparent that the definitions for these items were the most difficult to apply consistently.

During its systematic review of the work of the document readers, the group disagreed with the document readers' evaluations for 92 witnesses. However, the group members had little difficulty agreeing with each other about how the worksheet items should be evaluated for each witness, and the group made changes accordingly. Although many documents required lengthy discussions, arriving at a consensus for a particular item or witness was seldom difficult.

Because group members frequently disagreed with the responses of the document readers, the group decided that only items that have been quality checked should be considered the "official" work of the group.[3] However, because there was general agreement among group members concerning how to quality check the items, the group delegated all other quality control activities to NTSB staff. This was begun while the group was still in session and concluded shortly thereafter.

---

[3] Items 2, 3, 5, 6, 11, 12, 13, 14, 15, 16, 17, 21, 22, 23, 24, 25, 30, 31, 32, 33, 35, 38, 43, 44, 45, 46, and 47 have been quality checked.

While the group was in session reviewing the "streak of light" witnesses, Safety Board staff completed a quality check of the witnesses who the document readers said *did not* report seeing something that met the definition of a streak of light. The purpose of this review was to locate any witnesses who may have reported seeing a streak of light, but were evaluated differently by the document readers. Specifically, items 2, 6, and 11 from Appendix A were reviewed. Safety Board staff located seven witnesses (Witnesses 251, 255, 266, 268, 581, 717, and 735) who may have reported observing something that met the definition of a streak of light. These witness accounts were then presented to the group for evaluation. The group determined that one of these witnesses (Witness 581) did report observing something that met the definition of a streak of light.

During the following months, Safety Board staff completed additional quality control checks of the document readers responses to worksheet items. Witnesses who reported seeing something related to the accident, but did not report seeing a streak of light were reviewed. The purpose of this review was to locate witnesses who may have observed a fireball, but were not evaluated this way by the document readers. Specifically, items 2, 6, and 31 from Appendix A were reviewed. Witnesses who were determined to have reported seeing a fireball were reviewed in more detail. The responses to items 2, 31, 32, 33, 35, and 38 in the fireball section of the worksheet were evaluated. When Safety Board staff disagreed with the responses of the document readers, they made changes accordingly.

While the group was in session, many of the worksheet items related to a streak of light were reviewed. At a later date, Safety Board staff completed a review of the information entered by the document readers for worksheet items 22, 24, and 25.

Safety Board staff also quality checked the responses of the document readers to the worksheet items in the sound section of the worksheet; specifically, items 43 through 47 were reviewed. After completing this quality check, Safety Board staff conducted an additional review of the witnesses who reported making specific visual observations at the time that they reported hearing something (item 45). The results of this quality check are reported in the *Sight/sound witnesses* section, which begins on page 22.

Safety Board staff also quality checked the responses of the document readers to item 30, which was designed to determine which witnesses reported observing a streak of light and an airplane that could have been the accident airplane at the same time. The results of this quality check are reported in the *Airplane/streak witnesses* section, which begins on page 25.

Information about the documents

This section reports a number of findings about the documents that may be useful to readers who wish to read the witness accounts. The extent to which it was possible for the document readers and the witness group members to read and use the documents despite the redactions is discussed in the *Accessibility of the accounts* section. Information

about when the interviews were conducted relative to the accident is presented in the *Interview dates* section. Finally, a detailed discussion about some of the challenges presented by the documents is found in the *Interpreting the documents* section, which begins on page 13. The information presented in this section will also provide a framework for interpreting the findings presented in the *Information about the witnesses* section, which begins on page 20.

Accessibility of the accounts

Most names, social security numbers, phone numbers, street addresses, and other related information that could personally identify the witnesses were redacted from the documents. Further, a few of the documents are almost illegible due to poor photocopying. Although it can be challenging to read redacted documents, especially those with poor print quality, almost all of the actual document content can be read. Consequently, neither the redactions nor the legibility of the documents prevented the witness group or document readers from reading and interpreting the documents.

Interview dates

NTSB staff reviewed interview dates to determine when the FBI conducted initial interviews and re-interviews (item 3). Interview dates were provided in the FBI document catalog, and they were also extracted from the documents themselves by the document readers. Because the documents pertaining to each witness were read by at least two readers during the document reading project, at least two readers independently determined the interview dates for each witness. NTSB staff conducted a quality check of the initial dates recorded by the document readers for each witness, and where differences were found among the document readers, the appropriate witness documents were reviewed and any errors were corrected.[4]

Then, the list of initial interview dates determined by the document readers was compared to the corresponding information available in the document catalog. Again, where differences were found, the appropriate witness documents were reviewed and any errors were corrected. This resulted in a fully error checked list of initial interview dates by witness number. Initial interview dates were determined in this manner for 749 witnesses. An initial interview date could not be determined from the witness documents for 6 witnesses, each of whom was interviewed only once. Safety Board staff then reviewed the witness documents for each witness who was interviewed more than once to

[4] The witness documents available for each witness were consulted for this review. If only one witness document was available for a given witness, the date on which this interview was conducted was used as the date of the initial interview. When more than one witness document was available for a given witness, the date of earliest interview reported in one of these documents was used as the initial interview date.

capture each re-interview date. Dates for five re-interviews could not be determined from the witness documents.

Based on the documents provided, Safety Board investigators assigned witness numbers to 755 persons, 650 of whom were interviewed only once. Thus, 105 were interviewed more than once. Of those interviewed more than once, 76 were interviewed two times, 18 were interviewed three times, 6 were interviewed four times, 4 were interviewed five times, and 1 was interviewed six times.

Based on the interview dates extracted from the documents, Safety Board investigators determined that in the 3 days following the accident, FBI agents interviewed more than 300 of the 755 persons who received witness numbers, and another 300 during the following week (see Figure 1 for a graphical presentation of this information).[5]

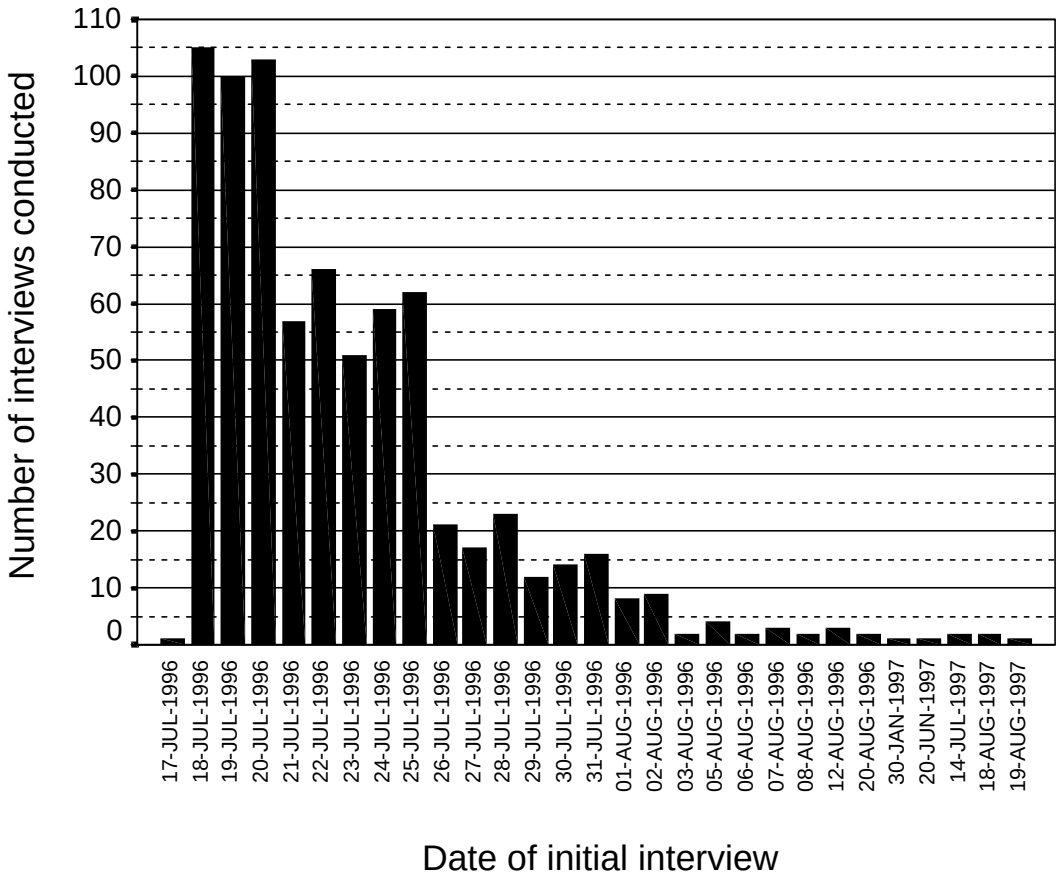

Figure 1: Number of initial interviews by date.

[5] Information presented about the dates of the interviews relative to the date of the accident is not intended to represent the entire scope of the FBI's investigative activities during this period.

Each day from July 17, 1996, through August 3, 1996, initial interviews were conducted. One initial interview was conducted on July 17, and approximately 100 initial interviews were conducted on each of the three days that followed. On July 21 through July 25, between fifty and seventy initial interviews were conducted each day. On July 26 through August 3, approximately fifteen to twenty initial interviews were conducted each day. About 40 initial interviews were conducted during the month of August. No initial witness interviews were conducted between late August 1996 and January 1997.

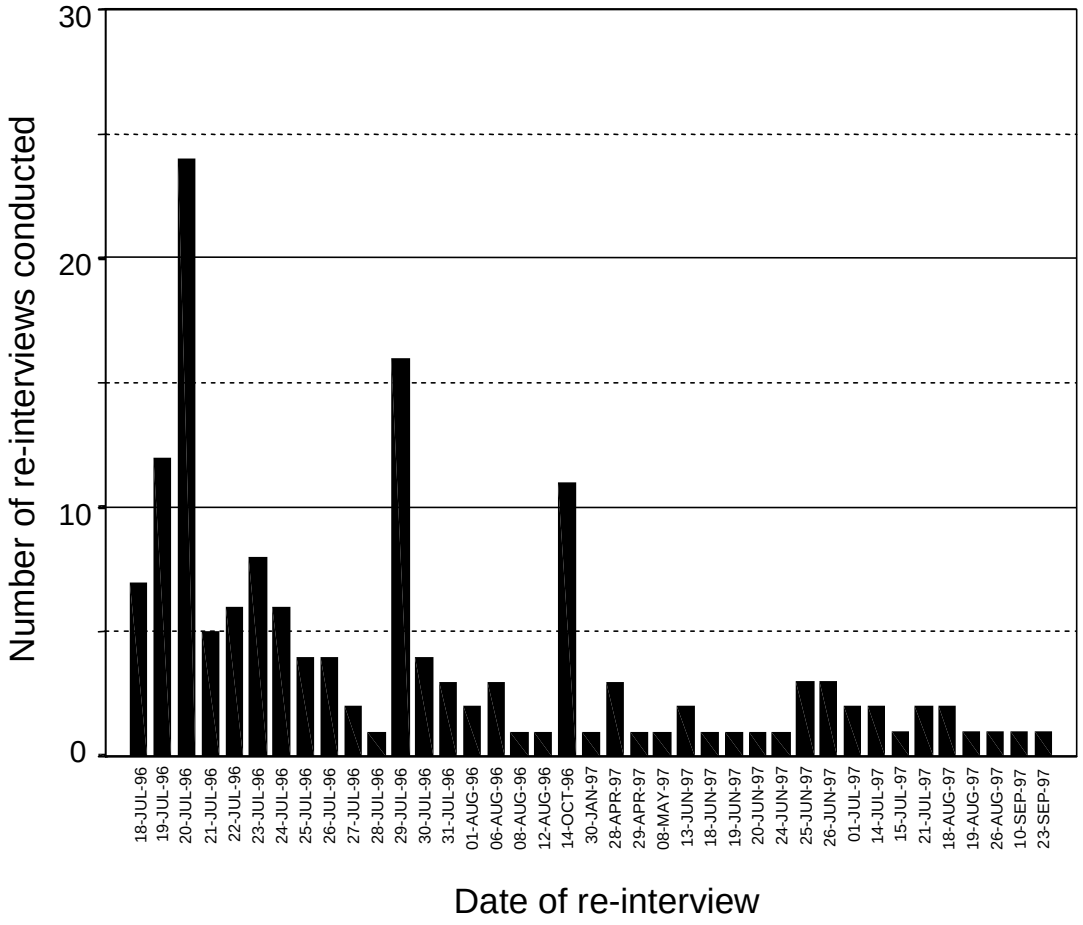

Figure 2: Number of re-interviews by date.

According to the documents provided, the FBI conducted about 125 re-interviews in 1996.[6] Almost all of these (about 100) were conducted during the month of July 1996.

[6] The FBI conducted re-interviews for a variety of reasons. As Special Agent Otto stated during his September 30, 1998, meeting with the witness group, a number of the witness documents prepared by FBI agents early in the investigation were primarily designed to provide investigative leads that would later be followed up with re-interviews (the meeting with Agent Otto was discussed on Page 11 of the *Witness Group Chairman's Factual Report*). A number of the re-interviews conducted by FBI agents early in the investigation were probably the result of this planned activity. During their briefing on April 30, 1999, CIA

In August 1996, about 10 re-interviews were conducted, and about 12 re-interviews were conducted in October 1996. No other re-interviews were conducted in 1996, but the FBI conducted about 30 re-interviews during 1997. The bulk of these were accomplished during the summer of 1997. The witness documents contain no interviews that were conducted after September 1997. Figure 2 presents a graphical depiction of this data.

Varying levels of detail

The documents vary greatly in the level of detail that they contain. Generally, interviews conducted in the days following the accident provided less detail than interviews conducted later in the investigation. During his September 30, 1998, meeting with the witness group, Special Agent Otto explained that this is because very early in the criminal investigation, the witness documents prepared by FBI agents were primarily designed to provide investigative leads that would later be followed up with re-interviews, as needed. Re-interviews were often accomplished for specific reasons; consequently, they led to more detailed documents. For example, Witness 2 (distance from flight 800 unknown) was interviewed on July 20, 1996, and the document that pertains to this interview (CC3-587) only states the witness observed an explosion.

Witness 571 (9.6 nautical miles slant range from flight 800) was originally interviewed on July 23, 1996, and re-interviewed on July 29, 1996.[7] The document pertaining to the second interview (CC1-215) was almost three full pages long, and provided significantly more details than did the half-page document pertaining to the first interview (CC1-27). Although both documents establish that the witness saw what he believed were fireworks being fired from the beach, document CC1-215 provides more details about the appearance and motion of the "fireworks," and also establishes the witness's location and action before observing the "fireworks." Both documents also establish that the witness heard several explosions, but document CC1-215 describes the relative intensity and timing of these explosions.

Interpreting the documents

The witness interviews conducted by the FBI were done in support of its criminal investigation. During the September 30, 1998, meeting, FBI Special Agent Otto told the witness group that in the initial days of the investigation, the FBI began to suspect that a missile might have been used against flight 800 because so many eyewitness accounts included descriptions of a flare-like object or fireworks in the sky prior to the appearance

---

analysts told the witness group that they asked the FBI for more information concerning some of the witnesses (this briefing was discussed on Page 12 of the *Witness Group Chairman's Factual Report*). A number of the re-interviews conducted later in the investigation were probably generated by the CIA's work with the documents.

[7] One statute mile equals 5,280 feet; one nautical mile equals 6,076.1 feet.

of a large fireball.[8] Consequently, rather than recording a complete accounting of the visual and aural events described by the witnesses, Special Agent Otto indicated that FBI agents tended to use the witness documents to capture information that appeared relevant to its criminal investigation.

It appears that during some interviews the questions asked by the FBI agents were framed in a manner that emphasized aspects relevant to the missile investigation. In fact, some suggested interview questions are included in document CC-5, which pertains to Witness 32. Some of these include:

- What was the timing of events? How long did the missile fly, etc.
- What does the terrain around launch sight look like? Were scorch marks visible?
- Where was the sun in relation to the aircraft and the missile launch point?

The witness group and the document readers found that a number of other aspects of the witness documents make it difficult to extract accurate and reliable information from them. These include possible interviewer and interviewee bias, ambiguous clock-point and angle references, potentially inaccurate distance estimates, combined accounts, reporting of witness speculation and conclusions, imprecise or vague language, internal inconsistency, and errors concerning the origin streak of light. Each of these issues will be discussed along with an example or two.[9]

Possible interviewer and interviewee bias. As mentioned previously, FBI witness interviewing was focused on the possibility that a missile had been used against the accident airplane. This focus may have resulted in bias on the part of some the interviewers. For example, the document (CC1-628) pertaining to Witness 590 (10.4 nautical miles slant range from flight 800, interviewed July 20, 1996) describes an ascending red ball.[10,11] The document further states, "Upon impact, [redacted] observed a

---

[8] This meeting was discussed on page 11 of the *Witness Group Chairman's Factual Report*.

[9] Although only one or two examples are provided to illustrate each point, unless otherwise noted, many other documents also exhibited each of the same characteristics described in this section.

[10] For more information about how distances were calculated, refer to the *Angle and distance calculations* section, which begins on page 33.

[11] Double quotation marks are used in this example and throughout this report to denote that material has been quoted from a witness document, not that the words of a given witness were quoted in that document. Words enclosed in single quotation marks in this report were actually enclosed in quotes in the source document. Unless it is obvious from the context, the serial number of the quoted document appears in parentheses following each quote. Interview dates pertaining to the source document, if available, are also provided for examples used in this report. Listed document serial numbers and interview dates may not be the only such documents and interview dates pertaining to a specific witness.

large fireball." Neither the document nor the attached interview notes states that the witness saw anything other than the red ball in the sky; thus, it is unclear what the "impact" mentioned in the document is. Although this incongruity could be due to other reasons, the witness appears to have described an ascending red ball and a large fireball, which the interviewer related using the word "impact."[12] For a similar example, see document CC1-382, which pertains to Witness 411 and Witness 412 (both of whom were 8.2 nautical miles slant range from flight 800, interviewed July 20, 1996). These witnesses describe seeing a flare-like object, but "they did not see what [the] flare struck, but it exploded in air into a large orange fireball." This characterization may suggest that the interviewer and/or the interviewees believed that the flare-like object was a missile, which must have struck something. Beliefs concerning the possibility of a missile attack may have biased or colored the word choices used in reporting the witness accounts; therefore, these accounts must be interpreted carefully.[13] The presence of missile experts at some interviews may also have influenced these biases.[14]

One document pertaining to Witness 243 (CC4-146, interview date not provided) states that the witness saw an ascending object and then an explosion. However, another document pertaining to this witness (CC1-28, interviewed July 18, 1996) states that the witness (12.0 nautical miles slant range from flight 800) noticed something similar to a flare and "the flying object was relatively slow in flying up and took about four or five seconds before hitting the airplane." Though the document implies that the witness saw an airplane, the document does not specifically state that the witness actually saw an airplane. The interviewer or the interviewee may have used these words to convey that the witness observed an explosion after seeing the flare-like object.

Some documents noted that the witness did not realize what he or she was observing, and some documents specifically state that the witness made conclusions about what he or she observed after learning about the accident in the media. For example, the document pertaining to Witness 326 (CC-368, 13.2 nautical miles slant range from flight 800, interviewed July 24, 1996) states that this witness did not think much about what was observed until watching the evening news. The document pertaining to Witness 271 (CC1-205, 39.2 nautical miles slant range from flight 800, interviewed August 2, 1996)

---

[12] It is also possible that the witness used the word "impact," but this is unlikely. Witness document CC1-628 pertains to Witness 590, and the original interview notes that were used to generate this FD-302 were also provided. These notes do not contain the word "impact."

[13] This is especially challenging because the witnesses are only rarely quoted in the witness documents; therefore, it is almost always impossible to determine whether the words used in a given document are the words of the interviewer or the interviewee.

[14] Missile experts were present for some of the witness interviews. For example, an analyst from the Missile and Space Intelligence Center, Redstone Arsenal, Alabama, was present for an interview of Witness 129 and an interview of Witness 372. A person from the Naval Air Warfare Center, China Lake, California, was present for an interview of Witness 649.

states that she did not realize that she had observed an airplane crash until about an hour later when family members told her that TWA flight 800 had exploded. The document pertaining to Witness 166 (CC1-374, 31.0 nautical miles slant range from flight 800, interviewed July 26, 1996) states that this witness concluded that he had observed a missile after hearing news accounts about the crash. Clearly, some witnesses discussed the crash with each other and/or learned about it from the media before they were interviewed. It is likely that media coverage about the crash and the associated criminal investigation may have led to bias on the part of some the interviewees.

Ambiguous clock-point and angle references. Sometimes direction or position is described using clock-point references that do not appear to be those generally used in aviation.[15] It is not always readily apparent whether "o'clock" is referring to the observed object's path of travel, its position, or its elevation angle. For example, the document pertaining to Witness 533 (CC-371, interviewed July 19, 1996) describes "the trajectory of the smoke trail initially as verticle [*sic*] (approximately 11:00 direction)." Without knowing the orientation of the clock face in space, this type of description is difficult to interpret. The clock face could be parallel to the line of sight of witness such that 11 o'clock is almost directly above the witness, perpendicular to the line of sight of the witness such that 11 o'clock describes a trajectory that is nearly perpendicular to the horizon, or the clock could be parallel to the horizon such that 11 o'clock is just to the left of being directly in front of the witness (8.1 nautical miles slant range from flight 800).

In another example, the document pertaining to Witness 216 states that he "observed to his right, at about forty-five (45) degrees, a flare vertically going 'down'… [and] saw a horizontal explosion about one-half (1/2) way down from where he first observed what he believed was a 'boat flare'" (CC1-261, interviewed July 23, 1996). From this description, it cannot be determined with certainty where the witness first observed the flare. It appears that the witness (10.3 nautical miles slant range from flight 800) said that he first observed the flare at 45 degrees above the horizon; however, the description could also be referring to the direction in which the witness first observed the flare. The flare may have been first observed 45 degrees to his right. Because the initial position is ambiguous, the description of an explosion half way down from that point is also ambiguous.

Reasonable assumptions and judgments can be made concerning the accounts of Witness 533 and Witness 216, but experience among the witness group members and document readers has shown that diligent readers do not always make the same assumptions.

[15] It is common in aviation to use clock points to indicate a direction from an observer. For example, to the observer's left is at his or her "9 o'clock," and straight ahead of the observer is at his or her "12 o'clock."

Potentially flawed distance estimates and direction information. It is quite reasonable to ask witnesses to provide distance estimates and direction of travel information, but the witness documents provide a wide range of both. Although some of this information may be reasonably accurate, distance and direction information must be cautiously interpreted. For example, Witness 531 and Witness 147 were in the same location while observing the accident, and they were subsequently interviewed together. Both witnesses saw an ascending flare-like object (CC3-355, interview July 21, 1996). Witness 531 estimated that it was about 30 miles away, and Witness 147 estimated that it was five or six miles away. The accident site was actually located about 26 statute miles ground distance from where these witnesses were located. Many of the witness documents provide distance estimates and direction of travel information concerning their observations. It must be remembered that most witnesses reported seeing a streak of light and/or a ball of fire, against the generally featureless background of the sky. Because few context clues are present, it would not be expected that the distance and direction information provided by the witnesses would necessarily be accurate.

Combined accounts. Safety Board staff assigned witness numbers to each witness identified in the documents (refer to the *Assigning witness numbers* section, which begins on page 22 of the *Witness Group Chairman's Factual Report* for more information). However, due to the construction of some documents it was sometimes impossible to attribute specific observations to specific witnesses. For example, the document pertaining to Witness 417, Witness 418, and Witness 419 states: "These individuals related only hearing explosions and/or visual observations of the aftermath or descent of firery [*sic*] wreckage" (CC1-329). From this account, it is impossible to determine which witness(es) heard, which witness(es) saw, and which witness(es) heard and saw an explosion.[16] This document provides so few details that attributing specific observations to specific witnesses is really of little value; however, later in this report, the number of witnesses who saw the fireball and the number who heard sounds likely associated with the accident will be reported. Descriptive statistics such as these are based on the documents, and could contain errors due to combined accounts.

The accounts of witnesses who were interviewed in small groups tended to be reported as if each person saw, remembered, and reported the same events. This was especially common for married couples interviewed together. For example, in the document pertaining to Witness 437 and Witness 438 (CC1-190), most of the information is provided by Witness 437. At the end of the document, it states that Witness 438 corroborated the information provided by Witness 437.

Reporting of witness speculation and conclusions. Some documents provide conclusions about what the witness observed without stating what the witness reported

[16] Because the specific observations could not be associated with the specific persons in this document, the group determined after the document reading project that none of these three persons met the definition of a witness.

observing. For example, the document pertaining to Witness 370 states, "He saw what he thought at the time to be a large bright flare in the sky" (CC1-123, interviewed July 30, 1996). A description of what the witness (14.8 nautical miles slant range from flight 800) actually observed is not provided. The document only states what the witness believed he was observing. Flares can climb and they also can fall, and some move faster than others. Some flares are designed to provide illumination, and others are designed to attract attention. Witness documents that do not report exactly what the witnesses saw are difficult to interpret.

In another example, a document pertaining to Witness 641 and Witness 642 (CC3-6, interviewed July 20, 1996) states, "They saw what appeared to be a flare being fired from a boat in the bay." The use of the word *appeared* suggests that some aspect of the account is actual observation and the remainder is speculation, but it is not possible to separate the two. The witnesses (8.7 nautical miles slant range from flight 800) may have reported seeing something rise up from a boat, or perhaps they did not report that they actually saw something launched from a boat.

Imprecise or vague language. Because of the language used in some documents, many interpretations of the written text are possible. For example, the document pertaining to Witness 614 (CC4-30, interviewed July 25, 1996) states that this witness reported seeing fire falling from the sky, and that "when it hit the water, approximately 8 to 10 seconds later, there was a big explosion." The witness (6.6 nautical miles slant range from flight 800) may have reported that the fire hit the water 8 to 10 seconds after he first saw the fire. Or, he may have reported that the explosion may have occurred 8 to 10 seconds after the fire hit the water.

The document pertaining to Witness 678 states, "He believed he saw what appeared to be a flare travelling from the water toward the sky" (CC-404, interviewed August 20, 1996). The witness, who was apparently unsure of his observation, may have reported that he observed a flare appear at the surface of a body of water (presumably the Atlantic Ocean) moving upward. Alternately, the witness (distance from flight 800 unknown) may have reported that he observed a flare travelling upward out over a body of water (but not necessarily from the surface of the water).

Occasionally, descriptions are so vague that it is nearly impossible to determine what the witness is describing. The document pertaining to Witness 666 (CC-329, interviewed July 23, 1996) states, "He only saw the object ascending for a split second when he observed an orange or light colored object ascending from the southwest direction. He stated it ascended for approximately five seconds." In the first sentence, the witness (10.1 nautical miles slant range from flight 800) describes two objects ascending. In the next sentence, *it* is described as ascending for five seconds. Determining what this witness observed is nearly impossible. This witness may have observed one or two objects ascending for a split second or five seconds.

The document pertaining to Witness 90 (CC1-550, interview date not provided, distance from flight 800 unknown) is also difficult to evaluate because of vague language, omitted details, and other difficulties. This document describes a red fire that "ascended to 12 o'clock." Then, the witness saw a descending and expanding orange/yellow light that "burst into massive flames 1/3 of the way down." The account concludes by noting that the witness heard three explosions that shook the water in the bay. The clock-point reference and the expression "1/3 of the way down" are apparently used to denote a position in the sky, but their exact meanings are unclear. Also unclear is whether the red fire and the orange/yellow light are the same object. Finally, the document notes that three explosions were heard, but no attempt was made to describe when these were heard in relation to what the witness saw, nor was any description of how the explosions sounded provided.

Internal inconsistency. Some witness accounts appear to contradict themselves. For example, the document pertaining to Witness 34 (CC-36, interviewed July 18, 1996) states that the witness (22.0 nautical miles slant range from flight 800) "observed what appeared to be a Coast Guard flare." The document states that the witness "went home and heard of the crash that he realized that approximately 30 seconds to 2 minutes before he observed what he thought was a flare, he observed what he thought was a shooting star." According to the document, this object looked like a "bottle rocket with a dull orange glow," and it moved from west to east "faster than an aircraft." The document states that he saw the object fly for about 10 to 15 seconds, but did not see a smoke trail. By the end of the document, the words used to describe the witness's observations have changed greatly: The document states that the witness saw a "straight" and "horizontal" trail, that the trail "approached the aircraft" but he "did not see it strike the aircraft," that the witness "could not comment on the launch site," and that the witness was "no more than 5 miles from the missile." Thus, the characterization of the witness's observations evolves from a "Coast Guard flare," to a "shooting star," to a "missile." At the end of the document, however, it states "that everything happened so quickly, making it difficult for him to remember any details."

Origin of the streak of light. Three witnesses were found who appear to characterize the origin of the streak of light differently over two interviews. Witness 562 (22.3 nautical miles slant range from flight 800) was first interviewed on July 22, 1996, and the document that pertains to that interview (CC1-82) states that the witness observed a flare rise straight up from the ocean. The witness was re-interviewed on June 26, 1997, and the document that pertains to this interview (CC1-657) states that the witness first observed the flare at about fifteen to twenty degrees above the horizon. It appears that careful questioning during the re-interview led to a clarification on an important point: whether the witness observed the origin of the streak of light, or began watching it in mid-flight.

Witness 536 (14.7 nautical miles slant range from flight 800) also characterizes the origin of the streak of light differently in two interviews. The document pertaining to the July 23, 1996 interview (CC1-327), reports that the witness saw a flare come from the

water. Conversely, the document pertaining to the July 15, 1997, interview (CC1-645) reports that the witness saw a flare begin ascending from three inches above the horizon.

According to the FBI documents, Witness 571 was interviewed on July 23, 1996, and on July 29, 1996. The document that pertains to the first interview notes that this witness saw "what appeared to be cheap fireworks coming off the beach" (CC1-27). The document pertaining to the second interview further describes this event as "a white light that was travelling skyward from the ground" (CC1-215). During their April 30, 1999, briefing to the witness group, CIA analysts noted that Witness 571 was interviewed at least one more time after July 29, 1996 (For more information about this briefing, refer to the *Witness Group Chairman's Factual Report*). According to CIA analysts, during a careful re-interview by FBI agents, it became clear that the firework-like streak was in mid-flight when it first became apparent to Witness 571. The Safety Board received no documentation from the FBI concerning any interviews that took place after July 29, 1996.

Information about the witnesses

This section reports the results of the document reading project. The tabulations that appear in this section were based on the work of the document readers that was quality checked by the witness group.

The group recognizes that any categorization of the witness accounts is subject to some interpretation. Because of the nature of the documents, the document readers were required to apply some degree of judgment and interpretation as they read the witness accounts and completed the worksheets; however, the procedures were specifically designed to promote as much objectivity as possible. Careful, unbiased document readers occasionally arrived at different conclusions about a specific witness, but there was no indication that these differences were the result of any outcome bias. More likely, they arose from ambiguities in the text of the witness documents. Some examples of these ambiguities are discussed in the *Interpreting the documents* section, which begins on page 13. The group further agreed that there is little value debating the specific categorization of any individual witness because of the high likelihood of being misled by the ambiguities and other limitations of the individual documents. The group agreed that the value of this work lies in viewing the witness accounts as a body of data, rather than focusing on the peculiarities of any one account.

At the outset of the project, the group believed that the definitions of a streak of light (item 11) and a fireball (item 31) were rather explicit and would be easy to apply. However, as mentioned previously, the group discovered that deciding whether a given witness reported observing a streak of light was actually rather challenging. Although many witness accounts used similar words to describe the streak of light (e.g., *fireworks* or *flare*), many descriptions of airborne events that may have met the streak-of-light definition were difficult to interpret because they did not include information about apparent motion. This made it difficult to distinguish a description of a streak of light from a fireball. It is likely that the fireball grew in size as it developed and descended.

Consequently, some streak-of-light witnesses may have actually observed only the development of the fireball. Determining whether a given witness reported observing only a fireball or a streak of light and a fireball was a judgment call that was dependent on the language in the document.

NTSB investigators originally identified 755 potential witnesses. The document readers and group members read these accounts and determined that 736 of these 755 potential witnesses met the group's definition of a witnesses.[17,18]

Sight witnesses

The group agreed that a "sight witness" is any witness who reported seeing an object in the sky on the date and at approximately time of the crash (whether or not they reported hearing something that might be associated with the accident). The definition requires that the sight was likely related to the crash. For more information, see Appendix A, item 6. Of the 736 witnesses, 670 were classified as sight witnesses.

Sound witnesses

The group defined a "sound witness" as a witness who reported hearing something on the date and at approximate time of the crash (whether or not they reported seeing something that might be associated with the accident). It must be likely the sound was related to the crash. For more information see Appendix A, item 5. It was also agreed that someone who reported feeling a vibration or concussion that was likely associated with the crash was a sound witness, even if he or she did not specifically report hearing anything. Of the 736 witnesses, 239 were classified as sound witnesses.[19]

Quantitative estimates (ranging from one to seven) of the number of sounds heard were sometimes given: 88 sound witnesses reported one sound, 58 reported two, 39 reported three, 7 reported four, 6 reported five, 1 reported six, and 1 reported seven.

Nineteen sound witnesses reported the number as a range: 1 reported hearing two to three sounds, 7 reported three to four, 1 reported three to five, 4 reported four to five, 1 reported four to six, 1 reported five to six, 1 reported six to seven, 1 reported hearing more than 2 sounds, 1 reported hearing more than 5, and 1 reported hearing about 5 sounds.

---

[17] The group's definition of a witness appears on page 20 of the *Witness Group Chairman's Factual Report*, and it was also repeated in the *Overview* on page 5 of this report.

[18] The following were determined to be non-witnesses: 13, 25, 33, 45, 111, 139, 181, 202, 249, 267, 311, 417, 418, 419, 422, 423, 582, 585, and 703.

[19] There were 497 witness who were not classified as sound witnesses. The documents pertaining to 218 of these witnesses noted that they did not hear a sound that fit the definition of a sound witness. There was no mention of hearing a sound in documents pertaining to the remaining 279 witnesses.

Finally, 11 sound witnesses characterized sound as "several" or a "series." See Appendix A, item 43 for more information about this item.

The reported sounds were frequently described as a boom, a roar, or a thunder-like rumble. Documents pertaining to 84 witness include the term "explosion" to characterize the sound, 74 characterized the sound as a "boom," 50 use the term "thunder" to describe the sound, and 36 characterize it as a "rumble." The documents pertaining to 13 witnesses described feeling a vibration or concussion. See Appendix A, item 44 for more information about this item.

Sight/sound witnesses

There were 179 sound witnesses who were also sight witnesses. Of these, some reported making specific visual observations at or about the same time that they reported hearing a sound. Item 45 (see Appendix A) was designed to help locate these witnesses. Safety Board staff quality checked the responses of the document readers to this item and determined that 89 witnesses provided (1) a description of a specific visual observation such as the fireball splitting into two fireballs or water impact, (2) a report that the specific visual observation was made at or about the same time that they heard the sound, and (3) sequence or timing information relating the specific visual observation to the sound.[20]

Some witnesses reported making specific visual observations *at the same time* as they reported hearing a sound. For example, witness document CC3-331 (interview date July 21, 1996) notes that Witness 648 (7.6 nautical miles slant range from flight 800) reported seeing a glow that became "progressively more intense until producing a mushroom of white smoke and a rushing roar-type sound. At that instant, he observed a plane which separated into two flaming parts."

Some witnesses reported making specific visual observations *at about the same time* as they reported hearing a sound. Some of these provided timing estimates and some provided only sequence information. For example, document CC1-319 (interview date July 25, 1996) states that Witness 492 (8.5 nautical miles slant range from flight 800) observed a reddish/orange object "burst into a larger fire" and that the witness "heard two explosions about fifteen seconds later." Although witness document CC1-319 provides timing information, document CC-457 (pertaining to Witness 576) provides only sequence information. According to document CC-457, Witness 576 (9.1 nautical miles slant range from flight 800, interviewed July 22, 1996) heard a boom and saw "two flames" descending, and then he heard other booms.

---

[20] These were Witnesses 21, 38, 46, 47, 50, 57, 68, 75, 83, 89, 90, 108, 129, 146, 148, 153, 155, 156, 157, 169, 177, 186, 190, 209, 228, 283, 284, 291, 293, 295, 298, 304, 313, 317, 325, 339, 349, 350, 356, 359, 365, 390, 398, 405, 406, 408, 411, 412, 426, 445, 449, 454, 461, 462, 473, 480, 481, 482, 492, 496, 497, 498, 499, 501, 503, 504, 506, 510, 526, 536, 548, 567, 570, 571, 576, 577, 614, 643, 645, 646, 648, 661, 675, 696, 713, 714, 732, 738, and 753.

Of the 89 witnesses who reported observing something specific at or about the same time that they reported hearing a sound, 35 provided timing information, and 54 provided sequence information.

Streak of light witnesses

The witness group defined a streak of light as an object moving in the sky that could be variously described in witness documents as a point of light, fireworks, a flare, a shooting star, or something similar. The definition noted that a streak of light is usually described as ascending, but could also be described as arcing over and/or descending. The group agreed that a streak of light must not meet the definition of a fireball, and it must precede any report of a fireball. For more information see Appendix A, item 11.

The group determined that 258 witnesses reported observing a streak of light. Almost all of these witnesses reported seeing one streak of light, but a few witnesses reported seeing more than one. For example, Witness 77 (10.4 nautical miles slant range from flight 800, interviewed July 23, 1996), Witness 86 (14.0 nautical miles slant range from flight 800, interviewed July 24, 1996), and Witness 218 (13.0 nautical miles slant range from flight 800, interviewed August 12, 1996) each reported observing two rising streaks of light.

Most of the 258 witnesses who reported seeing a streak of light either reported initially noticing the streak while it was airborne, or made no report of having observed its origin. Only 33 witnesses were judged to have reported observing the origin of the streak of light (see Appendix A, item 12).[21] Of these, 18 indicated that it originated from the surface, 2 reported that they saw it originate in the air, 7 said it originated at the horizon, and 6 reported that it originated behind an obstruction (see Appendix A, item 13). Of the 18 who indicated that it originated at the surface, 12 reported that it originated from the sea, 5 reported that it originated from land, and the document pertaining to 1 witness did not mention where it originated (see Appendix A, item 14).

Witness characterizations of the motion of the streak of light varied. Safety Board investigators attempted to determine which witnesses reported seeing a streak of light that appeared to travel straight up or nearly so. Safety board staff searched the vertical motion text item (item 22) for the witnesses documents that contained the words “straight” (as in straight up) or “vertical.” Thirty-eight witnesses who characterized the motion of the streak of light as vertical or nearly so were located.[22,23] The group plotted these witness

[21] Witness 536 and Witness 562 were not categorized as having reported observing the origin of the streak of light because contradictory information was reported in their witness documents (see the *Interpreting the Documents* section).

[22] These are: Witnesses 9, 80, 96, 117, 118, 151, 166, 175, 186, 199, 200, 233, 241, 242, 305, 356, 359, 372, 391, 432, 435, 436, 497, 500, 503, 527, 533, 536, 548, 562, 590, 641, 649, 653, 665, 675, 733, and 746.

locations and noted that they were widely dispersed throughout Long Island. The closest of these witnesses was about 7.8 nautical miles slant range from flight 800, and the farthest was about 47 nautical miles slant range from flight 800.

Of the streak of light witnesses who did *not* characterize the motion of the streak as vertical or nearly so, 126 provided information concerning the lateral motion of the streak. The group determined that 45 reported seeing the streak moving in an easterly direction, 23 reported seeing it moving in a westerly direction, 18, reported seeing it moving in a southerly direction, and 4 reported seeing it moving in a northerly direction. The group could not determine this information in the witness documents for the remaining 36.

Of the 258 streak of light witnesses, 44 reported that it left a rising trail of some kind. Of these, 37 characterized it as a "smoke trail," 2 described it as a contrail or vapor trail, 1 described it as a "fire trail," 1 characterized the trail as "wispy," and 3 did not specify.

Fireball witnesses

The group defined a fireball as one or more downward-moving ball(s) of fire in the sky. Although it may be characterized in the witness documents as stationary or descending, to meet the group's definition of a fireball, it must have been reported to have appeared in the sky after the termination of a streak of light, if a streak was reported. A fireball could not be an ascending object, or an object that meets the group's definition of a streak of light. For more information, see Appendix A, item 31.

Using this definition, 599 witnesses who reported observing a fireball were identified. Of these, 264 reported seeing the fireball originate (see Appendix A, item 33), 200 reported seeing the fireball split into two fireballs (see Appendix A, item 35), and 217 reported observing the fireball hit the surface of the water (see Appendix A, item 38).

There were 210 witnesses who reported seeing both the fireball and the streak of light.

---

[23] Two documents pertaining to two witness documents ambiguously describe the vertical motion of the streak of light. The document pertaining to Witness 90 (CC1-550, interview date not provided) and the document pertaining to Witness 506 (CC1-549, interview date not provided) state that the flare-like object reported by the witnesses traveled to "12 o'clock." These witnesses may also have reported seeing a streak of light travelling vertically or nearly so, but the clock point reference is an ambiguous characterization. Refer to the *Ambiguous clock-point and angle references* section, which begins on page 16, for more information.

Airplane/streak witnesses

Only a small number of witnesses reported knowing that they were watching an airplane at any time during the time that they made their observations.[24] Investigators wanted to determine if any witnesses reported observing what they identified as an airplane that could have been the accident airplane at the same time that they were observing a streak of light. The group defined an "airplane/streak witness" as one who reported seeing an airplane in the general vicinity of the streak at the same time that streak was visible (see Appendix A, item 30).[25]

The document readers identified 35 airplane/streak witness; however, upon review by Safety Board investigators, it was found that many of these witnesses did not actually meet the above definition of an airplane/streak witness. Eleven of these 35 witnesses were not streak of light witnesses. Two of the 35 witnesses did not observe a streak of light and an airplane *at the same time*. One of the 35 witnesses noted that *someone else* claimed to see an airplane. Five witnesses reported seeing a small airplane, rather than an airplane that could have been the accident airplane. Nine witnesses did not meet the airplane/streak witness definition because their witness documents contained no report that they actually saw an airplane.[26] After this quality check was completed, there were seven witnesses (of

[24] In fact, a number of witness documents specifically state that the witness did not see an airplane at the time that he or she made his or her observations. Examples of these include Witness 185 (CC1-342, interviewed July 22, 1996, 31.0 nautical miles slant range from flight 800), Witness 237 (CC1-61, interviewed July 22, 1996, 19.8 nautical miles slant range from flight 800), and Witness 303 (CC-435, interviewed July 31, 1996, 13.7 nautical miles slant range from flight 800).

[25] The intent of this item was to determine which of the streak of light witnesses might have observed an airplane that could have been TWA flight 800, a Boeing 747 operating above 13,000 feet MSL. A number of witnesses in or near Smith Point Park reported seeing a small general aviation aircraft operating at a low altitude near the beach at about the time of the accident (for an example, see Witness 29). Witnesses who reported seeing such a small general aviation airplane at the same time as they observed a streak of light were not included as airplane/streak witnesses because this small, low altitude aircraft was clearly not TWA flight 800.

[26] For example, a document pertaining to Witness 490 (CC1-130, interviewed July 20, 1996) states that the witness realized that he was watching an airplane explode, but the document does not say that the witness (11.6 nautical miles slant range from flight 800) observed both a streak of light and an airplane at the same time. Another example is the document pertaining to Witness 243 (CC1-28, interviewed July 18, 1996), which never establishes that the witness (12.0 nautical miles slant range from flight 800) saw airplane, but notes that he observed a "flying object" that flew for "four or five seconds before hitting the airplane."

the original 35) who reported seeing an airplane in the vicinity of and separate from a streak of light.[27]

Observations by situation

Safety Board investigators determined the situation (land, sea, or air) of 699 of the 736 witnesses (refer to the *Geographic information*, which begins on page 25 of the *Witness Group Chairman's Factual Report* for more information about witness situation). Of these 699 witnesses, 460 were on land, 202 were on water, and 37 were in aircraft. Most of the witnesses on land were outside, and most of the witnesses on the water were in boats. Table 1 provides more detail about the specific observations of the witnesses by situation.

Table 1: Number of witnesses by situation and observation.

	Witness situation					
Item	**Land**	**Sea**	**Air**	**Subtotal**	**Unknown**	**Total**
Sight	420	195	37	652	18	670
Sound	167	48	0	215	24	239
Streak	172	78	6	256	2	258
Fireball (FB)	365	182	37	584	15	599
FB Split	122	61	16	199	1	200
FB Water	122	69	21	212	5	217
Total	460	202	37	---	37	736

Note: See Appendix A for the definitions of the items appearing in this table. "Sight" is item 6 in Appendix A, "Sound" is item 5, "Streak" is item 11, "Fireball (FB)" is item 31, "FB Split" is item 35, and "FB Water" is item 38.

[27] These seven are Witness 73 (distance from flight 800 is unknown), Witness 88 (8.3 nautical miles slant range from flight 800), Witness 144 (11.5 nautical miles slant range from flight 800), Witness 145 (27.3 nautical miles slant range from flight 800), Witness 150 (15.7 nautical miles slant range from flight 800, Witness 157 (10.8 nautical miles slant range from flight 800), and Witness 640 (10.3 nautical miles slant range from flight 800). Documents CC1-412, CC1-603 (both interview date July 20, 1996), CC1-20 (interview date July 21, 1996), and CC1-607 (interview date April 29, 1997) pertain to Witness 73. Document CC1-553 (interview date July 27, 1996) pertains to Witness 88. Document CC1-644 (interview date July 14, 1997) pertains to Witness 144. Documents CC1-392 (interview date July 24, 1996), CC1-529 (interview date July 30, 1996), and CC1-643 (interview date June 20, 1997) pertain to Witness 145. Documents CC1-629 (interview date July 19, 1996), and CC-63 (interview date July 23, 1996), pertain to Witness 150. Document CC1-384 (interview date July 24, 1996) pertains to Witness 157. Documents CC1-195 (interview date July 24, 1996), and CC1-498 (interview date July 29, 1996) pertain to Witness 640.

Of the 460 witnesses who were on land, 172 reported seeing a streak of light, and 365 reported seeing a fireball (122 of whom reported seeing the fireball split into two fireballs during its descent). About one-third of the witnesses on land reported hearing something related to the accident. Table 2 provides more detail about the specific observations of the land witnesses.

Table 2: Land witnesses by specific situation and observation.

Item	Witness situation					Total
	Building	Vehicle	Motorcycle	Outside	Unknown	
Sight	49	56	1	292	22	420
Sound	44	5	1	106	11	167
Streak	18	18	1	126	9	172
Fireball (FB)	40	49	1	257	18	365
FB Split	8	12	0	97	5	122
FB Water	15	8	0	90	9	122
Total	66	59	1	308	26	460

Note: See Appendix A for the definitions of the items appearing in this table. "Sight" is item 6 in Appendix A, "Sound" is item 5, "Streak" is item 11, "Fireball (FB)" is item 31, "FB Split" is item 35, and "FB Water" is item 38.

Of the 202 witnesses who were on or in the water, 78 reported seeing a streak of light, and 182 reported seeing a fireball (61 of whom reported seeing the fireball split into two fireballs). About a quarter of the witnesses on or near the water reported hearing something related to the accident. Table 3 provides more detail about the specific observations of the sea witnesses.

Table 3: Sea witnesses by specific situation and observation.

Item	Witness situation		Total
	Boat	Swimmer or surfer	
Sight	185	10	195
Sound	42	6	48
Streak	74	4	78
Fireball (FB)	173	9	182
FB Split	57	4	61
FB Water	63	6	69
Total	192	10	202

Note: See Appendix A for the definitions of the items appearing in this table. "Sight" is item 6 in Appendix A, "Sound" is item 5, "Streak" is item 11, "Fireball (FB)" is item 31, "FB Split" is item 35, and "FB Water" is item 38.

Six of the 37 airborne witnesses reported seeing a streak of light, and all of the airborne witnesses reported seeing a fireball (16 of whom reported seeing the fireball split into two fireballs).

Seven witnesses were within 5 nautical miles ground distance of the last secondary radar return from the accident aircraft.[28] About 200 witnesses were located more than 5 nautical miles ground distance, but within 10 nautical miles ground distance of the last secondary radar return from the accident aircraft. Just over 200 witnesses were located more than 10 nautical miles ground distance, but within 15 nautical miles ground distance of the last secondary radar return from the accident aircraft. About 80 witnesses were located more than 15 nautical miles ground distance, but within 20 nautical miles ground distance of the last secondary radar return from the accident aircraft. Nearly 100 witnesses were located more than 20 nautical miles ground distance from the last secondary radar return from the accident aircraft.

Table 4: Witness ground distances by situation.

	Witness situation				
Item	**Land**	**Sea**	**Air**	**Unknown**	**Total**
5 miles	0	0	7	0	7
10 miles	139	57	7	1	204
15 miles	313	83	9	3	408
20 miles	365	106	17	4	492
25 miles	375	118	28	5	526
Total	417	135	33	6	591

Note: See the *Angle and distance calculations* section, which begins on page 33, for more information about how ground distance was calculated. The totals in this table do not match those in Table 4 because witnesses for whom insufficient geographic information was available and witnesses who were plotted representationally are not included in this table (refer to the *Geographic information* of the *Witness Group Chairman's Factual Report* for more information about mapping the witnesses).

Pilot witnesses

Most of the airborne witnesses were pilots and experienced observers of aircraft. Consequently, they are believed to be especially trained, qualified, and credible observers. These observers can be especially useful because their statements to air traffic controllers are often recorded, and because radar data can be used to determine their position and altitude at a given time. The air traffic control transcripts are in the public docket as Exhibit 3. For more information about the radar study of airborne witnesses, refer to the *Witness Group Recorded Radar Study*.

[28] See page 33 for an explanation of how ground distances were calculated. Ground distances reported in this paragraph do not include any witnesses for whom insufficient geographic information was available, or any witnesses who were plotted representationally (refer to the *Geographic information* of the *Witness Group Chairman's Factual Report* for more information about mapping the witnesses).

Several pilots who reported observing a fireball provided altitude estimates for the fireball. Each of these estimates is summarized below:[29]

- The captain of Eastwind flight 507 reported seeing an "explosion" and a "ball of fire" below his aircraft at what he estimated to be 13,000 to 15,000 MSL (see Appendix Z). Witness 138, Eastwind flight 507's first officer, reported seeing a "ball of fire" below his altitude (CC3-12, interviewed July 18, 1996). According to radar data, at about the time of the last secondary radar return from the accident airplane, Eastwind flight 507 was located about 24 nautical miles northeast of flight 800 at about 15,400 feet above mean sea level (MSL).

- Witness 329 also reported seeing an "explosion" and "ball of fire" below his altitude (CC3-321, interviewed August 5, 1996). Witness 329 was the captain of Alitalia flight 609. At about the time of the last secondary radar return from the accident airplane, Alitalia flight 609 was located about 21 nautical miles southwest of flight 800, at about 15,400 MSL (per radar data).

- Witness 657 and Witness 658 reported that they first saw "flaming debris" above them at an altitude of 4,000 to 5,000 feet (CC1-9, interviewed July 18, 1996). At about the time of the last secondary radar return from TWA flight 800, these witnesses were aboard a New York Air National Guard (NYANG) HH-60 helicopter located about 15 nautical miles north-northeast of flight 800 at about 600 feet MSL. Witness 692 was also aboard this helicopter, and reported seeing an "explosion" between 3,000 and 15,000 feet (LL-16a, interviewed July 19, 1996).

- Witness 684 was aboard , a NYANG C-130, and reported seeing a "fireball" descend from about 4,000 feet MSL (CC3-480, interviewed July 18, 1996). According to radar data, the C-130 was about 20 nautical miles northeast of flight 800 at about 2,000 feet MSL at about the time of the last secondary radar return from TWA flight 800.

- Witness 702 reported seeing an "explosion" and estimated that it occurred at about 7,500 MSL (CC3-416, interviewed July 18, 1996). This witness was aboard a general aviation airplane that was just north of the Francis S. Gabreski Airport (about 17 nautical miles north-northwest of flight 800) at about 8,000 feet MSL at about the time of the last secondary radar return from TWA flight 800.

---

[29] For each of the pilot witnesses mentioned in this section, radar data was used to give positions and altitudes for witness aircraft relative to he last secondary radar return received from flight 800. This is described in the *Geographic information* section of the *Witness Group Chairman's Factual Report* (see particularly footnotes 48 and 49).

- Witness 669 reported an "orange ball of light" and estimated that it was at 5,000-6,000 feet MSL (CC-283, interviewed July 26, 1996), and Witness 670 reported a "ball of flames" and estimated that it was at 5,000 to 5,500 feet MSL (CC3-372, interviewed July 24, 1996). These witnesses were aboard a general aviation airplane that was near Brookhaven Airport (about 18 nautical miles northwest of flight 800) at about 3,100 feet MSL.

- Witness 110, the captain of Great American Airways flight 507, reported seeing a "flash" between 3,000 to 5,000 feet (CC3-85, interviewed July 24, 1996). Witness 701, the first officer, reported seeing a "hot pink flash" below his aircraft (CC3-376, interviewed July 25, 1996). At about the time of the last secondary radar return from the accident airplane, Great American Airways flight 507 was located about 76 nautical miles southwest of flight 800, at about 22,800 feet MSL.

- Witness 441, the captain of Piedmont Airlines flight 3112, reported seeing a "bright orange ball of light" between 5,000 and 8,000 feet (CC3-245). Witness 475, the first officer, reported seeing a "yellow ball" between 4,000 and 6,000 feet (CC3-246). Piedmont Airlines flight 3112 was located at about 19 nautical miles southwest of flight 800, at about 10,600 feet MSL.

- Witness 705 reported seeing "multiple explosions" at about 1,000 feet (CC3-419, interviewed July 22, 1996). This witness was aboard a general aviation airplane that was located about 12 nautical miles northeast of flight 800 at about 1,200 feet MSL.

- Witness 718, the pilot of an East Hampton Airlines commuter flight, reported seeing a "big fireball" at about 4,000 feet (CC3-459, interviewed July 28, 1996). This flight was about 29 nautical miles northwest of flight 800, at about 2,000 feet MSL.

The captain of Eastwind flight 507 told the witness group that he had observed a "pretty bright landing light" and that he watched it "on and off for over two minutes, minimum, but I probably had seen him [the light] for over five minutes." (From page 19 of the interview transcript, which appears as Appendix Z to the *Witness Group Chairman's Factual Report*).

Eastwind flight 507 was the first airborne witness to report seeing the accident to the Sardi Sector controller at Boston center. At 0031:50 UTC (2031:50 local time), the captain of Eastwind flight 507 reported that "we just saw an explosion out here stinger bee five oh seven" to Boston Center, Sardi Sector (for the entire air traffic control transcript,

which does not use capital letters or punctuation, refer to *Air Traffic Control Transcripts I-L1*, which is Exhibit 3D in the public docket).[30,31]

About two minutes later, at 0033:48 UTC (2033:48 local), the captain of Eastwind flight 507 advised, "and center for stinger bee ah five oh seven we are directly over the site with that airplane or whatever it was just exploded and went into the water."

Finally, at 0037:20 UTC (2037:20 local), the captain of Eastwind flight 507 provided a description of what he had observed, "ah yes sir it just blew up in the air and then we saw two fireballs go down to the to the water and there was a big small ah smoke *(form) ah coming up from that also ah there seemed to be a light i i thought it was a landing light *(eye) and it was coming right at us at about i don't know about fifteen thousand feet or something like that and i pushed on my landing lights ah you know so i saw him and then it blew."[32]

The captain of Eastwind flight 507 was not the only airborne witness to report seeing what he described as landing lights. Document CC3-416 notes that Witness 702, who was operating a general aviation airplane reported that he "spotted a white light which suddenly exploded into a giant red orange ball."[33] However, at 0042:11, Witness 702 (or another person aboard the same aircraft) advised air traffic control, "we saw landing lights facing us and all of a sudden it turned into a bright orange flame" (this statement appears in Exhibit 3D to the public docket, *Air Traffic Control Transcripts 1-L1*, transcript L1, page 4).

Possible extended view

Members of the witness group were often asked which of the witnesses, if any, saw the entire accident sequence. Consequently, Safety Board investigators attempted to

---

[30] During his interview with the witness group, the captain of Eastwind flight 507 confirmed that he made the transmissions quoted in this section (rather than the first officer or another person on board flight 507).

[31] Eastwind flight 507 identified himself in this and other transmissions using the radio callsign "Stinger Bee 507."

[32] An asterisk is used in air traffic control transcripts to represent a questionable portion of a transmission; the words in parenthesis following this symbol are the best interpretation of this transmission.

[33] Document CC3-416 also pertains to Witness 703. Witness 702 and Witness 703 were together in the same general aviation aircraft, and the FBI interviewed them together. However, review of the document CC3-416 suggests that only Witness 702 reported making observations that met the definition of a witness. Consequently, Witness 703 was among the potential witnesses who were declared to be non-witnesses by the document readers. (See the *Information about the witnesses* section, which begins on page 20. The group's definition of a witness appears on page 20 of the *Witness Group Chairman's Factual Report*, and it was also repeated in the *Overview* on page 5 of this report.)

determine which witnesses might have observed more of the accident sequence relative to the others. It is assumed that those witnesses who saw the streak of light for the longest amount of time, probably saw most of the accident sequence. Therefore, two strategies were developed to determine which witnesses might have had an extended view of the streak of light.

Strategy 1: Witnesses who reported seeing the origin of the streak of light. There were 210 witnesses who reported observing something that met the definition of a streak of light who also reported observing a fireball. Of these, 24 reported observing the origin of the streak of light, but many of those reported seeing the streak for only a matter of seconds. Therefore it was decided to examine witness time estimates in greater detail. Thirteen of these 24 witnesses quantitatively estimated how long they observed the streak of light. Of the 13 witnesses who provided a quantitative time estimate, only 2 estimated that the streak was in view for more than ten seconds. It is possible that these two witnesses (Witness 359 who was located 9.5 nautical miles slant range from flight 800 and Witness 364 who was located 13.7 nautical miles slant range from flight 800) may have had an extended view of the streak.[34]

Strategy 2: Witnesses who reported seeing streak of light, but not its origin. The remaining 186 witnesses who reported observing both a streak of light and a fireball but did not report observing the origin of the streak were evaluated to identify witness who may have observed most of the event. Investigators determined which of these 186 witnesses (1) provided a quantitative time estimate of 10 seconds or more, and (2) described seeing the final portion of the fireball's descent (e.g., such as falling to the ocean or horizon). Witnesses who reported that someone else brought their attention to the streak of light were not included. Nine witnesses were found who met these criteria: Witnesses 32 (2.5 nautical miles ground distance to flight 800), 491 (10.4 nautical miles slant range from flight 800), 496 (10.1 nautical miles slant range from flight 800), 499 (8.4 nautical miles slant range from flight 800), 504 (10.3 nautical miles slant range from flight 800), 562 (22.3 nautical miles slant range from flight 800), 571 (9.6 nautical miles slant range

[34] Document CC3-106 (interview date July 23, 1996) pertains to Witness 359. Documents CC1-624 (interview date July 20, 1996), CC1-144 (interview date July 30, 1996), and CC1-256 (interview date October 14, 1996) pertain to Witness 364.

from flight 800), 579 (distance from flight 800 is unknown), and 648 (7.6 nautical miles slant range from flight 800).[35]

Using the two strategies, it was determined that 11 witnesses might have had an extended view of the accident sequence.

Angle and distance calculations

The *Witness Group Chairman's Factual Report* described how positions were determined for the witnesses (see page 25). For each of the witnesses for whom a position could be determined, six calculations were made: ground distance, slant range, elevation angle, initial azimuth, final azimuth, and sound time.[36] Each of these is explained in this section.

Ground distance. Ground distance is the linear distance (in feet) along the surface from the position of the witness to a point on the surface of the water directly underneath the last secondary radar return from flight 800, which was recorded at the FAA's radar site at Trevose, Pennsylvania. This position, which was recorded at 2031:12.00 EDT, was at 40.6490 degrees north latitude, 72.6708 degrees west longitude.[37]

Slant range. Slant range is the elevated distance (in feet) from the position of the witness to the position of the accident aircraft at altitude at the time of the last secondary radar return from flight 800, which was recorded at the FAA's radar site at Trevose, Pennsylvania. This value was calculated using the ground distance (see above) and the altitude of the aircraft (13,750 feet MSL, which was determined by a performance study (see *Aircraft Performance Study*, which is Exhibit 13A in the public docket).

---

[35] Documents CC-54 (interview date July 18, 1996) and CC-5 (interview date July 19, 1996) pertain to Witness 32. Document CC1-565 (interview date July 18, 1996) pertains to Witness 491. Documents CC4-109 (interview date July 19, 1996), CC-183 (interview date July 21, 1996), CC1-256 (interview date October 14, 1996), and CC1-620 (interview date June 19, 1997) pertains to Witness 496. Document CC3-496 (interview date July 22, 1996) pertains to Witness 499. Documents CC1-76 (interview date July 21, 1996) and CC1-483 (interview date July 29, 1996) pertain to Witness 504. Documents CC1-82 (interview date July 22, 1996) and CC1-657 (interview date June 26, 1997) pertain to Witness 562. Documents CC1-27 (interview date July 23, 1996) and CC1-215 (interview date July 29, 1996) pertain to Witness 571. Document CC-369 (interview date July 19, 1996) pertains to Witness 579. Documents CC1-133, CC3-28, CC3-331 (all interview date July 21, 1996), CC3-520 (interview date July 28, 1996), and document CC1-498 (interview date July 29, 1996) pertain to Witness 648.

[36] No attempt was made to calculate this information for the witnesses who were plotted representationally or for whom insufficient geographic data was available (refer to the *Geographic information* section of the *Witness Group Chairman's Factual Report* for more information). Further, no attempt was made to calculate slant range, sound time, or elevation for airborne witnesses.

[37] This position was calculated from information in radar data computer files that have been placed into the public docket. These files are described in the *Airplane Performance Study Addendum Number 1*, which is Exhibit 13C in the public docket.

Elevation angle. Elevation angle is the angle (in degrees) formed at the observer by (1) the line of sight from the witness to the accident aircraft at 13,750 feel MSL (see above) and (2) the surface of the earth. This calculation assumes that the surface of the earth along the ground distance (see above) is flat. This calculation also assumes that the eye level of the witness is at the ground. As the eye level of the witness rises, the angle of elevation decreases, so setting the eye level of the witness at mean sea level for computational purposes results in the greatest angle of elevation.[38]

Initial azimuth. Initial azimuth is the bearing (in degrees true) from the witness to the position of the accident aircraft at the time of the last secondary radar return from flight 800, which was recorded at the FAA's radar site at Trevose, Pennsylvania (see above).

Final azimuth. Final azimuth is the bearing (in degrees true) from the witness to a point in the northwest corner of the debris field known as the Green zone.[39]

Sound time. Sound time is the approximate amount of time that it would require for sound to travel to the witness from the position of the accident aircraft at altitude at the time of the last secondary radar return recorded at the FAA's radar site at Trevose, Pennsylvania (see above). This value was calculated for each witness using slant range as defined above, and a value of 1,074.47 feet per second as the speed of sound. The speed of sound was calculated as follows:

The speed of sound in air, v_s, is defined by the equation[40]

$$v_s = \sqrt{\frac{\gamma R T}{M}} \qquad [1]$$

where M is the mean molecular weight of air, 28.9644 x 10^{-3} kilograms;[41] R is the universal gas constant, 8.314 Joules/(mole*Kelvin);[42] T is temperature in degrees Kelvin; and γ is

---

[38] Given the distance between the witnesses and the accident site, increasing witness eye height by 100 feet would only affect the elevation angle of the accident airplane by 0.1 degree for a witness on the southern shore of Long Island. Note that no point in Long Island is more than 100 feet above sea level.

[39] The aft fuselage of the accident airplane was recovered from a major debris pile in the northwest corner of the Green zone. This pile was located near 40.6632 degrees north latitude, and 72.6237 degrees west longitude. For more information about the debris fields, refer to the *Data Management Report*, which is in the public docket. Additionally, in May 1998, the U.S. Navy published a report titled *U.S. Navy Salvage Report TWA Flight 800*. Documentation concerning the aircraft wreckage can be found in the *Structures Group Chairman's Factual Report* (Exhibit 7A in the public docket) and the *Airplane Interior Documentation Group Chairman's Factual Report* (Exhibit 6A in the public docket).

[40] National Oceanic and Atmospheric Administration (NOAA), et al. (1976). *U.S. Standard Atmosphere*. U.S. Government Printing Office: Washington, D.C.

[41] NOAA et al. (1976). p. 9.

the ratio of specific heats of air (the ratio of the specific heat of air at a constant pressure divided by the specific heat of air at a constant volume). For a diatomic ideal gas such as air, composed primarily of two diatomic molecules N_2 and O_2,[43] the dimensionless value of γ is 1.40.[44]

Using the previously stated values of γ, *R*, *M*, and the temperature in degrees Kelvin, equation 1 was used to calculate the speed of sound in meters per second. Results have been reported in non-metric units for convenience.

Equation 1 shows that the speed of sound varies with temperature. A weather balloon that recorded temperature and wind speed was launched from Upton, New York, at 2000 local time on July 17, 1996.[45] Upton is located approximately 15 nautical miles northwest of the accident site. The mean of the temperatures recorded by this balloon between 66 feet MSL and 14,003 feet MSL is 52.95° Fahrenheit (F).[46] Substituting this temperature into Equation 1, the speed of sound is 1,109.90 feet per second.

The wind also can affect the speed of sound. Vector addition was used to adjust the speed of sound for the maximum slowing effect of the wind recorded by the weather balloon. The greatest wind speed recorded by the balloon was at 6,000.66 feet MSL. The speed recorded at this altitude was 35.43 feet per second from 310 degrees true. Assuming

---

[42] Lide, D.R., and Frederikse, H.P.R., Eds. (1997). *CRC Handbook of Chemistry and Physics*, 78th ed. CRC Press: Boca Raton.

[43] NOAA et al. (1976). p. 3.

[44] NOAA et al. (1976). p. 18.

[45] For further information, refer to the *Meteorological Factual Report*, which appears as Exhibit 5A in the public docket.

[46] Two other methods for correcting the calculated speed of sound for ambient temperature were also explored: (1) the speed of sound was calculated for the temperature at 66 feet MSL, and at 14,003 feet MSL, and these values were averaged, and (2) the speed of sound was calculated for each altitude from 66 feet MSL to 14,003 feet MSL for which a temperature was available from the weather balloon and these values were averaged. These two methods and the method reported in the text were then used to calculate the time that it would take sound to reach a hypothetical witness 10 nautical miles away. The three methods yielded times that are within one second of each other. Consequently, the method reported in the text was chosen because it was the simplest.

that the wind was in direct opposition to the sound, the resultant speed of sound is 1,074.47 feet per second.[47]

Line of sight study

At the request of FBI agents, Deputy Inspector Douglas Matulewich of the Suffolk County Police Department's Marine Bureau conducted a line of sight study to try to determine the geographical area in which witnesses reported seeing a flare-like object. This project was undertaken at the request of FBI agents as part of the FBI's investigation of the possibility that a missile had been used against the airplane.

Some of the witness documents provided by the FBI and placed into the public docket as appendices to the *Witness Group Chairman's Factual Report* describe the work of Deputy Inspector Matulewich.[48] Between July 20, 1996, and July 30, 1996, he accompanied FBI agents on re-interviews of several witnesses who reported seeing a flare-like object on the evening of July 17, 1996. During these re-interviews, the witnesses were taken to the locations from which they made their observations. Deputy Inspector Matulewich recorded the position (latitude and longitude) of each witness and the horizontal direction (azimuth) from each witness to the area where he or she saw the flare-like object. A Garmin Model 45 Global Positioning System receiver was used to determine position (in degrees, minutes, and seconds), and a hand-held magnetic compass was used to determine azimuth (in magnetic degrees).

Later, Deputy Inspector Matulewich plotted data on nautical chart number 12353 published by the National Ocean Service from witnesses who could describe their positions

---

[47] Two other wind vectors were explored for correcting the calculated speed of sound: (1) the slowest wind speed, and (2) the average wind speed between 66 feet MSL and 14,003 feet MSL. These two wind vectors and the one reported in the text were used to calculate the time that it would take sound to reach a hypothetical witness 10 nautical miles away (assuming that the wind was in direct opposition to the sound). The calculated times were all within 1.5 seconds. Consequently, the method reported in the text was chosen because it was the one that resulted in the slowest travel of sound, and was thus a worst case scenario.

[48] The following documents describe the work of Deputy Inspector Matulewich: document CC1-70 pertaining to Witness 129, Witness 649, and Witness 650; document CC1-498 pertaining to Witness 129, Witness 363, Witness 640, Witness 641, Witness 642, Witness 643, Witness 644, Witness 645, Witness 646, Witness 647, and Witness 648; document CC1-256 pertaining to Witness 364, Witness 496, Witness 521, Witness 527, Witness 534, Witness 636, Witness 637, Witness 641, Witness 642, Witness 649, and Witness 694; document CC1-534 pertaining to Witness 93; document CC1-529 pertaining to Witness 145, document CC-183 pertaining to Witness 337 and Witness 496; document CC1-144 pertaining to Witness 364; document CC1-105 pertaining to Witness 372; document CC1-530 pertaining to Witness 521; document CC3-374 pertaining to Witness 527; document CC3-543 pertaining to Witness 636 and Witness 637; document CC1-195 pertaining to Witness 640, document CC1-80 pertaining to Witness 641; document CC1-87 pertaining to Witness 642; document CC1-106 pertaining to Witness 645; document CC1-71 pertaining to Witness 646 and Witness 647; document CC1-133 pertaining to Witness 648; document CC1-89 pertaining to Witness 650; and document CC3-373 pertaining to Witness 694.

and their observations of the flare-like object relative to fixed reference points (such as a flagpole or a building).[49] The positions of these witnesses were plotted, and lines depicting the azimuth from the witness's position to the area that the witness reported seeing the flare-like object (a "line of sight") were drawn. Witnesses who did not have fixed points of reference were not used.

Deputy Inspector Matulewich determined the latitude and longitude of two points at which these sight lines appeared to intersect. In a report to Agent Peter Casazza, Agent William Lynch, and Agent Paul Shea dated September 18, 1996, Deputy Inspector Matulewich suggested to the FBI that a 1 nautical mile area around these points should be searched by the FBI for evidence of a missile.[50,51,52]

Safety Board investigators plotted the data collected by Deputy Inspector Matulewich using ArcView GIS (Version 3.1).[53,54] This plot appears as Appendix B to this report. Table 5 below lists the witness numbers for the witnesses who are depicted in the map and provides the slant range distance to the accident airplane's last secondary radar return for each (see page 33 for a definition of slant range and a description of how it was calculated). Inspection of the sight lines map in Appendix B reveals that eight of the eleven sight lines intersect the debris field known as the Green zone.[55,56]

---

[49] The National Ocean Service is part of the National Oceanic and Atmospheric Administration.

[50] This report is included in document CC1-256 pertaining to Witness 364, Witness 496, Witness 521, Witness 527, Witness 534, Witness 636, Witness 637, Witness 641, Witness 642, Witness 649, and Witness 694. However, the map on which the data was plotted was not received from the FBI.

[51] These two locations were well within the undersea area covered by the nine month search and salvage operation that concluded in April 1997. For more information about the sea operation, refer to the references cited in footnote 39.

[52] One statute mile equals 5,280 feet; one nautical mile equals 6,076.1 feet.

[53] ArcView GIS is a geographical information system (GIS). A GIS is a software package that permits computer-assisted mapmaking and provides a variety of tools for studying these electronically-generated maps.

[54] To make this map, positions reported in degrees, minutes, and seconds were converted to decimal degrees. Also, azimuths reported in magnetic degrees were converted to true degrees using GEOMAGIX, a free software conversion package published by Interpex Limited of Golden, Colorado. Conversions made by GEOMAGIX are based on the 1995 World Magnetic Model produced by the United States Geological Survey (USGS) and British Geological Survey (The GEOMAGIX software package is available for download from the USGS's web site at *http://geomag.usgs.gov/Freeware/geomagix.htm*).

[55] See footnote 39.

[56] Note that three pairs of the eleven sight lines directly overlie each other; consequently, the map only appears to depict eight sight lines.

Table 5: Witnesses included in the line of sight study by slant range to flight 800's last secondary radar return from the accident airplane.

Witness number	Slant range (nautical miles)
364	13.71
496	10.10
521	15.47
527	14.73
534	10.21
636	27.03
637	27.03
641	8.65
642	8.65
649	10.54
694	14.60

Safety Board investigators studied the error sensitivity of the methodology used by Deputy Inspector Matulewich to determine the approximate geographical position of the flare-like object reported by the witnesses. Deputy Inspector Matulewich determined the azimuths used to draw the sight lines by sighting a magnetic compass on the fixed references identified by each of the witnesses. A slight error in this azimuth would affect the position of the flare-like object. Small errors could be introduced by magnetic interference with the compass, or parallax due to the user's viewing position, or from other sources such as a less-than-perfect conveyance of the relationship between the streak of light and the fixed reference by the witness.

Safety Board investigators studied how slight azimuth errors would affect the position of the flare-like object reported by the witnesses. The position of a Witness 641 located in Smith Point Park (8.4 nautical miles ground distance from flight 800) and the position of a Witness 527 in Shinnecock Inlet (14.6 nautical miles ground distance from flight 800) were used for the calculations. The reported azimuths for these two witnesses were mathematically varied to determine how this would affect the position of the resulting lines of sight. A one degree azimuth error displaced the sight line for the witness in Smith Point Park by 886 feet laterally (measured at the distance of the last secondary radar return from the accident airplane, perpendicular to the sight line). A one-degree azimuth error displaced the sight line for the witness near Shinnecock Inlet by 1,544 feet. A five-degree azimuth error displaced the sight line for the witness in Smith Point Park by 4,440 feet. A five-degree azimuth error displaced the sight line for the witness near Shinnecock Inlet by 7,738 feet. One of these cases is depicted in Figure 3 for clarity.

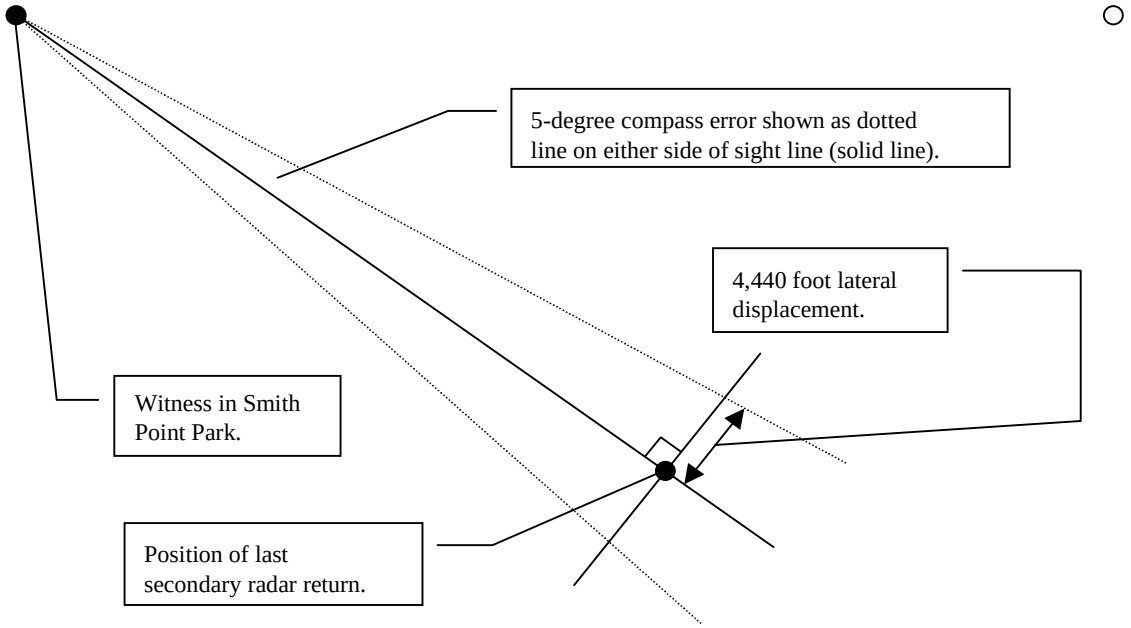

Figure 3: Lateral displacement resulting from a five-degree compass error for a witness in Smith Point Park (about 8.4 nautical miles ground distance from flight 800).

Sound propagation study

At the request of the witness group, Safety Board investigators asked acoustics experts affiliated with the National Aeronautics and Space Administration's (NASA) Langley Research Center, Structural Acoustics Branch, to conduct a study to determine if an explosion in the center wing tank of TWA flight 800 could have been audible to the ground witnesses who reported hearing sounds such as booms, or a thunder-like rumble. The NASA scientists conducted a computational study of the propagation of the sound associated with an explosion in the center fuel tank of flight 800. They are preparing a report documenting their study and conclusions. That report appears as Appendix C to this report.

Safety Board staff reviewed the list of 89 witnesses who reported hearing a sound at or about the same time that they made a specific visual observation (see *Sight/sound witnesses* section, which begins on page 22 of this report). After removing any witnesses for whom insufficient geographic information was available, and any witnesses who were plotted representationally, 83 witnesses remained on the list.[57] Safety Board staff provided

[57] This list of 83 witnesses was generated from preliminary data. Additional quality checks were completed after providing this list to the NASA scientists. If this list were generated from the final witness data, it would contain 73 witnesses.

this list of 83 witnesses to NASA scientists along with their positions at the time of the accident (for more information on how positions were determined see the *Geographic information* section, which begins on page 25 of the *Witness Group Chairman's Factual Report*).

The NASA researchers conducted their acoustic prediction in three steps: source analysis, propagation analysis, and receiver analysis. Source analysis predicts the blast wave generated near the source of the sound. For this study, the blast wave generated by the explosion in the center fuel tank of flight 800 was predicted using the theory of H.L. Brode.[58] This theory provides an estimate of the blast wave from the explosion based on ambient atmospheric pressure and the amount of energy in the explosion. The authors estimated the amount of available energy in the fuel vapor in the center fuel tank of flight 800 based on the physical properties and flammability of Jet A fuel in air, which were reported in a study conducted at the request of the Safety Board.[59] They estimated that the energy equivalent of the fuel tank explosion was approximately 20 pounds of TNT. This value and the atmospheric pressure on the evening of the accident were used to predict the amplitude and shape of the blast wave.[60]

The theory of H.L. Brode assumes that the blast wave is generated into a spherically symmetric field within a uniform atmosphere. Although these are not completely valid assumptions, the researchers determined that atmospheric pressure gradient and the wind gradient in the disturbance field are small enough that little error is introduced by neglecting them. The blast wave predicted by this theory was used as the input for the propagation analysis.

Propagation analysis mathematically simulates the travel of a sound signal from its source to the receiver. The authors used the Thomas code to simulate the propagation of the predicted blast wave from flight 800 to the witnesses.[61] The Thomas code is a standard simulation tool used by scientists who study acoustics. Temperature and wind velocity parameters are incorporated into this code because temperature and wind gradients affect the amplitude and the direction of travel of sound.[62]

---

[58] Brode, H.L. (1955). Numerical Solutions of Spherical Blast Waves. *Journal of Applied Physics* **26**(6).

[59] This work was conducted by J.E. Shepherd, J.C. Krok, and J.J. Lee of Caltech. See *Jet A Explosion Experiment: Laboratory Testing*, which appears as Exhibit 20D in the public docket.

[60] For information about the meteorological conditions on the evening of the accident, refer to the *Meteorological Factual Report*, which appears as Exhibit 5A in the public docket.

[61] Thomas, C.L. (1972). Extrapolation of Sonic Boom Pressure Signatures by the Wave Form Parameter Method. NASA TN D-6832.

[62] See footnote 60.

If the temperature is greater at the surface than it is at altitude, then the sound speed is greater at the surface. When the sound speed is greater at the surface, estimated sound energy is bent upward and away from the receiver. This was the case on the evening of the accident. The researchers modeled the propagation of sound energy from flight 800 though the temperature-stratified atmosphere to the surface. This produced a shadow boundary inside of which a sound energy path could be directly traced from the accident airplane to the witnesses. Outside of this boundary, sound energy could not be directly traced from the source to the witnesses. The calculated shadow boundary is a 20-mile-radius circle centered directly under flight 800 on the evening of the accident. All but two of the 83 witnesses included in this study were located inside the shadow boundary.

The wind also affects the propagation of sound energy. Generally, wind speed increases with increasing height above the ground. When this is true, sound energy traveling in the direction of the wind will be directed toward the surface, and sound energy traveling against the wind will be directed away from the surface. The researchers adjusted the shadow boundary by incorporating the winds recorded on the evening of the accident into the propagation model. Seventeen of the 83 witnesses were located outside of this adjusted shadow boundary, and an additional 6 witnesses were so close to the adjusted shadow boundary or so far from the source that it was difficult to directly trace a sound energy path from the accident airplane to them. Consequently, predictions were made for 60 witnesses.[63]

Receiver analysis determines if a sound would be sufficiently loud to be heard by a person inside the shadow boundary. To determine if the witnesses inside the shadow boundary could have heard the estimated sound signal generated by the center wing tank explosion, the sound pressure levels (in decibels) were calculated as a function of frequency (in Hertz) for three of the predicted blast waves: (1) the highest amplitude, (2) the lowest amplitude, and (3) the median amplitude. These sound pressure levels were compared (1) to the threshold of human hearing (the minimum sound pressure level necessary to be audible), and (2) to the sound pressure levels generated by ambient residential background noise.

Of the 60 witnesses for whom a prediction was made, the witness at the location where the lowest-amplitude spectrum was predicted is the least likely to have heard the explosion. Even for this observer, the sound would be well above the threshold of otologically normal human hearing. Consequently, the NASA scientists concluded that

---

[63] Although sound energy could not be directly traced to some of the witnesses using these techniques, it does not mean that these witnesses could not hear the sound generated by the explosion. The shape and position of the shadow boundary is sensitive to temperature and wind fluctuations. Weather balloon data reported in the *Meteorological Factual Report* were used to define the shadow boundary, but these data represent only one column of the atmosphere sampled about 15 nautical miles northwest of the accident site. More atmospheric sampling between the sound source and the witnesses would have resulted in a different shadow boundary. Further, sound energy can be propagated into the shadow boundary, the NASA researchers did not attempt to simulate this.

there is a high probability that the predicted blast wave would have been audible to this witness. They also conclude that the blast wave most likely would be audible to all of the witnesses who were inside of the shadow boundary. Therefore, the predicted sound level generated by a fuel tank explosion aboard TWA flight 800 could have been heard by the witnesses inside of the shadow boundary.

As a validation of their simulation methods, the researchers compared one of the blast-wave predictions with an estimate derived from empirical data. Data from an actual detonation of 5 pounds of TNT were available for an observer 10 miles away. Both the TNT and the observer were located at ground level. This measured sound spectrum was compared to the theoretically predicted spectrum for the airborne flight 800 fuel tank explosion for a witness at about the same distance. To make this comparison, the authors adjusted the measured sound spectrum to more closely match the accident conditions: The measured spectrum was adjusted to reflect the estimated fuel tank explosion equivalent of 20 pounds of TNT, and it was also adjusted to account for the altitude of the accident explosion. Although the theoretically predicted spectrum was adjusted for temperature and wind, no such adjustment was made to the measured spectrum. Nonetheless, because the two spectra are quite similar, the NASA scientists concluded that the predicted sound spectrum is a reasonable simulation of the flight 800 fuel tank explosion.

As a further check of their work, the authors also used the method of ANSI Standard S2.2-1983, "Estimating Airblast Characteristics for Single Point Explosions in Air, With a Guide to Evaluation of Atmospheric Propagation and Effects," to estimate the peak amplitude and shape of a blast wave propagated to the observers. The ANSI standard provides estimated upper and lower bound parameters for the peak amplitude of the blast wave. Almost all of the sound signals predicted by the Thomas Code are within the upper and lower bounds predicted by the ANSI standard. Therefore, the authors noted that the two methods produce very similar predictions, and either method would have led them to the same conclusions about the audibility of the sound signal. The authors noted that the ANSI standard method can be used to estimate signals for all the observers, including those for whom no prediction was possible using the Thomas code (because the observers were in the shadow). The sound signal predicted by the ANSI standard method for an observer about 35 miles (laterally) from the sound source is quite similar to the lowest-amplitude signal predicted using the Thomas code. Because they determined that the lowest amplitude signal predicted by the Thomas code would have been audible, the authors concluded that the sound signals predicted by the ANSI standard would also be audible to all of the 83 witnesses, regardless of their position relative to the shadow boundary.

Conclusions of the witness group

Nearing the end of the group's work, members met and developed the following conclusions concerning the witnesses and the witness documents. Each of the members of the group is in agreement with the following statements:

- The witness documents provided by the FBI documenting the results of its interviews represent the most complete record of eyewitness accounts gathered as quickly as possible after the accident.

- It would have been very difficult for the witnesses to avoid exposure to the intense media coverage that immediately followed the accident. The group believes that it is likely that some number of the accounts were influenced, at least in part, by this coverage.

- Given their distance from the event, the level of detail reported by some witnesses does not appear to be consistent with what would be visible to them. For example, the documents pertaining to Witness 150 describe the development of "'fissures'" on the accident airplane (CC-63, interviewed July 23, 1996), and the document pertaining to Witness 73 state, "The 'red streak' went passed [*sic*] the right side and above the [accident] aircraft before arcking [*sic*] back toward the aircraft's right wing" (CC1-603, interviewed July 20, 1996). Witness 150 was 15.7 nautical miles slant range from the position of the last secondary radar return, and Witness 73 was just over 8 nautical miles slant range.

- The documents are not first-hand accounts. Witness accounts were summarized in notes, and clerks prepared typed witness documents from these notes. FBI Agents reviewed the typed documents for accuracy, but the witnesses themselves did not have an opportunity to review these documents.

- The FBI witness documents reviewed by the witness group are poorly suited for purposes of an aircraft accident investigation. The FBI interviewed witnesses as part of its criminal investigation, and thus focused only on information that appeared relevant to that investigation. This did not result in witness documents that provided an overall picture of the factual sequence of events that the witnesses saw and heard.

- Although the witness group has focused its efforts on documenting the witnesses' descriptions of motion in time and space, this was not the primary goal of most of the interviews. Many of the interviews were conducted with the intent of establishing whether the witness observed a missile launch or not.

- Most FBI agents were not familiar with aircraft terminology, aircraft accident investigation, and flying in general; consequently, they usually did not document the kinds of information critical to an accident investigation. For example, the callsigns and transponder codes of aircraft were not generally recorded when interviewing witnesses who were piloting these aircraft at the time of the accident.

- The group believes that it is not appropriate to unduly focus on individual witness accounts, because at least a handful of witness accounts could be cited as support for a variety of theories about the accident.

- The group strongly believes that the witness accounts must be studied together as a whole, and that they must be considered along with the physical evidence and all of the other information available to investigators.

- It is the opinion of each of the group members, that no study of the eyewitness accounts alone can prove or refute the contention that the crash of TWA flight 800 was due to any particular cause.

- The group believes that any explanation of the accident sequence must generally fit the entire body of evidence, although it is unreasonable to expect every piece of evidence will fit perfectly. Because no single piece of evidence can fully explain an accident, the witness group encourages readers to consider all of the data in the witness documents, and to refrain from drawing conclusions based solely on any individual witness.

- Because of the nature of the witness documents, readers may arrive at different conclusions about any given witness (for example, a reader may disagree that a particular witness should have been categorized as a streak of light witness). Ambiguity and other problems make it difficult to interpret a number of the documents. Consequently, the group believes that there is little value debating the categorizations reached in this report about any individual witness or small groups of witnesses.

- The group determined that 258 witnesses observed a streak of light. This streak of light was frequently described as a flare or firework. The witness accounts vary in their characterization of the direction of travel and flight path of the streak of light.

- Of the 258 witnesses who reported seeing a streak of light, 210 also reported seeing ball of fire.

- The streak of light reported by many may have been the accident airplane during some stage of its flight before the fireball developed. Most of the streak of light accounts are generally consistent with the calculated flight path of the accident airplane, however, 38 witnesses described a streak of light rising straight up or nearly so. These 38 witness accounts seem to be inconsistent with the calculated flight path of the accident airplane.

- The group determined that 599 witnesses reported seeing a fireball. The group further determined that 200 witnesses reported seeing this fireball split into two fireballs. The group agrees that the descending fireball was the accident airplane. In all likelihood, the witnesses who watched this fireball split were observing the final stages of the structural breakup of the aircraft.

- At the time of their observations, almost none of the witnesses realized that they were witnessing an airplane crash. Most of the witnesses reported seeing streaks of

light and fireballs, or provided similar characterizations. Only a few reported being able to distinguish the accident aircraft as an airplane.

David L. Mayer
Witness group chairman