National Transportation Safety Board

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

October 1, 2000

MISSILE VISIBILITY STUDY

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. Group

N/A

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

Table of contents 2

List of appendices 3

Overview 4

Purpose and method 5

Launch conditions 5

Sun position 5

Meteorological conditions 6

Observers and observer locations 7

Launch parameters 8

Results 9

List of appendices

Test plan, MANPADS visibility test, April 2000 ..... Appendix A

Observer worksheet ..... Appendix B

Test results data ..... Appendix C

Overview

The National Transportation Safety Board (NTSB) conducted a test at Eglin Air Force Base (AFB), Ft. Walton Beach, Florida, on April 28, 2000, to study the visibility of a shoulder-launched missile. Visibility, for purposes of this test, refers to the ability to see and describe the missile launch and flight signatures from various distances.

Test planners (which included technical advisors from the Defense Intelligence Agency's Missile and Space Intelligence Center [MSIC] and the Short Range Air Defense [SHORAD] Project Office) believed that the visibility characteristics of the Basic Stinger missile are typical of modern man portable air defense systems (MANPADS). The test advisors informed Safety Board investigators that the missile engine would burn for 7 to 8 seconds before burning out, and then the missile would coast until it self-destructed.

At least two observers were positioned at stations every two nautical miles from the launch point out to 12 miles.[1] One Safety Board investigator and one video camera operator were also positioned at each station. No magnified optics (such as binoculars) were used by the observers at any location.

SHORAD personnel fired four Basic Stinger missiles via a remote launcher during this test.[2] The observers were told generally where to look, and they heard nine launch countdowns via hand-held radios. At the end of the first countdown, an orientation flare was fired. Each subsequent countdown terminated with either a missile launch or a control event (a countdown without an actual launch). About 3 to 4 minutes elapsed between each countdown. Safety Board investigators interviewed each observer between each countdown using a standard worksheet (see Appendix B).

The three missile launches were easily detected by all of the observers. According to the observers, the launched missiles appeared as a bright light or flame rising from the surface. The observers also indicated that the light was only visible during the engine burn phase, and then they observed nothing until the missile self-destructed.[3] Observers who reported seeing the missile self-destruct described it as an

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[1] In this report, the 2 nautical mile position is referred to as "Station 2," the 4 nautical mile position is referred to as "Station 4," etc.

[2] One of the four missiles did not operate properly and did not reach altitude; thus, there were three successful missile launches.

[3] About half of the observers reported seeing the missile self-destruct (refer to the *Results* section, which begins on page 9 for further information).

abrupt flash of light; some of the closest observers reported hearing a muffled boom about 20 to 30 seconds after they observed the flash of light. Observers at all stations reported that they were unable to see the body of the missile.[4]

Purpose and method

The purpose of this test was to determine the maximum distance at which a human observer is able to see a MANPADS in flight by firing up to four MANPADS under conditions similar to those on the evening of the TWA flight 800 accident, and to determine if any aspect of the MANPADS launches was visible to nearby radar facilities.[5] The test was conducted in accordance with the procedures developed by test planners, and the test plan appears as Appendix A.

Launch conditions

Test planners determined that the test should be conducted under similar or better visibility conditions that prevailed on Long Island, New York, the evening of July 17, 1996, at the time of the TWA flight 800 accident. Sun position and meteorological conditions on the evening of the accident were reviewed, and several test criteria were established.

Sun position

Test planners determined that the brightness of the sky on the test day should be similar to the brightness of the sky on the accident evening. The brightness of a clear sky is dependent on the position of the sun (azimuth and altitude).[6,7] On July 17, 1996, at

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[4] For the second launch, one observer at Station 10 replied "maybe" when asked if he saw the missile body. He answered negatively for the other two launches, including the first launch, which was conducted under lighting conditions that were most comparable to those that existed at the time of the TWA flight 800 accident.

[5] For further information, see *Radar Data for Missile Visibility Tests*, which is in the public docket.

[6] Commission Internationale de l'Eclairage (CIE) standard *Spatial Distribution of Daylight - CIE Standard Overcast Sky and Clear Sky* (CIE S 003/E-1996).

[7] The altitude of the sun is the angle of the sun above or below the horizon, and the azimuth of the sun is the angle of the sun along the horizon in degrees true East of North.

2030 EDT, near the accident site, the azimuth of the sun was 300.9 degrees true, and the altitude of the sun was 2.7 degrees below the horizon.[8,9,10]

The most similar position of the sun on April 28, 2000, near Fort Walton Beach, Florida, occurred at 1932 Central Daylight Time (CDT).[11] At that time, the altitude of the sun was 2.7 degrees below the horizon, and the azimuth of the sun was 288.6 degrees true.

Meteorological conditions

Test planners also determined that the meteorological conditions on the test day should be similar to or better than the meteorological conditions on the accident evening. July 17, 1996, surface weather observations recorded at John F. Kennedy Airport, New York (KJFK); Farmingdale, New York (KFRG); Islip, New York (KISP); and Westhampton Beach, New York (KFOK), are given below:[12]

- KJFK is located about 52 nautical miles west of the accident site. At 1951 EDT, the visibility was 10 miles, and the surface winds were from 220 degrees at 8 knots. A scattered cloud layer was present at 6,000 feet, a broken cloud layer ceiling was present at 7,000 feet, and a broken cloud layer was present at 9,000 feet.

- KFRG is located about 35 nautical miles west of the accident site. At 1945 EDT, the visibility was 7 miles, the surface winds were from 240 degrees at 5 knots, and a scattered cloud layer was present at 5,000 feet.

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[8] Sun positions were determined by reference to the US Naval Observatory's (USNO) *Sun or Moon Altitude/Azimuth Table for One Day* calculator located at the USNO's web site at http://aa.usno.navy.mil/AA/data/docs/AltAz.html.

[9] Because the USNO calculator determines the position of the sun relative to a surface position with a precision of degrees and minutes, the position 40 degrees 39 minutes north latitude, and 72 degrees 40 minutes west longitude was used as the location of the accident site. (The accident site is at about 40 degrees 38 minutes 56 seconds north latitude, 72 degrees 40 minutes 15 seconds west longitude.)

[10] The position of the center of the apparent disk of the sun is used to determine the position of the sun.

[11] The position 30 degrees 27 minutes north latitude and 86 degrees 36 minutes west longitude was used as the location of Fort Walton Beach, Florida, to determine the position of the sun.

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

- KISP is located about 23 nautical miles west-northwest of the accident site. At 1950 EDT, the visibility was 8 miles, the surface winds were from 220 degrees at 4 knots, and the skies were clear.

- KFOK is located about 12 nautical miles north of the accident site. At 1945 EDT, the visibility was 4 miles, and the winds were from 240 degrees at 4 knots. A scattered cloud layer was present at 6,000 feet, and haze was observed.

A weather balloon that recorded wind speed and direction was launched from Upton, New York, at 2000 EDT July 17, 1996. Upton is located about 15 nautical miles northwest from the accident site. The maximum wind speed recorded by the balloon was 21 knots from 303 degrees true at about 15,000 feet above mean sea level (MSL).

A U.S. Air Force certified weather observer at the Eglin AFB test site (about 6 nautical miles from the launch site) recorded surface weather observations for this test. On April 28, 2000, at 1930 CDT, at the Eglin AFB test site, a few clouds were observed at 8,000 feet, and the visibility was 7 miles.[13,14]

Observers and observer locations

Test personnel at Eglin AFB recruited fourteen test observers some of whom were friends and family of base personnel. The observers were ten males ranging in ages between 15 and 54 years old and four females ranging in ages between 41 and 54. Observers were required to have an uncorrected or corrected visual acuity of 20/25 or better and no known history of ocular pathology. Therefore, each observer was given a Snellen visual acuity test and completed an eye health worksheet. The visual acuity of the observers ranged between 20/13 and 20/25, and no significant eye health problems were reported on the eye health worksheet.

On the afternoon before the test, a Safety Board investigator gave a briefing to the test participants and to Safety Board interviewers. The observers were told that the purpose of the test was to determine how far a missile could be seen when fired during the specified conditions. They were told that there would be nine events that would include up to four missile firings, and that they would be interviewed after each event. After the observers were briefed, the Safety Board interviewers were separately given further instructions. They were told to follow the interview worksheets as much as

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[13] For further information about the test weather conditions, *see Meteorological Factual Report, Missile Visibility Test on April 28, 2000*, which is in the public docket.

[14] The test was originally planned for April 27, 2000. The cloud layers in the sky were greater than specified in the test plan (see Appendix A); therefore, the test was postponed.

possible and to tape record the interviews. Also, they were asked to individually interview each observers (instead of interviewing the observers as a group).

During the briefing, the test participants were randomly assigned to the observer stations.[15] There were six groups of observers who were located on Santa Rosa Island, Florida, at locations about 2, 4, 6, 8, 10, or 12 nautical miles West of the launch position.[16,17,18] Each group consisted of at least two observers and one Safety Board investigator.[19] A video camera was located at each observer location to record the test.

The observers were told generally where to look, and they heard the launch countdown via hand-held radio. After each event, Safety Board staff interviewed the observers and completed simple worksheets. A sample observer worksheet appears as Appendix B. The interviews were tape recorded.

Launch parameters

The test was conducted on April 28, 2000, and consisted of nine events: one flare launch, four missile firings, and four control events (a launch countdown without an actual launch). The flare launch was the first event of the test.[20] The first missile was launched at 1931 CDT,[21] and the second missile was launched 1935 CDT.[22] These

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[15] However, for reasons of convenience, family members were generally assigned to the same station.

[16] The observer locations were determined by a global positioning system (GPS) receiver using the precise positioning service (PPS).

[17] Because a sand dune would have obstructed the view of the observers, Station 2 station was actually located 1.8 nautical miles from the launch point.

[18] Because only a few of the witnesses who reported seeing the TWA flight 800 accident sequence would have been looking directly into the sun, the test observers were located West of the launch position so that they also would not be looking directly into the sun.

[19] Two observers were located at Station 2, two observers were located at Station 4, two observers were located at Station 6, three observers were located at Station 8, two observers were located at Station 10, and four observers were located at Station 12. However, one observer at Station 12 did not complete an eye exam and questionnaire, and was not included in the results of the study.

[20]The flare was an Orion Star-Tracer Aerial Flare manufactured by Standard Fusee Corporation. The product's package states that the flare reaches an average altitude of 450 feet.

[21] The altitude of the sun was 2.5 degrees below the horizon, and the azimuth of the sun was 288.5 degrees true.

[22] The altitude of the sun was 3.3 degrees below the horizon, and the azimuth of the sun was 289.0 degree true.

launches were followed by two control events. The third missile launch was at 1950 CDT.[23] This launch was followed by two more control events.[24] Each event was preceded by a three minute warning, a one minute warning, and a fifteen second countdown. About 3 to 4 minutes were allowed between each event.

The missiles were fired by SHORAD personnel via a remote launcher (an Avenger platform) from a launch position 30.3977 degrees north latitude, and 86.6510 degrees west longitude on Santa Rosa Island, Florida.[25] The direction of the missile launches was south, and the launch elevation was seventy degrees above the surface. The flare was launched at a ninety degree angle. A video camera was located at the launch position to record the test.

Results

The flare launch was visible to all of the observers at Station 2, Station 6, and Station 8 and one of the two observers at Station 10. The flare was generally described as a red dot, flare, or ball in the air. None of the observers at Station 4 and Station 12 reported seeing the flare launch. For the specific results from each launch, see Appendix C.[26]

The three missile launches were easily detected by all observers.[27] Generally, the observers reported seeing a rising light (the engine burning). During the first missile launch, 9 of the 14 observers reported seeing a "light," 1 reported seeing a "fireball," 1 reported seeing a "fire trail," 1 reported seeing a "glow," 1 reported seeing a "star," 1 one reported seeing a "ball."[28]

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[23] The altitude of the sun was 6.4 degrees below the horizon, and the azimuth of the sun was 291.0 degrees true.

[24] Four missile launches were planned; however, the last missile that was fired did not reach altitude and could not have been visible to any of the observers.

[25] The launch position was determined by a GPS receiver using the PPS.

[26] Because the forth missile fired (event 8) did not reach altitude and was not visible to the observers, this event is treated as a control event in the results.

[27] According to the test plan (see Appendix A), if a missile launch was visible to the Safety Board investigator at Station 12, the observer group would be repositioned to a farther distance. After the first two missile launches were visible to the investigator at this location, the group was repositioned to a position about 14 nautical miles from the launch point for the third missile launch.

[28] Although most of the observers did not report seeing anything in the sky after the control events, a few of the observers reported seeing something during these events. Three observers reported seeing light

During the second missile launch, 7 of the 14 observers reported seeing a "light," 1 reported seeing "flame," 1 reported seeing a "match," 1 reported seeing a "glow," 2 reported seeing a "dot,' 1 reported seeing a "pulsing," and 1 reported seeing a "ball."

During the third missile launch, 11 of the 14 observers reported seeing a "light," 1 reported seeing a "starlight," 1 reported seeing a "glow," and 1 reported seeing a "ball."

Some of the observers also reported seeing an abrupt flash of light (the missile self-destructing) after the rising light had disappeared. Five of the fourteen observers reported seeing the missile self-destruct during the first missile launch,[29] eight reported seeing the missile self-destruct during the second missile launch,[30] and ten reported seeing the missile self-destruct during the third missile launch.[31]

Thirteen of the fourteen observers reported that light or flame was visible during the first missile launch.[32] Nine of these thirteen observers reported the color of the light or flame. Four of these nine observers reported that the light was white, one reported that the light was yellow, one reported that the light was orange, one reported that the light was yellow-red, one reported that the light was yellow-white, and one reported that the light was white-golden.

Thirteen of the fourteen observers reported that light or flame was visible during the second missile launch. Ten of the fourteen observers reported the color of the light or flame. Five of these ten observers reported that the light was white, two reported that the light was yellow, one reported that the light was orange, one reported that the light was golden, and one reported that the light was yellow-red.

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during the first control event: one of these 3 observers (at Station 2) reported seeing the strobe of an aircraft; one observer (at Station 8) reported seeing something similar to a firework just before the interview; and, one observer (at Station 10) reported seeing thin orange light. One observer (at Station 2) reported seeing a white strobe during the second control event. One observer (at Station 2) reported seeing a light that was not near the launch site during the third control event. One observer (at Station 2) reported seeing a low glimpse of white light during the fourth control event. Although the military warning area near the test area was active, a few aircraft displaying navigational and landing lights transited the area during the test. It is likely that most of these "false alarms" reports were due to these aircraft.

[29] These five observers were located at Station 2, Station 4, and Station 6. During the first missile launch, none of the observers positioned more than 6 nautical miles from the launch site reported observing the missile self destruct.

[30] These eight observers were located at Station 2, Station 4, Station 6, Station 8, and Station 10.

[31] These ten observers were located at Station 2, Station 4, Station 6, Station 8, and Station 10.

[32] One observer (at Station 10) said that she did not see light or flame during any of the three missile launches. During the first and second launches, she reported seeing an ascending yellow "ball." During the third missile launch, she reported seeing an ascending white "ball."

Thirteen of the fourteen observers reported that the light or flame was visible during the third missile launch. Nine of the thirteen observers reported the color of the light or flame. Three of these nine observers reported that the light was white, two reported that the light was yellow, one reported that the light was orange, one reported that the light was golden, one reported that the light was amber, and one reported that the light was yellow-red.

The observers were not asked specifically to describe the missile's path of travel, but some did. Three of the fourteen observers reported that the light traveled "straight up" during the first missile launch,[33] four reported this during the second missile launch,[34] and two reported this during the third missile launch.[35,36] Two observers described an angle on which the light traveled. One of these two observers (at Station 6) reported that the light traveled on a 80 to 85 degree angle above the horizon, and one (at Station 2) reported that the light traveled on a 60 degree angle.

Of the fourteen observers, four reported that smoke was visible during a missile launch. Three of these four observers reported the color of the smoke.[37] One observer (at Station 2) reported seeing gray black smoke during the first missile launch, one observer (at Station 10) reported seeing gray or black smoke during the second missile launch, and one observer (the same observer at Station 2) reported seeing white gray smoke during the third missile launch.

One observer at Station 10 said "maybe" when asked if he saw a missile body (during the second missile launch). No other observers reported that they saw a missile body.

The observers located at Station 2 and Station 4 reported hearing sounds. Both of the observers at Station 2 reported hearing two types of sounds: (1) an initial rocket motor

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[33] One of these observers was located at Station 6, one was located at Station 8, and one was located at Station 12.

[34] One of these observers was located at Station 6, one was located at Station 8, and two were located at Station 12.

[35] Both observers were located at Station 12.

[36] The actual launch angle was about 70 degrees above the horizon.

[37] One of these 4 observers (at Station 8) reported seeing smoke during third missile launch, but he did not provide a description of the smoke.

or aircraft noise[38] and, (2) a boom after the light disappeared. Both of the observers at Station 4 reported hearing a small boom about 20 to 30 seconds after seeing the flash of light. The observers at Station 6, Station 8, Station 10, and Station 12 did not report hearing any sounds.

David L. Mayer
Witness group chairman

[38] During the first missile launch, one observer (at Station 2) reported hearing the rocket motor about 2 to 3 seconds after the light disappeared in the clouds and before he saw the missile self-destruct. During the second missile launch, the second observer at Station 2 reported hearing a ripping or aircraft noise.