

File # 1-0033

# AIRCRAFT ACCIDENT REPORT

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**TWA B-707, N748TW and  
EAL LOCKHEED CONSTELLATION N6218C  
Carmel, New York  
December 4, 1965**

**RELEASED:**

**December 20, 1966**

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U.S. CIVIL AERONAUTICS BOARD  
WASHINGTON, D.C. 20428

## CIVIL AERONAUTICS BOARD

## AIRCRAFT ACCIDENT REPORT

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**ADOPTED:** December 13, 1966**RELEASED:** December 20, 1966

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MIDAIR COLLISION - TRANS WORLD AIRLINES, INC.,  
BOEING 707-131B, N748TW, AND EASTERN AIR LINES, INC.,  
LOCKHEED 1049C, N6218C, NEAR CARMEL, NEW YORK,  
DECEMBER 4, 1965

SYNOPSIS

Trans World Airlines, Inc., Flight 42, (TW 42), a Boeing 707, N748TW, and Eastern Air Lines, Inc., Flight 853, (EA 853), a Lockheed 1049C, N6218C, were involved in a midair collision over the Carmel, New York VORTAC while en route to the New York City area at approximately 1619 e.s.t., December 4, 1965.

TW 42 departed San Francisco, California, and was approaching the New York area from the northwest for an approach and landing at the John F. Kennedy International Airport. The flight was on an IFR flight plan at an assigned altitude of 11,000 feet mean sea level (m.s.l.). EA 853 departed Boston, Massachusetts, and was approaching the New York area from the northeast for an approach and landing at the Newark Airport. This flight was on an IFR flight plan at an assigned altitude of 10,000 feet m.s.l.

As EA 853 was approaching the Carmel VORTAC on a southwesterly heading, the first officer saw TW 42 at his two o'clock position. Because he believed the jet was at his altitude and on a collision course he called "Look Out" and grasped the control wheel to assist the captain in a pull up. At approximately the same time, the captain of TW 42 observed EA 853 at his ten o'clock position on what he believed to be a collision course. He rolled into a right turn and pulled back on the yoke. He decided this maneuver would not clear EA 853 and he, assisted by his first officer, attempted to reverse the turn by rolling to the left and pushing on the yoke. The aircraft collided at an altitude of approximately 11,000 feet m.s.l.

The Board determines the probable cause of this collision accident was misjudgment of altitude separation by the crew of EA 853 because of an optical illusion created by the up-slope effect of cloud tops resulting in an evasive maneuver by the EA 853 crew and a reactionary evasive maneuver by the TW 42 crew.

1. INVESTIGATION1.1 History of Flight

Trans World Airlines Flight 42 (TW 42), a Boeing 707-131B, N748TW, departed San Francisco International Airport, San Francisco, California, at 0905 P.s.t. on an IFR flight plan, destined for John F. Kennedy International Airport (JFK), New York, N.Y. At departure the adjusted takeoff gross weight was 222,174 pounds in-

cluding 82,000 pounds of fuel. Aircraft loading was within allowable weight and center of gravity (c.g.) limits. The flight was routed via Sacramento, California, Reno, Nevada, Sioux Falls, South Dakota, and Buffalo, New York, at various altitudes. At Buffalo, the log indicated the flight was at flight level (FL) 3701/ at 1548.2/ Subsequently, the flight descended to FL 250 under the control of the New York Air Route Traffic Control Center (ARTCC). TW 42 was then cleared to descend to FL 210 and later to 11,000 feet m.s.l., and was given the JFK altimeter setting of 29.63. The flight reported level at 11,000 feet. A short time later, the flight reported to the New York ARTCC that it had a collision with another aircraft.

Eastern Air Lines Flight 853 (EA 853) a Lockheed 1049C, N6218C, departed Logan International Airport, Boston, Massachusetts, at 1538. At the time of departure, the aircraft had an operating weight of 97,019 pounds which was well below the maximum allowable takeoff gross weight of 113,075 pounds as specified for an intended landing at Newark, New Jersey. The c.g. was within allowable limits. The flight climbed to and maintained 10,000 feet m.s.l. and control was subsequently transferred to the New York ARTCC in a radar handoff from the Boston ARTCC at approximately 1610.

EA 853 subsequently reported maintaining 10,000 feet and radar identity was confirmed by New York ARTCC. At approximately 1618, the New York ARTCC recorded on a flight progress strip that EA 853 was passing the Carmel VORTAC. At 1621 the flight initiated a MAYDAY distress call and advised that they had been involved in a midair collision. See Attachment No. 1.

Testimony and aircraft records indicated that there were no carry-over airworthiness items at the time TW 42 departed San Francisco nor were any en route discrepancies entered on the flight log prior to the collision.

The crew of TW 42 stated that as they approached the Carmel VORTAC from the northwest, they were flying in clear air above an overcast with no restrictions to visibility. Although the aircraft was being flown on autopilot with the altitude-hold feature engaged, the captain had his left hand on the control yoke.

He observed a white and blue aircraft at his 10 o'clock position on what he assumed was a collision course. He immediately disengaged the autopilot by actuating the switch on the yoke with his left thumb, put the wheel hard over to the right and pulled back on the yoke. During this period the copilot grabbed the controls and reacted in concert with the captain. As the aircraft rolled to the right, it became apparent that this maneuver would not allow the two aircraft to pass clear of each other, and both crewmembers attempted to reverse the wheel to the left and pushed on the yoke. Before the aircraft had time to react to the control reversal, two shocks were felt and the jet entered a steep dive. Control was regained and the crew began an assessment of the damage. Contact was

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1/ 37,000 feet pressure altitude: A flight level is stated in hundreds of feet at 18,000 feet or above in the United States and is always related to an assumed sea level pressure or reference datum of 29.92 inches of mercury which is set into the altimeters.

2/ All times hereinafter are eastern standard based on the 24-hour clock.

made with the New York ARTCC and TW 42 was given vectors and clearance to the JFK. During this period the crew declared an emergency, requested crash and fire equipment be alerted and advised that the left wing tip was missing. After flying a large 360-degree left turn southeast of JFK in order to ascertain that the landing gear was fully down, TW 42 landed on runway 31L at approximately 1640.

The surviving first and second officers of EA 853 stated that prior to the collision there was no malfunction of the aircraft. The first officer stated that as the flight approached the Carmel VORTAC, their airspeed was 205 to 210 KIAS<sup>3/</sup> and that they were flying level at 10,000 feet indicated altitude. Just prior to reaching the Carmel VORTAC, the flight was flying in and out of the tops of a "fluffy" cloud deck, the tops of which were estimated to be approximately 300 feet above their altitude. Although EA 853 was flying toward the sun this was not a factor as far as visibility was concerned. Neither sun glasses nor glare shields were being utilized.

As EA 853 emerged from a cloud puff the first officer observed a jet from his right side window at what he described as the 2 o'clock position. The aircraft appeared to be converging and at the same altitude. The first officer exclaimed "Look out," placed his hands on the control wheel and made what he called a very rapid application of up elevator simultaneously with the captain. The pullup was described as one in which the crew were "pulled into their seats."

After impact, EA 853 continued to climb. The crew felt the aircraft shudder after which it began a left turning dive. Since there was no response from the controls or trim tabs, efforts to recover were made with power application only. The aircraft descended through solid clouds and recovery was made below the clouds by the use of throttles only. Several zooms were made back into the clouds. A power setting was found which would maintain a descent and a level attitude with some degree of consistency. The aircraft passed over the Danbury, Connecticut Airport at 2,000 to 3,000 feet, too high to make an approach. Airspeed could be maintained between 125 and 140 knots; the nose would rise when power was added and fall when power was removed. The rate of descent could be maintained at approximately 500 feet per minute.

It was apparent that flight could not be maintained and a decision was made to effect a landing in an open field. Just prior to ground contact, power was added to bring the nose up to parallel the sloping terrain. The left wing of the aircraft struck a tree immediately before contact with the ground was made.

Five passengers aboard TW 42 reported seeing the other aircraft prior to the collision. All five were seated on the left side of the aircraft at the time of the collision. One stated the other aircraft was "coming from behind a white cloud." Two observed the other aircraft in a climbing maneuver, and one observed the other aircraft in a climbing right turn. Eleven passengers recalled a steep right turn in connection with the collision and three of these eleven recalled experiencing a steep left turn after the initial right turn. Nine passengers said that during the collision avoidance maneuvers they saw clothing and articles leave the overhead storage shelves and fall into the cabin area. Five of these nine passengers said this occurred after the impact. After the

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<sup>3/</sup> Knots indicated airspeed.

aircraft was brought under control, the passengers were informed by the captain of an impending emergency landing. None of the passengers were informed that a midair collision had occurred.

Several passengers aboard EA 853 stated they felt a definite pullup followed by impact. The passenger estimates of the time interval between the pullup and the impact varied from one to several seconds. None of the passengers were able to establish the time of impact. One passenger aboard EA 853 saw the jet prior to impact. He was attempting to take a picture through a window on the right side of the aircraft when TW 42 appeared approximately 45 degrees to the right of EA 853. He attempted to take a picture of the jet but said he was prevented from doing so when EA 853 pulled up and started a left turn. Following the impact the aircraft entered a tight left spiral, entered the clouds, and then recovered below the clouds. The captain of EA 853 made announcements to the passengers regarding the midair collision. They were briefed on preparation for an emergency landing and a few seconds prior to the landing were told to brace themselves.

### 1.2 Injuries to Persons

Injuries to persons aboard EA 853 are as follows:

<u>Injuries</u>	<u>Crew</u>	<u>Passengers</u>	<u>Others</u>
Fatal	1	3	0
Non-fatal	4	45	0
None	0	1	

### 1.3 Damage to Aircraft

The impact damage to TW 42 consisted of the complete severance of the outer 25 feet of the left wing at about wing station 700. There was a moderate impact damage area noted on the top of the No. 1 engine cowl and heavy score marks angling inboard along the No. 1 engine nacelle and pylon. There was considerable secondary structural damage caused by heavy impact forces and flying debris.

EA 853 was destroyed by impact and subsequent fire.

### 1.4 Other damage

Grass on a large area of the hill was burned and several gouge marks caused by impact were evident.

### 1.5 Crew Information

Captain Thomas H. Carroll of TW 42, age 45, was employed by Trans World Airlines on September 24, 1945, and was promoted to captain on May 28, 1956. He had a total of 18,842 flying hours, 1,867 of which were in Boeing 707 aircraft. He held valid FAA airline transport pilot certificate No. 6511-40, which included a type rating in Boeing 707 aircraft. His last proficiency and line checks in the Boeing 707 aircraft were on September 7, 1965, and October 17, 1965, respectively. His last first-class medical certificate was dated September 22, 1965, with no limitations.

First Officer Leo M. Smith of TW 42, age 42, was employed by Trans World Airlines on November 2, 1953, and was promoted to first officer on December 30, 1953. He had a total of 12,248 flying hours, 2,607 of which were in Boeing 707 aircraft. He held valid FAA airline transport pilot certificate No. 466676. His last proficiency check in Boeing 707 aircraft was June 25, 1965. His last first-class medical certificate was dated September 10, 1965, with no limitations.

Flight Engineer Ernest V. Hall of TW 42, age 41, was employed by Trans World Airlines on August 8, 1947, and was promoted to flight engineer on July 19, 1951. He had a total of 11,717 flying hours, 5:52 of which were in the Boeing 707 aircraft. He held valid FAA flight engineer certificate No. 1220132 and commercial pilot certificate No. 1204221. His last proficiency and line checks in the Boeing 707 aircraft were on November 24, 1965, and December 1, 1965, respectively. His last second-class medical certificate was dated February 17, 1965, with a waiver that "holder shall possess correcting glasses for near vision while exercising privileges of his airman certificate."

The four hostesses aboard TW 42 had received their most recent emergency procedure refresher training in November 1965.

Captain Charles J. White of EA 853, age 42, was employed by Eastern Air Lines on October 26, 1953. He had a total of 11,508 flying hours of which 1,947 were in L-1049 aircraft. He held valid air transport pilot certificate No. 1271200 with a type rating in L-1049 aircraft. His last proficiency check and line check was on November 8, 1965, and November 5, 1965, respectively. His last first-class medical examination was dated October 25, 1965, with no waivers.

First Officer Roger I. Holt, Jr., of EA 853, age 34, was employed by Eastern Air Lines on February 5, 1962. He had a total of 8,090 flying hours, 899 of which were in L-1049 aircraft. He had 241 hours in L-1049 aircraft as flight engineer. He held valid FAA commercial pilot certificate No. 1095281 with appropriate ratings, and FAA flight engineer certificate No. 1542827. He also held a valid free balloon pilot rating. His last proficiency check was dated September 14, 1965. His last first-class medical examination was dated March 9, 1965, with no waivers.

Flight Engineer Emile P. Greenway of EA 853, age 27, was employed by Eastern Air Lines on January 27, 1964. He had a total of 1,011 flying hours of which 726 were in L-1049 aircraft. He held valid FAA commercial pilot certificate No. 1485388, and flight engineer certificate No. 1599427. His last flight engineer check was dated July 17, 1965.

The two stewardesses aboard EA 853 had received appropriate evacuation and ditching training.

## 1.6 Aircraft Information

N748TW, a Boeing 707-131B, serial number 18387, was owned and operated by Trans World Airlines, Inc., 10 Richards Road, Kansas City, Missouri. The aircraft had a total airframe time of 12,965:29 hours. Total time since the last base overhaul performed on March 7, 1965, was 2,831:44 hours. Total time since the last "C" check<sup>4/</sup> on October 12, 1965, was 539:28 hours. Total time since

<sup>4/</sup> Number 4-600 hour check.

the last station service check on November 11, 1965, was 61:55 hours. The aircraft was properly maintained in accordance with FAA approved company maintenance procedures and there was no evidence of any malfunctions or irregularities in either the systems or the maintenance thereof that could have contributed in any way to the accident. The aircraft was equipped with four Pratt & Whitney JT3D engines.

N6218C, a Lockheed Constellation 1049C, serial number 4526, was owned by Eastern Air Lines, Inc., 10 Rockefeller Plaza, New York, New York. The aircraft had a total airframe time of 32,883.76 hours, of which 7 hours had been accumulated since the last major inspection. This was a phase check conducted on December 3, 1965. The aircraft was equipped with Curtiss-Wright 972-TC-18-DA 3/4 engines and Hamilton Standard model 34E60 propellers.

N6218C had one altimeter installed which did not meet Technical Standard order (TSO) requirements nor was it of the type on the accepted list for certification. Examination of the instrument (S/N 19723), subsequent to the accident indicated it had been modified in compliance with Kollsman Service Bulletin No. 9. This instrument when modified in accordance with this service bulletin should have been capable of meeting the performance requirements of TSO C10A.

#### 1.7 Meteorological Information

At the time of the accident, U. S. Weather Bureau surface weather charts indicated the northeastern section of the country was in a post frontal zone with a frontal system extending into the Atlantic Ocean from a low pressure area centered 100 to 150 miles off the Massachusetts coast. A general north-westerly flow of air was shown from the upper Great Lakes and New England region to the Carolinas.

The 1540 White Plains, New York<sup>5/</sup> surface weather observation was in part: 4,000 feet scattered clouds, 8,000 feet broken clouds, 12 miles visibility, temperature 46°F, dewpoint 35°F, wind from 300 degrees at 7 knots.

U. S. Weather Bureau forecasts for the area which included the Carmel VORTAC, and valid at the time of the accident, called for variable cloud conditions with cloud tops near 8,000 feet and isolated tops to 13,000 feet.

Radar weather observations were taken approximately 30 minutes before and after the accident. The observation taken before the accident, at 1545, showed broad areas of scattered showers with the tops of detectable moisture 10,000 to 15,000 feet. The observation taken after the accident, at 1645, showed an area of broken light rain showers with the tops of detectable moisture 8,000 to 12,000 feet south of the New York area, and 12,000 to 16,000 feet north of New York with snow showers in the northwest portion of the observed area.

The pilot of a corporate aircraft en route from Syracuse, New York to John F. Kennedy stated that he climbed through multi-layered clouds after his departure from Syracuse, and was on top of an overcast at 15,000 feet, approximately 25

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<sup>5/</sup> The nearest official surface weather observations to the scene of the accident were made at White Plains, New York, which is located approximately 14 nautical miles southwest of the Carmel VORTAC.

miles southeast of Syracuse. He described the overcast as continuous and relatively smooth with some billowing in the Carmel area. At 1645, approximately 30 minutes after the accident, he descended in the area of the Carmel VORTAC and reported that he was just clear of the tops of the clouds at 11,000 feet and in the clouds at 10,000 feet. He also reported the visibility was unrestricted above the overcast.

Statements of crewmembers of other aircraft in the general area of the Carmel VORTAC near the time of the collision indicated that there was a solid overcast whose ragged tops were between 10,000 and 11,000 feet. Visibility was unrestricted above this cloud layer.

Thirteen passengers aboard TW 42 recalled flying on top of a solid cloud layer prior to and at the time of the midair collision. A few of the thirteen recalled puffs of clouds that extended up from the cloud layer and they estimated these to be fifty to a few hundred feet above the layer of clouds. Eleven of the passengers aboard TW 42 stated they were in the clouds at the time of the collision.

A majority of 24 statements from EA 853 passengers indicated the flight was flying over a solid overcast just before the collision. They estimated that their height above this overcast was from 100 to 1,500 feet. A few of the passengers stated they were flying through puffs of clouds just prior to the collision.

#### 1.8 Aids to Navigation

All pertinent NAVAIDS and facility equipment were reported to be operating satisfactorily at the time of the accident.

#### 1.9 Communications

When TW 42 was approximately 42 miles northwest of the Carmel VORTAC, control was transferred from the New York ARTCC high altitude to the low altitude sector, and the crew was instructed to descend to 11,000 feet and given the JFK altimeter setting of 29.63. TW 42 reported at 11,000 feet at 1617:30 approximately one minute before the collision.

The last altimeter setting given EA 853 was the Bradley Field, Connecticut setting of 29.58 given at 1556. No acknowledgement from EA 853 could be heard on the re-recording of the Boston ARTCC tape.

At 1606:45 a radar handoff of EA 853 was effected between Boston ARTCC and New York ARTCC Sector 8. At 1610:20 EA 853 reported to the New York ARTCC as maintaining 10,000 feet and was radar identified. At 1618 the New York ARTCC controller observed EA 853 passing the Carmel VORTAC and recorded the time of that radar position on the Carmel flight progress strip.

Less than a minute later the crew of TW 42 advised another New York ARTCC controller at the same sector that they had been in a collision with another aircraft. Emergency procedures were initiated and TW 42 was radar vectored for an approach to runway 31L at JFK. A successful landing was accomplished at 1639:43.

Following the collision a period of approximately 2-1/2 minutes elapsed before radio communications were re-established with EA 853. The crew reported the collision and advised of the difficulties they were encountering in maintaining control of the aircraft. The controller monitored the progress of the flight until radar contact was lost. The last position given to the crew was 6 miles northwest of the Carmel VORTAC. EA 853 effected an emergency landing in an open field near Danbury, Connecticut, three miles northeast of the Carmel VORTAC at 1628:15.

Data obtained from computer readouts of three SAGE centers<sup>6/</sup> indicated the speed and track of the two aircraft just prior to the estimated time of the collision were as follows:

TW 42 - Ground speed 355 knots; True track 128°

EA 853 - Ground speed 213 knots; True track 252°

Information from the same SAGE centers indicated that the time the tracks of the two aircraft crossed was approximately 1618:43, which was selected to represent the approximate time of the collision.

The volume of traffic operating in the area of the collision was described by the New York ARTCC controller as light to moderate. JFK radar was operating satisfactorily with good target presentation on a radar display free of clutter. No traffic information was given to either crew and none was required since a standard vertical separation minimum of 1,000 feet was being provided. Pilot reports indicated that this separation existed. Radar monitoring service was being provided as the flights progressed toward the Carmel VORTAC.

#### 1.10 Aerodrome and Ground Facilities

A flight check of the Carmel VORTAC and the JFK radar was conducted by the FAA approximately four hours after the accident. The flight inspection report shows satisfactory performance of these two facilities and the communications frequencies of 126.4 and 125.5 mcs. Other aids or equipment in use at the time of the accident were re-certificated by technicians of the FAA. All equipment was certified to be operating satisfactorily.

#### 1.11 Flight Recorder

A Lockheed Air Service model 109C flight recorder, serial number 857, conforming to FAA TSO C-51, was installed in the aft area of the left main landing gear wheelwell of TW 42. The flight recorder case exterior and internal mechanism components did not reveal any evidence of mechanical damage as a result of impact loads or forces to which it may have been subjected. The recorder provides data concerning altitude, airspeed, vertical acceleration, and heading.

A readout was accomplished for that portion of the flight encompassing the last 29 minutes prior to touchdown at JFK and beyond this point covering the landing rollout for approximately one minute. The readout was begun with the

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<sup>6/</sup> Semi-automatic Ground Environment System. The SAGE centers were Detroit, Boston, and New York.

descent from approximately 21,200 feet pressure altitude. During the approach descent from 21,200 to 11,000 feet, the change over in the altimeter barometric pressure setting from a standard setting of 29.92 to a m.s.l. setting of 29.65 at the 18,000-foot altitude datum point is reflected in the readout altitude data. No significant variations were indicated by any of the four parameters during the transition to the apparent flareout point at an m.s.l. altitude of approximately 11,150 feet which is recorded at a time point of 22 minutes and 52 seconds before touchdown. Gradual descent to and level flight at 11,000 feet continued until a time point of 21 minutes and 38 seconds before touchdown was reached. At this time point, the acceleration parameter showed that suddenly applied loads were initiated causing the acceleration trace to peak at plus 2.5 "g"<sup>7/</sup> while the airspeed trace showed the start of a decrease in speed. The altitude trace remained relatively steady, and small variations are indicated by the heading parameter.

Immediately subsequent to the above aberrations, at a time point of approximately 21 minutes and 32 seconds before touchdown, small variations occurred in all of the parameter traces except the altitude trace. Significant negative acceleration indications began to occur and continued to approximately 21 minutes and 12 seconds before touchdown. Throughout this period, significant changes transpired in the other parameter traces. Acceleration trace variations appeared to stabilize at approximately 21 minutes and 10 seconds before touchdown. The airspeed trace indicated the start of an increase in speed, the altitude trace indicated an increase in altitude, and the heading trace showed the start of an abrupt yaw to the right within one second. All the recorded traces appeared to become normal from the time point of 21 minutes and 11 seconds until touchdown.

There was no requirement for a flight recorder aboard EA 853 and none was aboard.

#### 1.12 Wreckage

TW 42 showed primary impact damage in three areas: (1) the outer left hand wing panel from the No. 1 nacelle outboard was severed; (2) the No. 1 engine cowl and pylon showed impact abrasions from sliding contact but did not separate from the aircraft; (3) the wing leading edge at wing station 555 just inboard of the No. 1 engine had sustained a deep slash. In addition, secondary structural damage was noted from impact loading and flying debris.

EA 853 crashed on a hillside 4.2 miles north of an area where numerous separated parts from both aircraft were found. First impact was in a tree which was broken 46 feet above the ground. Nearly 250 feet farther the left wing contacted a large tree and separated from the aircraft. Contact with the ground was made 250 feet beyond the first tree and the aircraft came to rest 700 feet up a 15-percent slope on a magnetic heading of 243 degrees. Portions of the fuselage slewed around to a nearly reciprocal heading. The fuselage was separated into three main pieces which remained in their respective positions but were at varying angles to each other. All engines separated from their nacelles. The flaps and landing gears were in the retracted position at impact.

Upon completion of the structures examination of both aircraft, a three dimensional mockup of TW 42's outer wing panel and EA 853's tail assembly was

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<sup>7/</sup> "g" An acceleration equal to the acceleration of gravity.

accomplished, and the collision evidence of both aircraft was studied and documented. This study revealed that initial contact of the two aircraft was between TW 42's left outer wing and the right hand outboard vertical fin and stabilizer tip assembly of EA 853. The relative motion was such that the wing passed, leading edge first, through the horizontal stabilizer from the outboard leading edge to the inboard trailing edge. The average angle of this relative motion was measured at 40 degrees downward relative to EA 853's longitudinal axis, and at a 78-degree angle to the right of EA 853's longitudinal axis.

The captain's and first officer's static system selector valves were found in their respective No. 1 static source positions on EA 853. The Eastern Air Lines' L-1049C flight manual provides a No. 1 (normal) static source correction factor of minus 43 feet to be applied to the altimeter indicated reading at an indicated altitude of 10,000 feet, 210 KIAS, gear and flaps up. This correction factor would give a corrected indicated altitude of 9,957 feet when the aircraft's altimeter indicates 10,000 feet.

A review of the maintenance records of the Eastern Air Lines Constellation fleet reflects static system leakage rates of up to 1,000 feet per minute. The rate of the leakage was found using test equipment and was not noted on cockpit instruments. These rates of leakage are not directly related to altimeter accuracy in respect to finite numbers. Eastern Air Lines flight tests reflected a maximum 44 feet altimeter error under the most adverse static system leakage rate noted in the tests.

Taking into account all of the possible tolerances and errors, including the EAL flight test data, the maximum error would have ranged from minus 123 feet to plus 81 feet.

#### 1.13 Fire

Nearly all parts of EA 853 were exposed to some degree of ground fire. The right wing was not extensively fire damaged and the right outboard wing fuel tank still contained fuel.

#### 1.14 Survival Aspects

During the time prior to collision, the seat belt sign aboard EA 853 had been on. At collision, passengers reported a jolt and change of attitude followed by an altitude loss and varying degrees of recovery. The captain advised passengers that there had been a collision, that he was unable to control the aircraft and that they should prepare for a crash landing. Passengers were advised by a stewardess to remain seated, fasten their seat belts, and read the emergency instruction cards in the seat back pockets. The captain was again heard over the cabin address system and stated the aircraft was definitely out of control and that a crash landing would be made. He advised everyone to remove sharp objects from their pockets and to fasten their seat belts tightly. Just prior to impact, the captain announced: "Brace yourselves!"

At impact, there was a continuous upslope yaw to the left. The fuselage aft of the trailing edge of the wing broke open on the right side, "hinging" on the left side. All passengers with the exception of one who believed he had been

thrown clear of the fuselage during the slide, and another who jumped out of an emergency exit window after it popped open before the airplane came to a stop, remained in the fuselage in the vicinity of their seated locations throughout the crash sequence. Seat 14-CDE located at the fuselage break, was the only seat not found in the fuselage wreckage and was located 10 yards back along the crash path. All other seats remained in their relative original locations. Some passengers found themselves out of their seats following impact and several had difficulty unfastening their seat belts.

Passengers exited through the torn-open fuselage, the right side forward cockpit crew door, the left main cabin door, and the opening in the aft end of the cabin in the pressure dome area.

Two bodies were removed from the fuselage. Death was due to inhalation of products of combustion. The captain's body was found just inside the fuselage in the left forward service doorway. A passenger's body was found in the forward passenger cabin in the left aisle area between seat rows 7 and 8. Two passengers succumbed later at a local hospital of injuries received in the crash.

Residents in the vicinity of the crash offered immediate rescue assistance and care for the injured.

#### 1.15 Tests and Research

During the investigation, tests were conducted by Eastern Air Lines with a similar airplane from its fleet to determine the climb performance of the airplane, duplicating as closely as possible the conditions prevailing at the time of the midair collision. Cruising at an altitude of 10,000 feet, a rapid pullup was made by the crew. A motion picture camera was used to record time and altitude. During three practice runs made, it was determined that the time to climb to 11,000 feet was 10.8 seconds, 14.2 seconds, and 10.2 seconds, respectively. It was believed that under actual emergency conditions, a slightly greater rate of climb could have been obtained or exceeded than that obtained in the tests.

Tests were also made with a U. S. Air Force Super Constellation simulator in attempts to obtain times for a climb from 10,000 feet to 11,000 feet. In four tests, the average time required to climb from 10,000 to 11,000 feet was 11 seconds.

Eastern Air Lines conducted a flight test in which a leakage rate of 1,500 feet per minute was introduced into the static system behind the first officer's instrument panel. The test was performed at 210 KIAS, 10,000 feet altitude and with the cabin pressurized to sea level. This test resulted in an error of minus 44 feet. This change would result in a corrected altitude of 10,044 feet when the altimeter reflects a 10,000-foot altitude. This is a result of the cabin pressure leaking into the static system and causing the altimeter to read lower than the true indicated altitude.

The static source correction factor for TW 42 was plus 55 feet at 10,000 feet which resulted in the addition of 55 feet to the indicated altitude displayed on the cockpit altimeter. Trans World Airlines conducted flight tests with the static sense line disconnected at the flight recorder and found a maximum error of minus 50 feet at 11,000 feet.

The three altimeters recovered from the wreckage of EA 853 were set at 29.56. The setting in TW 42's altimeters was 29.65. This would result in a difference of 65 feet assuming that both aircraft were at the same point in space.

### 1.16 Optical Illusions

Aircraft pilots are susceptible to many types of flight conditions which may result in spatial disorientation and optical illusion. These illusions or disorientations result from reliance on the physiological sensing elements of the body which can give false or conflicting information to the senses.

The primary device used to provide orientation with respect to the horizontal and vertical planes, depth, and distance is the eye. Experiments<sup>8/</sup> have been conducted to determine the effect of pilot warning indicators on the ability of pilots to discriminate between aircraft observed on collision and non-collision courses. These experiments revealed that as the miss vector<sup>9/</sup> decreased, the decision that a collision course existed increased.

The evaluation of the threat a target offers may depend on the observed angular velocity (sight-line rate)<sup>10/</sup> and the observed rate of change in range-rate<sup>11/</sup> of the target. If the sight-line rate of a target is well above the motion threshold, the pilot can be fairly certain the target is on a non-collision course. If the sight-line rate is below the motion threshold (no perceptible motion) and there is perceptible increase in target size, the threat may be evaluated as a collision course. For vertical misses, a sight-line rate of about six minutes of arc per second was judged to be a collision course regardless of the background structure or miss vector. With a sight-line rate of about nine minutes of arc per second the courses were judged as misses. The fact that the sight-line rate for miss decisions was about three minutes of arc per second higher than for collision judgment may indicate that perceived movement may sometimes have been used as a cue to help decide that the target was on a non-collision course. However, in those instances a horizon line was observable and the pilots reported using it in addition to a perceived motion. The presence of the horizon may have provided a structured reference for misses in the vertical plane when other structure was lacking. One criterion frequently used by the pilots was the amount of separation between the target and the horizon. Targets that appeared stationary but were clearly above the horizon were immediately judged to be misses.

## 2. ANALYSIS AND CONCLUSIONS

### 2.1 Analysis

There were no structural, powerplant, system, or navigation component failures that contributed to this accident. The investigation, including the

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<sup>8/</sup> A study of Requirements for Pilot Warning Instrument for Visual Airborne Collision Avoidance, Sperry Gyroscope Company, December 1963.

<sup>9/</sup> Distance between aircraft either vertically or horizontally.

<sup>10/</sup> Sight-line rate is the observed angular velocity or relative movement of a target in a horizontal or vertical plane.

<sup>11/</sup> Range-rate is the observed rate of change in angular subtense of a target or the rate at which the target appears to change in size as the range opens or closes.

testimony of all surviving crewmembers, substantiates that both aircraft were capable of operation within their design criteria.

Flight 42 (N748TW) was certificated and maintained within the framework of the existing Federal Aviation Regulations and company rules in effect at the time of the collision.

Although one altimeter installed aboard Flight 853 (N6218C) was not of an acceptable type, it could be expected to perform with accuracy equal to a like model that had met the TSO requirements. N6218C was capable of safe flight and there was no evidence to indicate the unauthorized altimeter in any way contributed to the accident. The following factors tend to discount the likelihood of any material error:

- (1) The static system design incorporates separate static systems for the captain's and first officer's positions.
- (2) The altimeter scale error correction at 10,000 feet is usually much less than the 80 feet maximum tolerance.
- (3) During the several flights flown after the completion of the phase check, there were no reported discrepancies in the altimeter systems.
- (4) The testimony of the first officer of EA 853 that nothing abnormal was noted in the altimeter system during the flight from Boston.
- (5) Eastern Air Lines procedures require altimeter change if the crew notes as much as a 50-foot difference in readings.

The Board must rule out the possibility of collision because of altimeter malfunctions or false altitude indications. The possible errors caused by altimeter system design, scale correction, and atmospheric conditions are so negligible that both aircraft would not have been more than approximately 100 feet above or below their indicated altitudes. The design incorporation of separate aircraft altimeter-static systems on the EA 853 aircraft would make it highly improbable that any significant errors would go undetected by crewmembers. In addition, there were no reported discrepancies in the altimeter systems of either aircraft during the previous several flights and surviving crewmembers stated there was nothing of an abnormal nature noted in the altimeter systems of their respective aircraft just prior to the collision. It is therefore concluded that the maintenance of the altimeters system aboard EA 853, while not meeting standards as specified in the maintenance manual, was not a factor in the accident.

Testimony and flight recorder data indicate that TW 42 was being flown in accordance with the clearance issued by Air Traffic Control. Just prior to arriving at the Carmel VORTAC from the northwest, the aircraft had been descended to an altitude of 11,000 feet and was flying above a cloud deck with no restrictions to visibility.

EA 853 was being operated in accordance with the clearance issued by Air Traffic Control and was in level flight at 10,000 feet, in and out of the tops of clouds as it approached the Carmel, New York VORTAC from the northeast. This

conclusion is based on the surviving crewmembers' testimony, passenger statements and testimony as to cloud conditions being experienced just prior to the accident, and the flight engineer's log of EA 853 made some 20 minutes prior to the accident.

Both aircraft were being operated on IFR flight plans and were under the control of the New York ARTCC. Altitude separation between these aircraft was being provided in accordance with existing procedures. Neither aircraft was given (nor is there a requirement to give) an advisory as to the presence of the other aircraft even though the controllers testified they observed the converging tracks. Both aircraft had reported to ATC at their assigned altitudes and all evidence indicates they were flying at these altitudes shortly before the collision occurred.

There was a solid overcast in the vicinity of the Carmel VORTAC. New York Weather radar showed tops 12,000 to 16,000 feet to the north and 8,000 to 12,000 feet to the south. Pilot reports, passenger reports, and crew testimony establish that in the near vicinity of Carmel, the tops were generally at 10,000 feet with small buildups or puffs in evidence.

The testimony of the first officer of the EA 853 indicates that he first observed a jet at about his 2 o'clock position and that the jet appeared to be at their altitude. At the time of sighting, EA 853 had just emerged from a cloud and as he (first officer) observed the other aircraft, he shouted a warning to the captain who was flying the aircraft. Both he and the captain pulled straight back on the yoke in an effort to evade the other aircraft. He further testified that after EA 853 was in its climb, he observed the jet bank to the right. Actual tests of a Lockheed L-1049C in the weight and configuration similar to EA 853 indicate the aircraft could have climbed 1,000 feet in altitude in approximately 9 to 14 seconds

The first officer of EA 853 testified that the crew departed from their assigned altitude when they sighted the TWA aircraft. This departure occurred because the first officer, and apparently the captain, believed the aircraft he saw was on a collision course, at or very near the altitude of EA 853. The Board believes this impression was caused by an optical illusion. A review of the weather information obtained during this investigation shows that the cloud tops were relatively smooth with some "cauliflower" type buildups protruding several hundred feet above the general cloud tops. The evidence also indicates the tops of the clouds were generally higher to the north and northwest of Carmel. The first officer, knowing his aircraft was passing through or very near the tops of the clouds, observed another aircraft on a converging track. With higher clouds behind TW 42, the first officer would receive an impression of an aircraft on or very near the apparent horizon. In the small amount of time that he had to judge the separation of the two aircraft he had no visual aid to assist him in determining the true horizon and the buildup of clouds toward the north would present a false horizon on which to base his analysis of separation.

The most logical explanation of the reaction pullup is again based on the small amount of time the crew had to evaluate the relative position and course of the other aircraft. They would not have been able to determine whether the other aircraft was in level flight in or just above the tops of the clouds or in the process of letting down and just entering the clouds. Had EA 853 pushed over, the aircraft would have gone into the solid overcast and the crew would have had no way to observe and evade the converging traffic if it were also entering the clouds.

As the captain of TW 42 sighted the other aircraft, he also believed he was on a collision course with it, made an immediate right bank and pulled back on his yoke. He testified that he realized the bank to the right would not allow his aircraft to pass clear of the other aircraft and he attempted to reverse the direction of bank and pushed the yoke forward. There was insufficient time for the aircraft to react to this control reversal and the aircraft's left wing, outboard of the No. 1 engine, struck the right horizontal stabilizer of EA 853.

The flight recorder data indicate that approximately 13 seconds prior to impact, TW 42 was maneuvered in a manner which produced a  $\neq 2.5$  "g" load. This time period correlates with the testimony of the TW captain that as he sighted EA 853, it assumed a climbing attitude, and the TWA captain rolled into a right bank, and pulled back on the yoke. This is compatible with the time required for EA 853 to climb the thousand feet or portion thereof, separating the two aircraft. The left wing of TW 42 sliced through the right horizontal stabilizer of EA 853 from a point near the leading edge of the right hand vertical fin and horizontal stabilizer exiting near the center of the trailing edge of the elevator. The swath through the stabilizer formed a relative angle of 12 degrees forward of the stabilizer rear spar.

The Board does not have sufficient information to determine the exact pitch, roll, and yaw attitude in reference to the horizon of each aircraft at the time of the collision. However, the scuff marks and break-up pattern indicate a collision angle of 74 degrees between the longitudinal axes of the two aircraft. By plotting the geometrics of the impact angle with the heading of TW 42 established from the flight recorder readout as approximately 139 degrees, it was determined that EA 853 was on a heading of 213 degrees and at an approximate airspeed of 140 knots.

Flight test data from the Lockheed L-1049C test flight and data supplied by the aircraft manufacturer indicate that the expected decay of airspeed from the estimated 210 to 215 knots cruise speed of EA 853 during a rapid pullup of 1,000 feet would result in airspeed of from 130 to 150 knots.

As TW 42 passed under and toward the rear of EA 853 the No. 1 engine cowling and a portion of the left wing of the former struck the underside of the main fuselage of the latter. This impacting tore out the hydraulic boost package and the control cables to the rear empennage of EA 853, effectively rendering the elevator and rudder flight controls inoperative.

The pilots' abilities to effect visual separation in the short time of visual contact provided insufficient response time for collision avoidance. Analysis of the cloud conditions, the positioning of the two aircraft, and the reactionary evasive maneuvers attempted, left no opportunity for a frame of reference to the horizon. The up-slope effect of the cloud coverage resulted in a misjudgment by the crew of EA 853 of their altitude separation, the resultant evasive maneuver, and the subsequent reactionary evasive maneuver by TW 42 ended in collision.

## 2.2 Conclusions

### (a) Findings:

1. Both aircraft crewmembers were properly certificated and trained for the operation involved.
2. TW 42 was properly certificated, maintained, and dispatched for the flight.

3. EA 853 was properly certificated, and dispatched and was capable of safe flight.

4. Altimeter (SN 197523) had been modified in compliance with Kollsman Service Bulletin No. 9, and should have been capable of meeting the performance requirements of TSO C-10A.

5. Both aircraft were capable of operating within their normal design limitations.

6. The powerplants of both aircraft were developing power to the time of impact.

7. TW 42 crew reset the altimeters to 29.63 upon passing through 18,000 feet on their descent.

8. EA 853 was given the Bradley altimeter setting of 29.58 upon passing Hartford, Connecticut.

9. TW 42 was at the assigned altitude of 11,000 feet just prior to the collision.

10. EA 853 was at or near the assigned altitude of 10,000 feet just prior to sighting the TWA aircraft.

11. In the Carmel, New York area at the time of the accident there was an overcast cloud condition, the tops of which were generally just above 10,000 feet m.s.l. Buildups were scattered through the area with tops tending to be higher to the north than to the south, providing an apparent upslope condition to the north.

12. The crew of EA 853 observed TW 42 at about their 2 o'clock position and believing them to be at their same altitude on a collision course, executed an emergency pullup to avoid a collision.

13. The crew of TW 42 had an instantaneous view of the EAL aircraft and executed an immediate reactionary evasive maneuver by making an abrupt right turn.

14. The left wing of TW 42 collided with the right vertical fin and horizontal stabilizer of EA 853.

15. The aircraft collided at an altitude of approximately 11,000 feet at approximately 1619 e.s.t.

(b) Probable Cause

The Board determines the probable cause of this collision accident was misjudgment of altitude separation by the crew of EA 853 because of an optical illusion created by the up-slope effect of cloud tops resulting in an evasive maneuver by the EA 853 crew and a reactionary evasive maneuver by the TW 42 crew.

BY THE CIVIL AERONAUTICS BOARD:

/s/ CHARLES S. MURPHY  
Chairman

/s/ WHITNEY GILLILLAND  
Member

/s/ ROBERT T. MURPHY  
Vice Chairman

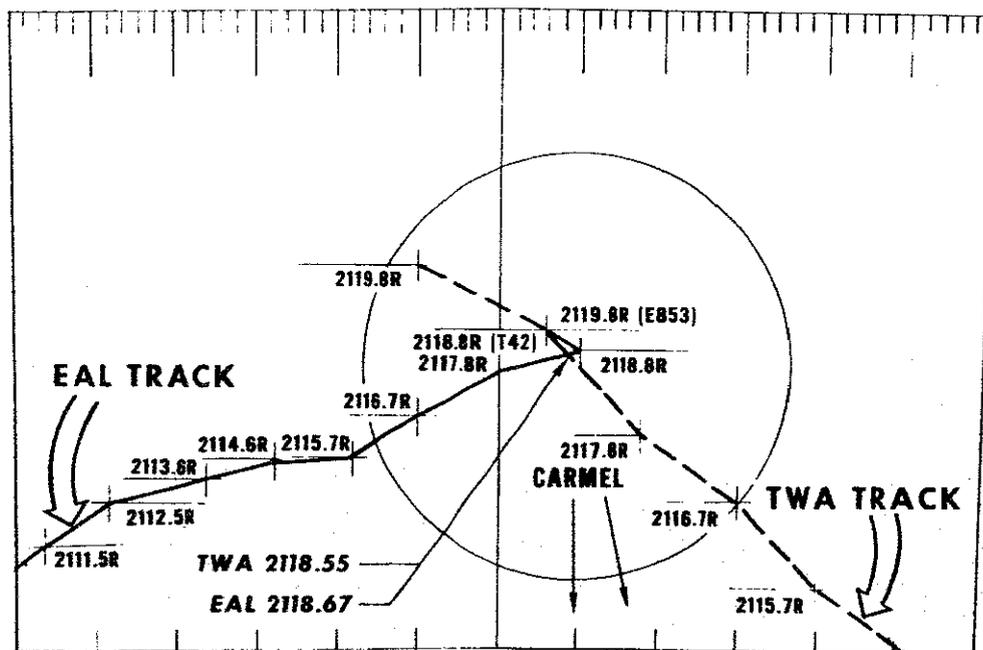
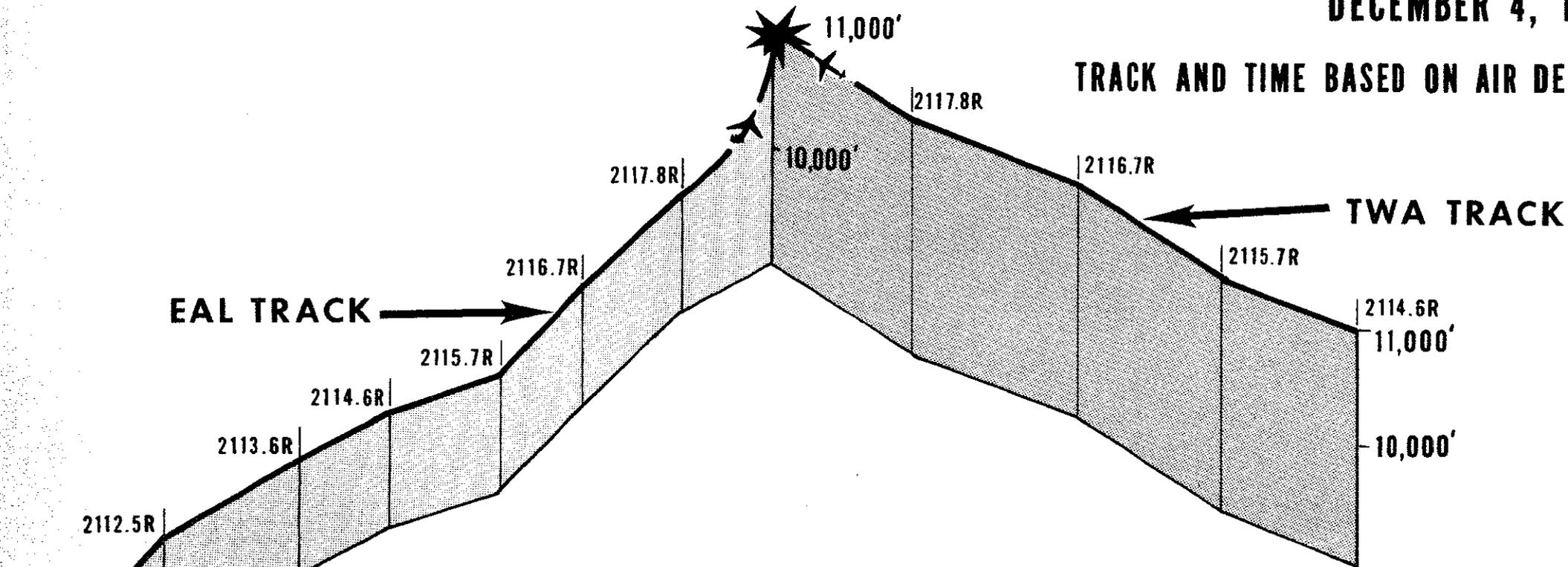
/s/ JOHN G. ADAMS  
Member

/s/ G. JOSEPH MINETTI  
Member

# APPROXIMATE FLIGHT PATH CHART LOOKING SOUTH TWA 42 and EAL 853 ACCIDENT OVER CARMEL VORTAC, N.Y.

DECEMBER 4, 1965

TRACK AND TIME BASED ON AIR DEFENSE COMMAND DATA



PLAN VIEW OF FLIGHT PATHS

**NOTES:**

- Not to scale
- Altitudes are M.S.L.

**CIVIL AERONAUTICS BOARD  
BUREAU OF SAFETY  
Washington D.C.**