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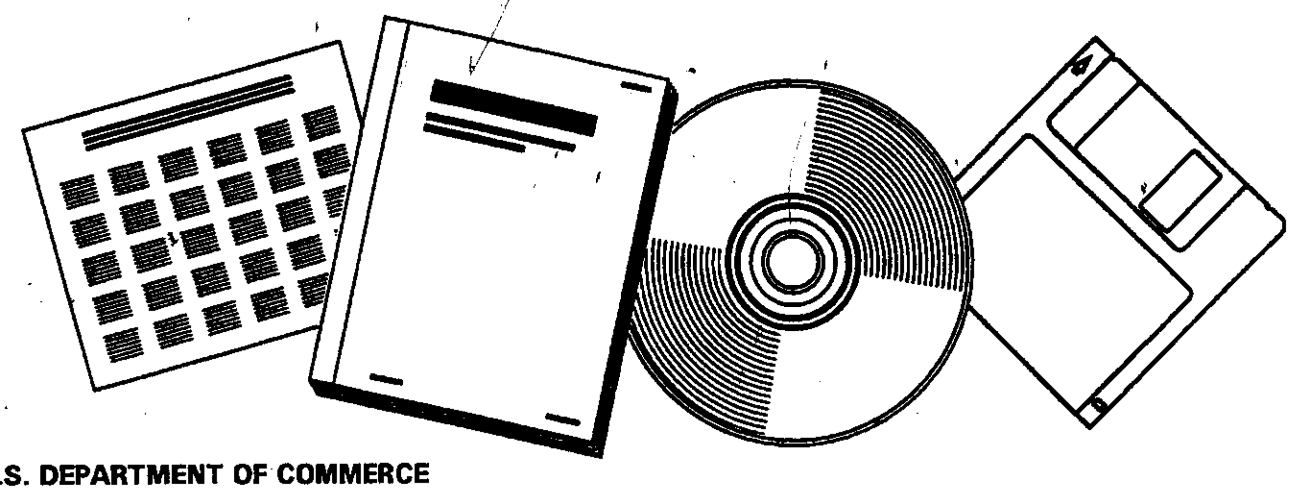
AIRCRAFT ACCIDENT REPORT. TRANS WORLD AIRLINES, INC., DOUGLAS DC-9, TANN COMPANY BEECHCRAFT BARON B-55 IN-FLIGHT COLLISION NEAR URBANA, OHIO, MARCH 9, 1967

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, DC

19 JUN 1968



U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

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PB177-3398

AIRCRAFT ACCIDENT REPORT

Adopted: June 19, 1968

TRANS WORLD AIRLINES, INC., DOUGLAS DC-9
TANN COMPANY BEECHCRAFT BARON B-55
IN-FLIGHT COLLISION
NEAR URBANA, OHIO
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NATIONAL TRANSPORTATION SAFETY BOARD
DEPARTMENT OF TRANSPORTATION
WASHINGTON D.C. 20591

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SYNOPSIS

A Trans World Airlines, Inc., Douglas DC-9, N1063T, Flight 553, and a Tann Company Beechcraft Baron B-55, N6127V, collided at an altitude of about 4,525 feet m.s.l., approximately 25 nautical miles northeast of the Dayton Municipal Airport, Dayton, Ohio, at 1153:50 e.s.t., March 9, 1967. The pilot of the Beechcraft (only occupant) and the 21 passengers and 4 crewmembers aboard Flight 553 received fatal injuries. Both aircraft were destroyed. Flight 553 was a regularly scheduled passenger flight from New York City to Chicago, Illinois, with en route stops at Harrisburg and Pittsburgh, Pennsylvania, and Dayton, Ohio. The Beechcraft, being utilized for a company business flight, was en route from Detroit, Michigan, to Springfield, Ohio. The pilot was operating under Visual Flight Rules. No flight plan was filed nor was one required. Flight 553 was operating on an Instrument Flight Rules flight plan in visual flight conditions. The flight was descending from 20,000 feet to 3,000 feet on Victor Airway 12 North in preparation for a landing at Dayton. Dayton RAPCON was exercising control over Flight 553 and had established radio and radar contact with the flight just prior to the collision. The Beechcraft was not under the control of, or in radio contact with, any FAA traffic control facility.

It was, however, in radio contact with the fixed base operator at the Springfield Airport just prior to the collision.

The weather at the time of the accident was high thin broken clouds with visibility 5-6 miles in haze.

Eighteen seconds before the collision occurred, the radar controller who was controlling Flight 553 initiated a traffic advisory to that flight: "TWA 553, roger, traffic at twelve thirty, one mile, southbound, slow moving." Fourteen seconds prior to the collision the captain of Flight 553 acknowledged that transmission with "Roger." This was the last recorded radio communication with the aircraft. Recorded crew conversation on the Cockpit Voice Recorder (CVR) tape during the last 14 seconds of the flight provided no information to indicate that the TWA crew ever saw the Beechcraft. The last recorded crew comment on the CVR tape was "Ready on the checklist, Cap'n" which began at 1153:46. The cockpit voice recording stopped at 1153:50.

The Board determines the probable cause of this accident was the failure of the DC-9 crew to see and avoid the Beechcraft. Contributing to this cause were physiological and environmental conditions and the excessive speed of the DC-9 which reduced visual detection capabilities under an air traffic control system which was not designed or equipped to separate a mixture of controlled and uncontrolled traffic.

1. INVESTIGATION

1.1 History of Flight

A Trans World Airlines, Inc., Douglas DC-9, N1063T, Flight 553, and a Tann Company Beechcraft Baron B-55, N6127V, collided at an altitude of about 4,525 feet m.s.l., approximately 25 nautical miles northeast of the Dayton Municipal Airport, Dayton, Ohio, at 1153:50 1/ March 9, 1967. The pilot (only occupant) of the Beechcraft and the 21 passengers and four crewmembers aboard Flight 553 received fatal injuries. Both aircraft were destroyed.

Flight 553 was a regularly scheduled domestic passenger flight from New York, New York, to Chicago, Illinois, with en route stops at Harrisburg and Pittsburgh, Pennsylvania, and Dayton, Ohio. The flight departed Pittsburgh at 1125 on an Instrument Flight Rules (IFR) flight plan destined for Dayton and operated under radar surveillance for the duration of the flight.

As the flight approached the Dayton terminal area it was cleared to descend from its cruising altitude of Flight Level 200 (20,000 feet) to 5,000 feet, and a transfer of radar control was accomplished by passing control of the flight from Indianapolis Air Route Traffic Control Center (ARTCC) to the Dayton Radar Approach Control facility (RAPCON). The Dayton RAPCON approach controller established radio contact with Flight 553 at 1152:36. At the time of the radar handoff, Flight 553 was approximately 8 miles northeast of the Urbana Intersection on Victor Airway 12 North.

1/ All times herein are eastern standard time expressed on the 24-hour clock unless otherwise specified.

The flight was cleared to maintain 5,000 feet and "fly two four zero" (magnetic heading) for a vector to the final approach course (ILS) and report leaving 6,000 feet.

At 1153:22, the controller cleared Flight 553 to descend to and maintain 3,000 feet and turn left to a heading of 230°. This instruction was correctly acknowledged by the captain of Flight 553 at 1153:28 2/.

The controller later stated, "Immediately following this (issuance of the clearance) I observed for the first time a radar target (unidentified) ahead and slightly to the right of TWA 553. I then issued the following traffic advisory, 'TWA five fifty three, roger, and traffic at twelve thirty, one mile, southbound, slow moving'." 3/

This transmission began at 1153:32 and terminated at 1153:35. The captain of Flight 553 acknowledged this transmission with "Roger" 4/ at 1153:36. This was the last recorded air/ground transmission from Flight 553.

Approximately 14 seconds later, the radar targets of the two aircraft merged, separated, changed shape on the radar screen, and then disappeared. At 1154:02 the controller advised Flight 553 it was "clear of traffic" but no reply was received from the flight. Subsequent efforts to establish contact with the flight were unsuccessful.

2/ The captain's voice was identified making all radio transmissions emanating from the flight between Pittsburgh and Dayton.

3/ Directions are given in a clock code in a horizontal plane with the pilot sitting in the center of an imaginary clock dial with 12 o'clock being straight ahead. Each hour of the clock represents 30° of a circle. Thus 12:30 would be approximately 15° to the pilot's right.

4/ "Roger" means, "I have received and understand your transmission."

The Beechcraft, being utilized for a company business flight, was en route from Detroit, Michigan, to Springfield, Ohio. The aircraft departed Detroit City Airport at 1101 for a VFR flight to Springfield, Ohio. No flight plan was filed, nor was one required. The flight departed Detroit on a Special VFR clearance to leave the control zone 5 miles from the airport. Approximately two minutes after takeoff, the pilot reported "on top" of the smoke and haze and then left the Detroit tower frequency. No record of any further communication with any FAA communication facility or air traffic control facility could be found that related to the Beechcraft, nor was such communication required.

The operator of Springfield Aviation Inc., at the Springfield Airport, testified that at approximately 1154 the pilot of the Beechcraft established radio contact with his office and requested a courtesy car. During this conversation the pilot stated that he would be landing shortly. There is no record of any subsequent radio contact with the aircraft. This communication was not recorded because it was conducted with the Springfield UNICOM, a private aeronautical radio station handled by the fixed base operator at the Springfield Airport.

Ground witnesses in the area reported the weather as clear with good visibility. The only witness who saw both aircraft in flight did not see the collision. His attention was drawn to the Beechcraft by the sound of its engines and he observed the aircraft traveling in a southerly direction. He also observed the DC-9 traveling in a southwesterly direction. After seeing each aircraft his attention was diverted and thus he did not see the collision. The witness heard a loud noise and when he looked up again he saw the DC-9 pass slightly north of his position. He did not see any fire on the aircraft until it crashed into the ground. After the DC-9 passed the witness's position he watched it and stated that the left wing was down and the angle of bank increased, the nose went down, and the aircraft dove into the ground. The witness testified that he did not observe any damage to the aircraft after he heard the loud noise nor did he see the Beechcraft after that time. He did observe aircraft parts falling to the ground after he heard the noise.

Other ground witnesses in the area saw the DC-9 prior to the collision but did not see the other aircraft or the collision. The witnesses did see a cloud of vapor or smoke near the DC-9 and, using that as the point of collision, estimated that the collision occurred just north of the intersection of Lippincott Road and State Route 29 in Champaign County, Ohio. 5/

The witness who saw both aircraft estimated that the DC-9 was at 3,000 feet and slightly above the Beechcraft. Other witnesses estimated the DC-9 to be at an altitude of 2,000 to 3,000 feet. None of the witnesses reported seeing any lights on either aircraft before the collision.

Pilots of other aircraft operating in the accident area near the time of the accident were interviewed and reported that the weather was clear, with haze the only obstruction to visibility. Their estimates of the top of the haze layer varied from 3,000 to 5,000 feet. None of them saw the accident. These pilots testified that the ground appeared to be 80 to 90% snow covered. One pilot stated that visibility was restricted looking toward the ground, and others that visibility was restricted looking toward the sun.

5/ 40°10'N. - 83°50'W.

The flightpaths for the DC-9 and the Beechcraft were computed subsequent to the accident. The ground tracks of each are depicted in Attachment No. 1. The DC-9's flightpath was reconstructed utilizing the flight recorder readout corrected for barometric pressure, wind direction and velocity, temperature, and flight recorder installation calibration. The Beechcraft's flightpath was chosen based on its probable route from the Findlay VOR to Springfield, Ohio. Since the attitude and speed of the Beechcraft were unknown, the Beech Aircraft Corporation was requested to determine the speed and deck angle of the Beechcraft, based on the aircraft weight, in level flight and at a 300-foot per minute rate of descent. They were computed to be 194 m.p.h., calibrated air speed (cas) at 0.8 negative deck angle and 210 m.p.h., cas at 2.1° negative deck angle, respectively. From these data two flightpaths were calculated. These speeds and headings were also corrected for temperature and winds, and plotted on Attachment No. 1. From these ground tracks and headings, the bearing and range of each aircraft from the other were determined. The elevation angle from each aircraft was calculated utilizing the pitch and roll data of the DC-9 and the pitch data for the Beechcraft. The results of these calculations are depicted in Attachment No. 2. The plots were prepared for five-second intervals from 1152:50 through 1153:50 and the points connected to show the approximate path the presented target would have traced on the cockpit windows of each aircraft.

The accident occurred in bright daylight. At the request of the Board, the Director of the Nautical Almanac Office of the United States Naval Observatory determined and reported the position of the sun at

1155 as observed from the accident site. This position was 44° above the horizon and 18° east of south.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Other
Fatal	4 (DC-9) 1 (B-55)	21 (DC-9) 0 (B-55)	0 0
Nonfatal (Both aircraft)	0	0	0
None (Both aircraft)	0	0	

1.3 Damage to Aircraft

The Beechcraft disintegrated in flight at the time of the collision. The DC-9 was destroyed by the collision, ground impact, and post impact fire.

1.4 Other Damage

None.

1.5 Crew Information

The crews of both aircraft were properly certificated and qualified to conduct their respective flights. (For details see Appendix A).

1.6 Aircraft Information

Both aircraft were properly certificated and their maintenance records indicated that they had been maintained in accordance with existing requirements. The weight and center of gravity of each aircraft were calculated to be within their respective limits. The DC-9 was serviced with Jet A turbine fuel and the Beechcraft was serviced with 100 octane gasoline. (For details, see Appendix B).

1.7 Meteorological Information

The 1200 weather reported by various stations in the vicinity of the accident site was high thin scattered clouds, visibility 6-7 miles in haze, temperature 23-35°F. with southwesterly winds at 8-10 knots. The 0700 Dayton radiosonde recorded very moist absolutely unstable air from the surface to near 2,500 m.s.l., a 6°C. temperature inversion from near 2,500 to near 3,000 feet m.s.l., with relatively dry stable air above approximately 2,500 feet m.s.l. The freezing level was at the surface.

The Dayton 0700 and 1300 winds aloft observations were in part as follows:

Height (m.s.l.)	Directional (True)	Velocity (Knots)
	0700 e.s.t.	
4,000	270	23
5,000	270	25
	1300 e.s.t.	
4,000	230	26
5,000	240	28

The crew of Flight 553 was provided with the current weather information pertaining to their flight at each point of departure en route. Updated information was available to them en route through the FAA and company communication systems.

There is no record of any weather briefing being provided to the Beechcraft pilot. However, with the exception of the Detroit area, the weather was reported to be suitable for VFR operation.

1.8 Aids to Navigation

Special flight checks of radar equipment and pertinent navigational aids were performed after the accident. Of special interest was the capability of the Indianapolis ARTCC and Dayton RAPCON radars to detect targets similar to those presented by the DC-9 and the Beechcraft proceeding through the areas approaching the Urbana intersection. These checks utilized a Douglas DC-3 and a Beechcraft Baron. The Beechcraft used in these tests was equipped with two-bladed propellers rather than three-bladed propellers as installed on N6127V.

The flight checks utilizing the DC-3 disclosed that the radar, navigational aids, and communications systems in use at the time of the accident were operating in a normal manner and no difficulty was found in detecting the primary radar target of the aircraft or its radar transponder return.

The special flight check using the Beechcraft was conducted with the aircraft flying on a direct course from the Findlay VOR to Springfield Airport at 4,550 feet m.s.l. This check revealed that primary [6] radar targets from the Beechcraft received in both the Indianapolis ARTCC and the Dayton RAPCON met the criteria specified for operational use. Primary radar returns on the Dayton RAPCON radar scopes were recorded for the Beechcraft from a point approximately 36 miles from the Dayton radar antenna inbound to a point over the accident site, which is about 23 miles northeast of the antenna site. Marginal returns were evident between 36 miles and 30 miles northeast of the antenna. These data were later verified by a series

[6] Primary radar targets are the reflection of the radar energy from the reflecting surfaces of the target aircraft.

of tests conducted by the FAA using a similar type target aircraft under a number of different time and atmospheric conditions.

Ground checks confirmed satisfactory operation of the navigational radio aids believed to have been used by the two involved crews.

During the public hearing held as part of the investigation of this accident several of the Dayton RAPCON controllers testified that in the area beyond 30 miles northeast of the RAPCON radar antenna, in the vicinity north to northeast of the Rosewood VOR, primary radar returns from light twin-engine aircraft were sometimes difficult to detect. These witnesses also testified that there had never been to their knowledge any Notice to Airmen or other information provided to the aviation community indicating any restriction of radar service to traffic operating in this area or that less than adequate radar coverage existed to the north.

The FAA Manual of Air Traffic Control Procedures, section 370, Merging Target Service, contained the following instructions pertaining to traffic advisories. "Issue radar traffic information to a scheduled air carrier aircraft when its target is likely to merge with another aircraft target unless: The traffic is known to be separated by more than the minimum approved vertical separation or; It (the target) is known to be in a holding pattern . . . If the pilot (air carrier) requests, vector his aircraft to avoid the target of previously issued traffic to the extent that the targets do not touch . . . Provide these vectors subject to the conditions of Additional Services . . . If unable to vector, inform the pilot." The "conditions" applied to the provision of additional services were not mandatory. Section 351.1 NOTE states: "The provision of these additional services is not mandatory. Many factors (such as limitations of the radar, volume of traffic, controller workload, and communications frequency congestion) could prevent the controller from providing them. The controller possesses complete discretion for determining whether he is able to provide these services in a specific case. . . ." The RAPCON controller testified that in this instance had the pilot requested a vector, the controller would not have had time to issue an avoiding vector before the targets merged. At the time of this accident, the controller was handling two other aircraft on the same radio frequency. During the 14 seconds between the acknowledgment of the traffic advisory and the collision there were about 10 seconds of radio time available to the crew of Flight 553 to request a vector. No such request was made. The controller also stated that it requires between 4 and 7 seconds for him to determine the course and relative speed of a target return presented on his radar scope.

1.9 Communications

There were no reported difficulties with air-ground communications between TWA 553 and the ground facilities. Investigation revealed no record of any communication between the Beechcraft and any ground stations except the Detroit tower and the Springfield Aviation Company. No communication requirement existed in this case because the Beechcraft was operating VFR without a flight plan.

1.10 Aerodrome and Ground Facilities

Not involved in this accident.

1.11 Flight Recorders

Flight 553 was equipped with a flight data recorder and a cockpit voice recorder (CVR) both of which were recovered from the wreckage in satisfactory condition.

The flight data recorder was a Lockheed Aircraft Service Model 109D S/N 225. It was recovered from the wreckage area with considerable mechanical damage but no fire damage. The recording medium had received some mechanical damage but no fire damage. Examination of the recording medium revealed no evidence of parameter malfunction, abnormalities of traces or styli alignment, or other abnormal functioning between the calculated liftoff time at Pittsburgh and a time 28 minutes and 50 seconds later. Good correlation was established between parameters but all traces beyond the time point of 28 minutes and 50 seconds are considered unreliable due to aberration. The flight recorder readout indicated that, at the time of impact with the Beechcraft, the DC-9 was descending through 4,525 feet, m.s.l., at an indicated air speed of 323 knots, on a heading of 232°. The rate of descent for the 20 seconds prior to impact averaged approximately 3,500 feet per minute.

No flight recorder was installed on the Beechcraft and none was required.

Flight 553 was also equipped with a Fairchild Model A-100 cockpit voice recorder, installed in the aft baggage compartment of the aircraft on the right side of the fuselage at approximately fuselage station (FS) 700.

The unit was recovered in the DC-9 wreckage area with the chassis partially crushed and deformed. There was no evidence of fire or heat damage. Despite the mechanical damage to the recorder and its case the tape was intact and the recording surface had no remarkable damage. The recording was integrated with the Air Traffic Control information and a time correlated transcription of the last 2-1/2 minutes of the recording was prepared. This transcription contained the following timed records:

Time	Recorded Data
1151:52	Sound of high speed warning clacker. 7/
1151:56	Sound of landing gear warning horn. 8/
1151:58	Clacker sound stops.
1152:24	Flight 553 told to contact Dayton Approach Control.
1153:16	Flight 553 reported vacating 6,000 feet and was instructed to turn left to a heading of 230° and descend to and maintain 3,000 feet. (This was correctly acknowledged.)
1153:29.5	"TWA five fifty three roger (1153:31) traffic at un, twelve thirty, one mile southbound slow moving (1153:35)." Followed by "Roger" from TWA 553.
1153:46	"Ready on the checklist, Cap'n."
1153:50	Recording ends.

7/ The clacker is an audible warning device which operates when the indicated airspeed exceeds 350 KIAS or .84 Mach.

8/ This warning horn sounds when the throttles are retarded below a predetermined point and the landing gear is either retracted or in an unsafe condition.

There are two other recorded transmissions on the tape addressed to another aircraft from Dayton Approach Control between 1153:46 and 1153:50. The total measured time between the initiation of communication between Flight 553 (1152:36) and Dayton Approach Control and the collision (1153:50) was 1 minute and 14 seconds. The time from the beginning of the traffic advisory (1153:32) until the end of the tape (1153:50) was 18 seconds.

1.12 Wreckage

The wreckage of the two aircraft was found scattered over an area approximately 2.3 miles long and 1/2 mile wide, oriented along a line 230° magnetic. The major portion of the DC-9 was found in one area. The Beechcraft components and fragments were generally located 4,500 to 9,000 feet northeast of the primary DC-9 impact area. Some parts of the DC-9, including portions of the forward fuselage nose section, the nose landing gear, skin from both right and left sides of the nose section, top skin from the crew windshield lower frame and from the bottom fuselage, numerous components from the electronics compartment, the electronic compartment door, part of the air stair door from the left side of the fuselage, and one set of DC-9 rudder pedals, were recovered approximately 1 mile from the primary DC-9 wreckage site, in the area where the Beechcraft fragments were also located. The rudder pedals could not be identified as to their installed position in the aircraft.

The Beechcraft was extensively fragmented, with the nose section being the largest intact piece recovered.

The DC-9 had a white top, a red stripe along the fuselage and black paint on the radome and the top of the nose section. The rest of the aircraft was unpainted aluminum. The Beechcraft wings and the lower half of the fuselage were painted red and the upper half of the fuselage and the empennage section were painted white.

A number of pieces of the DC-9 forward fuselage between FS 110 and FS 229 were recovered with red scuff marks displayed on the aluminum surface. These pieces included: a section of fuselage skin from the right side; the water service access panel from the right side between FS 129.624 and FS 148.550; a section of the right fuselage frame with skin attached at FS 218; a section of right fuselage skin between FS 299 and FS 313; and the right and left forward nose landing gear doors. Sections of left wing upper skin between the forward and rear spar approximately 30 inches long also contained red scuff marks.

Portions of wing structure identified as coming from the Beechcraft were found imbedded in the DC-9 nose landing gear tire, between the strut housing and the right taxi light of the nose landing gear, and imbedded in the leading edge of the left outboard wing section. There were numerous red scuff marks found on the aluminum surfaces on the right side of the DC-9 fuselage at various places forward of the wing and on the left wing. These scuff marks ran fore and aft, and were inclined upward as they progressed aft on vertical or near vertical surfaces such as the side of the fuselage.

The DC-9 flight controls surfaces were all accounted for in the main wreckage area. The horizontal trim setting was measured to be 3/4°

nose up. There was no evidence of pre-impact malfunction of the flight control system, nor was there evidence of corrosion or fatigue failure found on any component examined.

The recovered Beechcraft fragments were laid out in a two-dimensional mockup and the direction and angles of scuff marks and scratches were measured clockwise relative to the longitudinal axis of the aircraft. These scuff marks and scratches averaged 103°. The vertical component of the scuff marks on the gravity water door of the DC-9 and on the vertical stabilizer of the Beechcraft were found to be approximately 10° and 20° from the horizontal, respectively.

Using these angles, the collision geometry was calculated and the horizontal angle between the longitudinal axes of the two aircraft was found to be approximately 47°. The vertical angle between the longitudinal axes of the two aircraft was calculated to be approximately 10°.

Examination of the flight control systems of the Beechcraft revealed no evidence of pre-impact malfunction or distress.

The engines of the DC-9 and the engines and propellers of the Beechcraft were examined, and no evidence of pre-impact malfunction was found.

1.13 <u>Fire</u>

Witnesses in the area of the accident reported that no fire occurred until the DC-9 crashed and exploded. There was no evidence of inflight fire found on the wreckage of either aircraft.

1.14 Survival Aspects

This was a nonsurvivable accident. All persons aboard the two aircraft died of traumatic injuries. Toxicological studies were conducted on three crewmembers of the DC-9, the pilot of the Beechcraft, and 12 passengers from the DC-9. No evidence of ethyl alcohol, drugs (other than salicylates), or elevated levels (more than 10%) of carbon monoxide was found. The salicylates found in toxicological specimens taken from the captain were less than that present after a therapeutic dose of aspirin.

A review of the medical records and the post-mortem examination of all the involved pilots did not reveal any pre-existing disease or impairment which would have compromised the safe operation of the aircraft.

1.15 Tests and Research

Because the accident occurred during daytime VFR flight conditions, a special study was conducted to determine the visibility afforded the three pilots involved.

The DC-9 was certificated under the provisions of Part 4b of the Civil Air Regulations, dated December 31, 1953, and Amendments 4b-1 through 4b-15. The pilots' compartment visibility requirements were contained in Section 4b 351. The manufacturer was required to demonstrate that the cockpit visibility met the intent of Civil Aeronautics Manual 4b which contained the FAA policies applicable to these requirements. These policies provided detailed technical information on recommended methods of complying with the Civil Air Regulations. Such policies are for guidance of the public and are not mandatory in nature.

Investigation disclosed that the DC-9 cockpit visibility did not meet the letter of the FAA policy. The only pertinent deviation from these policies was the width of the windshield posts on the outboard side of the side windshields. The recommended maximum post width was 2.5 inches but the posts in the DC-9 were 3-5/8 inches wide as projected to the pilot's eye.

The cockpit visibility was approved as meeting the intent of these recommended policies.

Under conditions of good visibility and atmospheric conditions the threshold of visibility is less than one minute of arc. 9/ The determination of the color of a target requires approximately twice the arc as that required for the threshold of visibility. In detecting a target at considerable distance from the eye, the fovea, or central part of the retina of the eye, is used. At long ranges, on the order of 1 mile, the peripheral vision cannot be used to detect a target. Peripheral vision comes into play at close distances where the eye does not have to see or identify definite objects. For example, with peripheral vision, motion and objects can be detected but the object or color cannot be identified. The conspicuity of a target depends on a number of items including its size, color, relative motion, and brightness contrast. The characteristics of the atmosphere through which the target is viewed also affect the detectability of the target, in that any contamination of the

9/ An angle of arc is that angle a target subtends as seen by the observer. There are, in this usage, 60 minutes of arc per degree.

atmosphere such as haze, visible moisture, or smoke would make the target more difficult to detect and would in effect require it to subtend a greater arc in order to be detected.

With regard to the differences in conspicuity of various colors under favorable conditions, international orange has by far the most outstanding conspicuity. Under conditions of decreased visibility and in combination with other colors, the combination of red and white was not one of the most conspicuous sets.

Under the physical conditions that appear to have existed in this case, the maximum range of target detection would have been approximately 4 miles. At this range each target would have subtended 1.5 minutes of arc or more when viewed from the other aircraft. This estimate of the detectability of the Beechcraft was the result of a computation based on a rectangle of red, 8 feet long and 4 feet wide, the approximate area of one wing of the Beechcraft. At a range of 6,000 feet this target would subtend 5 minutes of arc and at a range of 2,000 feet this red target would have subtended 14 minutes of arc under ideal conditions, or approximately 10 minutes of arc when viewed through haze sufficient to reduce visibility to 5 miles. On this basis each of the crews should have been able to detect the other aircraft if it were presented in the areas of visibility provided by the windows of the cockpits. According to a recent study [10] the probability of detection for targets which exceed 1.4 minutes of arc, visual angle, is 100 percent in clear visibility. Once the pilot's attention has been directed toward a target which has no

10/ Collision Avoidance Visibility May 22, 1966, Lockheed California Company, Burbank, California.

relative motion, color would be the thing that would attract the eye and lead to focusing on the target. If relative motion existed it would lead the eye to the target. Given the circumstances presented to the DC-9 crew, they should have detected the Beechcraft within 3 seconds after receiving the warning from ATC, if it was presented in the clear visibility area of the windshield. Assuming 1/2-second pilot decision time, and pilot motor-response time of 1/3 second, the TWA crew should have been able to detect the target and initiate a change in their aircraft's direction in not more than 5 seconds, if the target was presented continuously in the clear glass windshield.

Extensive studies of many collision accidents have shown that there was an opportunity, of varying degree, for the pilot or pilots to see the conflicting traffic in sufficient time to take evasive action. In many cases where the pilots have survived, they have testified that they were maintaining a careful lookout but despite it they did not see the other aircraft in time to avoid a collision, or they did not see the other aircraft at all.

Collision studies, including controlled flight tests, have demonstrated that seeing other aircraft in flight is difficult. The degree of such difficulty is variable, with numerous tangible and intangible factors affecting it. The tangible factors include the angular limits of cockpit vision, interfering cockpit structure, and detection range. The latter is influenced by many things, including the color of the target, background against which the target is displayed, its apparent angular size and shape, atmospheric conditions, and apparent relative motion or lack thereof. In this connection note that aircraft converging on collision courses provide no apparent relative motion when viewed from each other. Another factor which is allied to relative motion is termed "range rate", or the rate at which the apparent size of a target increases or decreases when the range is closing or opening.

Intangible factors of a physiological nature include the individual's physical condition, degree of fatigue, and training.

Finally, it is important to recognize that the operation of a modern aircraft requires regular and frequent attention of the pilot, or pilots, to duties within the cockpit. Attention to instrumentation, both operational and navigational, is required during all phases of flight, particularly during the approach to a terminal area in preparation for landing.

Many combinations of these factors can result in a limited opportunity to see other aircraft. In the case at hand, there were obvious distractions within the cockpit which inhibited the DC-9 crew's lookout for other traffic. These distractions included controlling the airspeed, checking the altitude of the aircraft in relation to the clearance limit of 3,000 feet, preparing to perform the pre-landing checklist, and turning to their assigned headings. All of these items required the attention of at least one of the pilots inside the cockpit for various periods of time. It is estimated that the preparations necessary before reading the checklist would take from 10 to 15 seconds, during which time at least one of the pilots would have his attention concentrated inside the aircraft.

The lack of verbal comment on the part of either crewmember of the DC-9 indicates that neither of them saw the Beechcraft. Observation of routine aircrew operations of air carrier flights has shown that when designated traffic is not observed, crewmembers shift their positions and institute some form of visual search pattern in an effort to detect the target. There is also, generally, some verbal comment between crewmembers regarding the detection or failure to detect the target.

1.16 Other Pertinent Information

Part 91.85 of the Federal Air Regulations stated in part:

91.85 . . .

(c) No person may operate . . .

(1) An arriving aircraft below 10,000 feet MSL within 30 nautical miles of an airport of intended landing (or an airport where a simulated approach is to be made) at an indicated airspeed of more than 250 knots (288 m.p.h.).

Draft Release No. 61-9, published in the Federal Register May 9, 1961, gave notice that the Federal Aviation Agency had under consideration amending Part 60 of the Civil Air Regulations to prohibit the flight of arriving aircraft at airspeeds in excess of 250 knots indicated airspeed (IAS) while in the airspace below 14,500 feet mean sea level (m.s.l.) within 50 miles of destination airport. The Draft Release (D.R.), made reference to a previous D.R. (60-17) which established, among other things, a maximum speed limit in the vicinity of certain airports. However, it was believed that the earlier D.R. did not deal with the problems towards which

D.R. 61-9 was directed. Accordingly, D.R. 61-9 cited the need for an additional regulation by discussing the benefits to be gained through reduced aircraft speed. Some of the benefits discussed were increased ability of the pilot to see and avoid other aircraft during flight in VFR weather conditions and to enhance the pilot's capability to comply with the procedures associated with instrument flight rules (IFR) operations. It was also mentioned that the proposal would simplify the provisions of standardization of speed and would facilitate the application of control procedures by improving the response of aircraft to pilot actions.

Amendment 60-25 published in the Federal Register November 7, 1961, incorporated D.R. 61-9 into Part 60 of the Civil Air Regulations (CAR). This amendment stated that written comment received in response to Draft Release 61-9 revealed both strong endorsement and strong opposition. For example, one civil aviation organization voiced strong opposition to the proposed rule, emphasizing the economic burden that it felt would be imposed by its adoption. A second organization advocated a speed limit more stringent than the one under consideration, while a third such organization tempered its endorsement with recommendations that the area of applicability be reduced and that the ceiling of applicable airspace be established at 10,000 feet m.s.l.

Amendment 60-25 also mentioned that an informal conference was held on August 24, 1961, at which interested parties elaborated upon their views. During this conference, and as a result of subsequent activities, the FAA felt that sufficient persuasive arguments had been presented to warrant reducing the area in which the speed limitation would be applicable. Accordingly, the area of applicability was reduced to include that airspace below 10,000 feet m.s.l. within 30 nautical miles of the destination airport. A speed limitation of 250 knots was retained but the pilot was permitted to begin reduction of speed at a point he considered to be best suited to current flight conditions.

Thus, Part 60.27 of the Civil Air Regulations pertaining to aircraft speed became effective on December 19, 1961. The substance of this regulation subsequently was incorporated in Part 91.85 of the Federal Aviation Regulations under the Agency's recodification program.

Acknowledgment is made that on the date of the accident there were no FAA-approved devices or systems available on the commercial market which, if installed on either the DC-9 or the Beech Baron aircraft, would have assured positive separation of the two aircraft. However, it is recognized that much time, money, and manpower have been spent by various segments of the aviation community in seeking a means of reducing the risk of midair collisions.

One of the avenues which is presently being explored is the use of a Collision Avoidance System (CAS). Two types of collision avoidance systems have been considered. One is non-cooperative and the other is cooperative. The non-cooperative type would consist of a self-contained unit on board the known aircraft and would not require the intruder aircraft to carry any CAS equipment in order to be detected by the known aircraft. The cooperative type, in contrast, would require both the known aircraft and the intruder aircraft to carry CAS equipment. Because the non-cooperative system would be self-contained, it is generally conceded to be the more desirable of the two. However, studies have shown that the state of the art is such that implementation of a practical non-cooperative system is not within the foreseeable future. Thus, most of the present efforts in the field of CAS have gone toward developing techniques for cooperative systems.

One member of the aviation industry has designed and is currently utilizing a cooperative type CAS in its flight test operations. This company, in addition to other companies working in the CAS field, is presently engaged in developing a commercial version of its collision avoidance systems.

One factor of concern, particularly to those within the general aviation community, is the cost of the airborne equipment now being developed for the CAS. For this reason some consideration has been given to studies of ways for simplification by developing a so-called "minimum station" system. One such comparatively simplified system would consist of only that airborne unit or units which would be required to be on board the intruder aircraft in order for the fully equipped known aircraft to get all the benefits of its own CAS equipment. It is hoped that development of "minimum station" systems will reduce the unit cost and thereby make the advantages of CAS more widely available.

Still another area which has received considerable study has been the development of a proximity warning instrument (PWI). This in its simplest form is an airborne device whose function is to warn the pilot of the proximity of other aircraft. Generally, it is intended to use this device in VFR weather and when closure rates are low enough so that the "see and avoid" concept is valid. This type of device, to be most desirable, should be self-sufficient and as such would not require the installation of cooperative devices in other aircraft in order to be effective. Several members of the aviation industry are working on developments in this area.

The CAS and PWI systems are not intended to be used as a replacement for air traffic control but only as a supplement to the system. Therefore, a fail-safe air traffic control system under the jurisdiction of a central agency exercising control from ground units is at the present time the most adequate method of collision avoidance. However, all types of collision avoidance systems must be given careful consideration until a fail-safe system is developed that applies to all types of aircraft operating under both IFR and VFR weather conditions.

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

This was an operational accident and the search for the causal factors was concentrated in that phase of the investigation. These areas are the operation of the aircraft in the terminal area, the radar capability of the

ARTCC and the RAPCON, and the visual detection of airborne targets by the crews of other aircraft.

The operation of the Beechcraft was, according to the evidence, carried out in accordance with existing FAA regulations pertaining to the conduct of a VFR flight from point to point. Based on the collision geometry and the flight recorder data from the DC-9, it has been determined that when the collision occurred, the Beechcraft was being operated at a proper altitude (approximately 4,500 feet m.s.l.) in accordance with FAR Part 91.109 for the heading being flown (195° magnetic). There was no requirement for the Beechcraft pilot to contact any FAA air traffic control facility, use his transponder, or display the rotating red beacon with which his aircraft was equipped. We do not believe that a requirement for the mandatory use of this equipment would be in order at this time because such a requirement would not necessarily resolve the midair collision problem.

There might, for example, be a greater possibility of accidents occurring if all aircraft were required to display a rotating beacon while in flight without qualifying the conditions under which it must be used. On small aircraft where the beacon cannot be far away from the pilot there is a possibility of inducing vertigo if the aircraft is operated in areas of low visibility or in clouds. This has, in the past, been cited as a cause of general aviation accidents. Also, the record of this investigation indicates that in bright light conditions, the beacon is practically useless because the aircraft carrying the beacon is most often seen before the beacon is detected. The condition where the beacon best serves its purpose is during clear, dark periods.

Similarly, the use of transponders by all aircraft operating in terminal areas could create a hazard because of the problem of "ring-around" or radar scope clutter caused by large numbers of transponder targets. These conditions would force the controller to turn off his transponder receiver or instruct all aircraft to turn their transponders to either low power or standby. Such a requirement would also require radio communication with all aircraft in the terminal areas in order to control the use of the transponders. Finally, with regard to the use of transponders, there are many terminal areas where there is no ground equipment capable of detecting transponder returns because either no radar is installed or the installed radar is not equipped to interrogate airborne transponders.

Any requirement that all aircraft operating in terminal areas be in radio contact with the controlling facility would create a tremendous overload on radio frequencies, would require additional ATC manpower to carry out these communications, and would require all aircraft to be equipped with two-way radios which, in many cases would be used only for this purpose.

In summation, there is no readily available single solution to these problems at this time. The effect of imposing such restrictions on operations in terminal areas would penalize the air transport business by creating unreasonable delays in most terminal areas due to the necessity of providing positive control on all aircraft entering, overflying, and leaving the area, and would overload the existing air traffic control system.

The Beechcraft pilot should have been familiar with the local airway structure by virtue of his frequent flights into the Springfield area and his conversations with the fixed base operator at that airport. He was qualified and his aircraft was equipped for instrument flight, had he desired to conduct one.

During the descent from cruising altitude in preparation for landing at Dayton the cockpit workload of the DC-9 flight crew would probably have been as high or higher than at any other phase of the flight. The crew would have been performing such functions as monitoring air traffic control transmissions, making aircraft heading and speed changes, accomplishing checklist items and looking out for other traffic in the area.

The identification of the captain's voice as having made the ATC radio transmissions during the descent would indicate that he was engaged in acknowledging the controller's instructions while the first officer was probably flying the aircraft. Accordingly, such sounds on the CVR tape as the high-speed warning clacker immediately followed by the landing gear warning horn would indicate that the first officer was making power adjustments as well as heading changes in response to vectors issued by the ATC controller. The captain, as pilot-in-command, would probably have been monitoring these heading and power changes in addition to offering certain instructional comments to the first officer.

The company operating procedure is for the pilot flying the aircraft to go over the checklist silently before requesting the other pilot to read the list aloud. The first officer's comment "ready on the checklist," issued just prior to the collision, could have been such a request. It can be assumed, therefore, that sometime during the descent the first officer had made a complete check of the cockpit, including positioning of certain switches, and was requesting the captain to read the preliminary landing checklist.

The testimony of the radar controllers from the Dayton RAPCON, and the flight test results, indicate that the area of radar coverage beyond 30 miles from their antenna in the vicinity north to northeast of the Rosewood VOR was an area in which light twin-engine aircraft may not provide a good primary radar return at low altitudes. A direct route from Detroit to the Springfield Airport would take the Beechcraft through this area. However, the tests indicated that this area of marginal returns did not exist within 7 miles of the accident site. Therefore, considering the speed of the Beechcraft, it could have been proceeding through an area of adequate primary radar coverage for approximately 2.5 minutes prior to the collision. (From 1151:30 to 1153:50). The Board notes, however, that it is not possible to duplicate exactly the conditions that existed on the date of the accident, particularly with regard to tuning of the radar and reproducing atmospheric conditions, both of which have significant effects on the detection of aircraft targets. Taking into account the inconclusiveness of these tests and the other information in the record regarding the absence of targets in the area of the DC-9 at the time the handoff was accomplished, the Board has no reason to disbelieve the controller's statement when he said he gave the DC-9 crew the conflicting traffic as soon as he saw it on the radar scope.

Under the existing circumstances the controller was required to provide traffic information to Flight 553. He would not normally provide a radar vector to keep the targets separated unless the pilot requested such service. Radar vectors would then be provided subject to time available and or existing workload. Although there were 7 seconds available, the TWA crew did not request an avoiding vector and under the circumstances there was no reason for them to have done so. Even had the TWA crew immediately requested a vector around the given traffic, there would not have been sufficient time for the controller to provide effective vectoring service.

Part 91.85, FAR, restricts an arriving aircraft operating below 10,000 feet m.s.l. within 30 nautical miles of the airport of intended landing to a maximum indicated airspeed of 250 knots. The flight recorder readout indicates that the DC-9 was operating at a speed of 323 knots at the time of the collision, approximately 25 nautical miles from the point of intended landing. The excess speed contributed to the accident in that it reduced the available time for the crew of either aircraft to see and avoid the other or for the controller to take appropriate action. In this connection it is noted that, based on the CVR transcription, the DC-9 crew was devoting some of their attention to speed control, clearance response, maneuvering for the approach, and the pre-landing checklist, shortly before the traffic advisory was issued. This activity could direct both DC-9 pilots' attention inside the cockpit, reducing the effectiveness of any visual search for potentially conflicting traffic.

It is noted that the DC-9 crew acknowledged receipt of the controller's radio transmission relating to traffic information by using the word "roger." The word "roger" normally means that the pilot has received and understood the transmission, and is the usual response of many pilots under similar circumstances. It is believed that sound safety practice warrants an immediate response from the crew involved as to their visual sighting or failure to sight the target indicated by the controller. A more informative response would be an immediate "roger no contact" or "roger, have him in sight," whichever is the case. This amplified response would alert the controller to the necessity to continue following the traffic and take further action if the need arose.

From the presentation in Attachment No. 2, it is apparent that, between times 1152:50 and 1153:35 and again from 1153:45 to 1153:50, the Beechcraft was in such a position as to be visible to the DC-9 captain in the center windshield. During this same period of time, however, the target as presented to the first officer of the DC-9 would have been partially obscured by the windshield post to the right hand side of his front windshield. Both these calculations assume the pilots to have been in the normal position in their seats, and that they did not move forward to the alert position. Had either or both of them moved their heads forward to the alert position, they would have enhanced their ability to detect the target presented by the Beechcraft.

Attachment No. 2, page 3, depicts the position of the DC-9 in relation to the left side cockpit cabin window of the Beechcraft. It was in a position to be seen by the Beechcraft pilot. However, the geometry of the situation would have required the Beechcraft pilot to look to his left between 92 and 108° and between 6 to 14° up to see the DC-9.

Although the DC-9 was in the clear glass area of the Beechcraft side window, the Board is of the opinion that the attention of the Beechcraft pilot was predominately focused in the direction of his flightpath. It is reasonable to assume that pilots who are proceeding under VFR conditions and maintaining a lookout for other aircraft can expect other pilots to do the same.

The primary responsibility of all pilots operating under VFR conditions is to assure that they have a clear flightpath and to avoid other traffic in that airspace. The present day "see and be seen" concept is based on all flight crews maintaining a lookout for other aircraft when they are operating under VFR flight conditions. This applies equally to the crew of the DC-9 who, although they were operating on an IFR flight plan, were in VFR conditions and were required to maintain their own lookout for other traffic in their flightpath. In addition, the DC-9 crew received an accurate traffic advisory from the RAPCON controller concerning the conflicting traffic, an advantage not afforded to the Beechcraft pilot.

The right-of-way rules are specific on two counts in this instance. The rule governing traffic gave the right-of-way to the Beechcraft who was on the right, as did the rule regarding an overtaken aircraft being given the right-of-way. In both instances the Beechcraft had the right-of-way and the DC-9 crew was required to alter course. Nothing is implied here to indicate that, had the Beechcraft pilot seen the DC-9, he should stubbornly maintain course expecting the DC-9 to take the necessary evasive action. All indications are that the Beechcraft pilot did not see the DC-9.

Based on the lack of intra-cockpit conversation concerning the traffic given to the DC-9 crew and the lack of evasive maneuvers on the part of the DC-9, the Board concludes that the DC-9 crew did not observe the Beechcraft.

While there were certainly a number of conditions which might have hindered the visual detection of the Beechcraft from the DC-9, such as haze, the lessened contrast between the red and white Beechcraft and the partially snow-covered ground, and the small size of the target, the DC-9 crew should have been able to detect the Beechcraft in time to avoid the collision.

In view of the evidence the Board concludes that, although each aircraft was in a position to see and be seen by the other at a distance of approximately 4 miles, each of the involved aircrews failed to see and avoid the other. The DC-9 was the overtaking, converging aircraft and thus in the better position to afford the pilots an opportunity to observe and avoid the Beechcraft. Therefore, primary responsibility for avoiding traffic within its flightpath rested with the DC-9 crew.

The lack of positive control over aircraft operations conducted in terminal areas under the present day air traffic control system is not satisfactory. Had the Beechcraft been under the control of an air traffic controller the accident could have been avoided because the controller could have arranged to sequence the two aircraft in such a manner as to avoid any converging of their flightpaths. The Board is aware, however, that present day air traffic control facilities are not adequate to handle the workload which would be created by requiring positive control of all aircraft operating in terminal areas. Until such time as the air traffic control system is able to provide positive separation between aircraft at all times, or some other system to achieve the safe separation of aircraft is available, some version of the "see and be seen" concept will have to be used by all aircrews operating in VFR flight conditions.

In operating in a "see and be seen" environment, particularly in the vicinity of terminal areas, constant vigilance must be maintained by all pilots and by controllers, both in handling aircraft under positive control and in furnishing radar advisories concerning noncontrolled traffic. This is especially critical in terminal areas such as Dayton where there is a mix of large high speed aircraft and small relatively low speed aircraft which present a high potential for hazard.

The Board recognizes that the operation of high speed aircraft with accelerated closure rates; frequent, but necessary, diversion of attention to cockpit duties; and current conspicuity problems, places a difficult burden upon flight crews. Nevertheless, maximum vigilance must be maintained in terminal areas when operating in a "see and be seen" environment. The aid provided flight crews by ATC in the form of radar traffic advisories is critical to safe operations in this environment. To provide the protection required, the system must bend every effort to provide advisories of conflicting traffic as soon as possible. To this end, the most reliable equipment available must be utilized and controllers must be continually vigilant for targets which may appear to be on converging courses.

The professional background of the DC-9 flight crew was such as to conclude that they had been exposed innumerable times to the congestion of terminal areas such as Dayton. Any pilot is, or most certainly should be, well aware that terminal areas are areas of congestion where a mix of high and low speed aircraft operating with or without IFR flight plans in VFR weather can be expected. If there are any portions of flights during which greater vigilance is required to clear visually the flightpath and prepare to yield the right-of-way, it is those portions conducted in a terminal area.

Dayton has been classified as a medium hub, with approximately 45,000 scheduled arrivals and departures annually. Of the 34 medium hubs, Dayton ranks twelfth in respect to traffic congestion. In addition, several general aviation airports, and two military airports located at Wright-Patterson AFB, add to the congestion.

Although it cannot be stated that traffic at the time of Flight 553's entry into the terminal area was heavy, the DC-9 crew had no way of knowing this. They should be expected to enter and operate in this terminal area, or any terminal area, with caution and vigilance in anticipation of traffic congestion.

2.2 Conclusions

(a) Findings

1. Both aircraft were properly certificated and airworthy at the time of their last takeoff.

2. Both flight crews were properly certificated and qualified to conduct the flights.

3. There is no evidence of any malfunction of either aircraft or any component thereof before the collision occurred.

4. The Beechcraft was operating on a VFR flight without flight plan and none was required.

5. The radar transponder aboard the Beechcraft was not being utilized nor was it required.

6. The Beechcraft was operating on a magnetic heading of approximately 195° and at an altitude of approximately 4,500 feet m.s.l.

7. The DC-9 was descending to 3,000 feet on a heading of approximately 232°.

8. The weather was suitable for VFR operation in the accident area. The sun was in such a position as not to affect the detectability of either aircraft by the crew of the other.

9. The Beechcraft pilot was not in radio contact with any FAA controlling facility and no such contact was required.

10. The Beechcraft pilot was in radio contact with the Springfield Airport just prior to the collision.

11. There was no way the Beechcraft pilot could have been warned of the fact that his intended flightpath would intersect that of the DC-9.

12. The DC-9 was operating on an IFR flight plan under radar control of the FAA throughout the flight.

13. The DC-9 radar transponder was operating and being observed by the Dayton RAPCON controller. The rotating beacon, actuated by the flight recorder switch, was operating at the time of the collision.

14. The headings and altitudes of the DC-9 were being flown in accordance with instructions from FAA controllers for an approach and landing at Dayton, Ohio.

15. The RAPCON controller advised the DC-9 crew of the presence of a slow speed target at 12:30, 1 mile. This warning was acknowledged approximately 14 seconds before the collision.

16. The CVR indicates that the DC-9 crew never detected the traffic reported to them even though it was displayed in the clear glass areas of the windshields before the traffic advisory was issued.

17. The DC-9 crew was in a better position than the Beechcraft pilot to see and avoid the other aircraft.

18. Approximately 5 seconds should have been sufficient to detect the target and initiate a change in direction of the DC-9.

19. The aircraft response time would have been approximately 3 seconds.

20. There is no evidence of any attempted evasive action by either crew.

21. The Beechcraft appeared on the radar scope at the Dayton RAPCON as a primary target and the controller reported the target to the DC-9 crew as soon as he determined the aircraft were on conflicting courses.

22. The Dayton RAPCON radar has an area where poor primary radar returns are occasionally received from light twin-engine aircraft and the Beechcraft passed near or through this area prior to being observed by the controller.

23. There was an area of good primary radar return between the accident site and a point approximately 7 miles north.

24. Flight checks indicate the Dayton RAPCON radar is suitable for performance of its function as an aid of air traffic control in accordance with existing criteria.

25. The collision occurred at an altitude of approximately 4,525 feet m.s.l. The time of the collision was 1153:50.

26. The descending DC-9, overtaking and converging from the left, struck the level Beechcraft from the left rear quarter.

27. The collision angle between longitudinal axes of the two aircraft was approximately 47° in the horizontal plane and 10° down in the vertical plane.

28. The collision destroyed the Beechcraft by causing it to disintegrate, and the pilot was killed instantly.

29. Portions of the Beechcraft penetrated the forward fuselage section of the DC-9 and destroyed the integrity of the DC-9 flight control system.

30. The DC-9 entered a descending left turn, crashed and burned.

31. Under existing right-of-way rules, the right-of-way belonged to the Beechcraft pilot.

32. The Beechcraft pilot, while flying in an area of increased traffic potential, did not use his radio or transponder to make his presence known to the air traffic controllers; however, he was not required to do so.

(b) Probable Cause

The Board determines the probable cause of this accident was the failure of the DC-9 crew to see and avoid the Beechcraft. Contributing to this cause were physiological and environmental conditions and the excessive speed of the DC-9 which reduced visual detection capabilities under an air traffic control system which was not designed or equipped to separate a mixture of controlled and uncontrolled traffic.

Corrective Action

When the Board considers the Air Traffic Control (ATC) aspects of this accident, it must reflect for a moment on the capabilities of the present Air Traffic System with respect to collision prevention.

Historically, the primary goal of Air Traffic Service has been to provide for the safe, orderly, and expeditious flow of air traffic. One key factor in the entire ATC operation, past and present, is that control service or traffic separation is predicated upon "known traffic." Insofar as the ATC system and the procedures utilized for the control of known traffic are concerned, past records show that the Air Traffic Service has enjoyed a high degree of success in achieving the desired goal.

In the past 20 years, the Air Traffic Control System has developed slowly to the point where it must now be considered a highly complex operation. Primary factors in system development were the technical advances in the state of the art concerning communications, radar, and electronic navigational aids. Efficient utilization of the navigable airspace is also significant. One factor believed most responsible for the many improvements to the ATC System has been the ability of the aircraft manufacturers to produce, in ever increasing numbers, aircraft of advanced design with performance capabilities that exceed the ability of the ATC System to handle these aircraft efficiently. This has stimulated progress in system development, but the race between aircraft design and development of a safe, efficient, modern Air Traffic Control System has been one in which the ATC System usually lags behind. Although many of the same basic concepts of traffic control utilized 20 years ago are still evident in today's system, the introduction of computers, high speed printers and other means of automation now being used in modern facilities, have modified the system to such a degree that only the basic concept remains. Furthermore, advanced electronic navigational aids which make possible a better airways system, the establishment of positive control airspace for high altitude flight operations, remote radars, altitude reporting transponders, remote radio communications, etc., have also modified the system significantly. However, the ATC System with all of its improvements needs further refinement to gain the additional measure of safety required to handle present and future generations of aircraft.

In this accident, the Dayton area control procedures and facility equipment available for traffic control are not unlike those utilized in other high density terminal areas within the ATC System.

It is the Board's opinion that insofar as the existing ATC system is concerned, the equipment and procedures utilized by those facilities controlling air traffic may provide adequate safeguard for handling known traffic, but an equivalent level of safety is not provided when unknown traffic operations are mixed with known traffic.

The facts developed by the investigation of this accident show that facility equipment was operating satisfactorily and the control service provided TWA Flight 553 was rendered in accordance with specified procedures. Just prior to the collision, the Dayton controller observed unknown traffic on his scope which he judged to be on a conflicting course with Flight 553. Under the existing conditions and circumstances the controller's only procedural requirement was that he provide a traffic advisory to Flight 553, and this was accomplished. That advisory should have assisted the crew in the performance of their duties to search for, detect, and avoid conflicting traffic while operating in VFR conditions. However, it is fact that the traffic advisory given to TWA 553 did not prevent the accident. The Board also recognizes that the "see and be seen" concept is not a practical solution to the problems of high-speed closure rates which, on certain occasions, confront the crews of modern aircraft.

The situation as it now exists is one in which ATC cannot assure an appropriate level of safety between "known" and "unknown" traffic operations, nor can the pilots of high-speed modern aircraft safely operate these aircraft in accordance with "see and be seen" VFR right-of-way rules in the short period of time available to them for detection and corrective action.

One answer to this perplexing problem might lie in a program whereby larger segments of the navigable airspace be designated as positive control areas to include terminal areas. Operation in positive control airspace normally requires that: the aircraft operate under IFR at a specific flight level assigned by ATC; the aircraft be equipped and instrumented for IFR; the pilot must be rated for instrument operation; and the aircraft must have an operational transponder and two-way radio. It may well be that in those areas where the radar coverage is adequate for designation as a positive control area this type of operation could prevent recurrence of an accident of this type. Such a program would not be without impact on many of the airspace users and would be subject to many limitations including economic considerations.

Recognizing that almost any approach to the problem of ensuring greater safety for present day flight operations is one in which the cost will usually be objectionable to some, the Board is of the opinion that the development of a practical Collision Avoidance System (CAS), suitable for use on the majority of aircraft, would provide a great contribution to flight safety. Such a system would detect a potential collision hazard, call the pilot's attention to the hazard, and display the evasive action required by the pilot in order to avoid a collision. The system would be automatic and intended to be utilized when operating under both IFR and VFR weather conditions. A CAS would serve to supplement the ATC system by increasing flexibility, and also return a measure of control to the cockpit. Since the ATC system is basically a cooperative system, the CAS would therefore tend to restore balance to a system which has in the past been moving progressively in the direction of control from the ground to a point fast approaching the limits of effectiveness. It is still in the experimental development state, however.

Subsequent to the accident the FAA took action aimed at prevention of similar accidents.

On August 15, 1967, the FAA issued Advisory Circular No. 90-32 titled Air Traffic Control and General Operations, Radar Capabilities and Limitations. The stated purpose of this Circular was to . . . "advise the aviation community of the inherent capabilities and limitations of radar systems and the effect of these factors on the service provided by air traffic control facilities." This Circular discussed the capabilities and limitations of the air traffic control radar and concluded that radar is highly beneficial to the control and separation of IFR air traffic, but some aircraft may not be seen. This fact, together with the increasing amount of traffic which is flying while not radar-identified and under control of ATC facilities, decreases the capability of a controller to cope with every contingency which may arise and occasionally precludes his capability to provide traffic advisory services. After separation between controlled traffic has been ensured, the controller may then direct his attention to providing additional services such as radar advisories to visual flight rules aircraft. The pilot who requires these services will substantially assist the controller, and himself, by immediately advising the controller of the exact nature of his request, weather conditions, type of aircraft, route and type of flight plan, altitude, magnetic heading, as well as by understanding ATC radar and controller limitations.

The FAA has adopted a rule establishing that all aircraft flying below 10,000 feet, m.s.l., will be limited to a maximum speed of 250 knots effective December 15, 1967. The rule was promulgated to ". . . provide a more realistic 'see and avoid' environment in the airspace below 10,000 feet mean sea level (MSL) where traffic congestion is greatest. . . ."

It is recognized that speed control is only part of the answer to the collision threat, and the Administrator is presently studying the feasibility of climb and descent corridors for use by high performance aircraft at major air terminals.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOSEPH J. O'CONNELL, JR.
Chairman

/s/ OSCAR M. LAUREL
Member

/s/ JOHN H. REED
Member

/s/ LOUIS M. THAYER
Member

/s/ FRANCIS H. McADAMS
Member

CREW INFORMATION

Captain Karl B. Kohlsaat, age 39, was employed by TWA on April 2, 1956. He possessed airline transport pilot certificate No. 1179537 with type ratings for the Lockheed Constellation, B-720/707, DC-9, and commercial privileges, airplane single-engine land. His last First-Class Medical Certificate was dated December 20, 1966, and there were no waivers or limitations against this certificate.

Captain Kohlsaat had 9,832 1/ hours flying time including 1,364 of military time. Of this, 193 hours were logged in the DC-9. He had flown the DC-9 136 hours in the last 90 days. The captain's rest period prior to this trip was 31 hours and he had not flown in the 24 hours preceding the trip. He had flown approximately 2:11 hours immediately prior to the accident.

Captain Kohlsaat completed initial DC-9 captain's training on November 1, 1966, DC-9 line qualification November 14, 1966, and had his last line check February 23, 1967.

First Officer Donald Binder, 29, was employed by TWA July 12, 1965. He possessed a commercial pilot certificate No. 1628329 with airplane single and multi engine land and instrument ratings. His last First-Class Medical Certificate was dated January 9, 1967, and there were no waivers or limitations against this certificate.

Mr. Binder had a total flying time of 1,560 hours including 1,156 accumulated as a naval aviator prior to his employment by TWA. His total DC-9 flying time was 15 hours. He had flown 290 hours during the preceding

1/ Flying times are reported to the nearest hour unless otherwise noted.

year including 5 hours in the seven days preceding the accident. He completed DC-9 first officer training February 3, 1967, and completed his line qualification on February 12, 1967. The flight which terminated in the accident was Mr. Binder's second scheduled flight as a first officer in DC-9, although he had performed as a first officer on Constellation aircraft since his employment with TWA. Mr. Binder's crew rest time was the same as the captain's.

The two flight attendants were regularly employed by TWA for that position and their training records indicate their emergency training was current.

Mr. Cyrus H. Burgstahler, 54, was the pilot and sole occupant of the Beechcraft. He possessed a private pilot certificate No. 1274805, with airplane single and multi engine land and instrument ratings. His third-class medical certificate was dated July 13, 1966, and contained the limitation, "Holder shall wear correcting glasses while exercising the privileges of his airman certificate." 2/ The FAA reports that the limitation on Mr. Burgstahler's certificate was not required and was incorrectly affixed to that certificate. The last FAA physical examination for Mr. Burgstahler recorded his vision to be: distant vision 20/30 right eye; 20/20 left eye; and 20/20 both eyes. These values were corrected to

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2/ Section 67.17 of Part 67 of the Federal Aviation Regulations states in part: "67.17 Third-class medical certificate. ... (b) Eye: (1) Distant visual acuity of 20/50 or better in each eye separately, without correction; or if the vision in either or both eye is poorer than 20/50 and is corrected to 20/30 or better in each eye with corrective glasses, the applicant may be qualified on the condition that he wear those glasses while exercising the privileges of his airman certificate.

20/15-3 in each instance. His near vision was: right eye 20/30; left eye 20/30; both eyes 20/30; and these values were corrected to 20/20 in each instance.

Mr. Burgstahler's pilot logbook was reviewed and it reflected a total flying time of 4,074 hours through March 2, 1967. This included 575 hours in Beechcraft Model B-55 aircraft of which 493 hours were in the aircraft involved in the accident. He had recorded 274 hours in the preceding year and 37 hours in the preceding 90 days. The flights recorded in the logbook were predominantly cross-country and contained entries of one flight from Detroit to Dayton and twelve entries of flights between Detroit and Springfield. The last recorded flight from Detroit to Springfield was dated March 2, 1967.

It was learned that Mr. Burgstahler reported for work on the morning of March 9 about 45 minutes earlier than his normal schedule. He had retired at about 2300 March 8 and had followed essentially the same schedule for the 3 days prior to the accident.

AIRCRAFT INFORMATION

The DC-9, N1063T, was manufactured by the Douglas Aircraft Company. An Airworthiness Certificate issued by the FAA on January 13, 1967, indicated the date of manufacture was January 11, 1967. It had accumulated 309 hours since new and 129 hours since its last Station Service Check. The aircraft was equipped with two Pratt & Whitney JT8D-7 engines which were being operated as JT8D-1's. Both engines had 309 hours recorded operating time. The aircraft records indicated the aircraft was maintained in accordance with TWA's FAA approved maintenance procedures. According to ground maintenance personnel at Pittsburgh, the last point of departure, the flight crew did not report any malfunctions nor request any maintenance for the aircraft or any of its systems. The aircraft records indicated that all applicable airworthiness directives had been accomplished. There was no record of pilot or maintenance writeups indicating deficiencies or malfunctions in the pitot static system. All non-routine safety of flight items had been accomplished, according to the records, and no open items were found.

The last recorded maintenance performed on the aircraft, aside from routine en route servicing, was accomplished at New York City prior to departure on March 9, 1967. This work consisted of replacing the flight recorder tape, inspection of the auxiliary pitot-static system, tightening a filter bleed which was leaking water into the galley and electronics compartment, and replacement of 5 electronic components of the navigation and communications systems which had been exposed to the water.

There were no known or reported maintenance discrepancies that could be related to this accident.

Computation of the aircraft weight and balance showed the aircraft to have been within both weight and center of gravity limits from takeoff to the time of the collision. The takeoff weight was reported to be 73,069 pounds and fuel burn-off was computed to be 3,680 pounds resulting in a computed gross weight at collision of 69,389 pounds. The extreme center of gravity (c.g.) positions computed were: With all passengers seated forward the c.g. would have been 21.7%; with all passengers seated aft the c.g. would have been 34%. The limits for the c.g. were 15.3% forward and 39.2% aft at a gross weight of 69,389 pounds.

The Beechcraft Baron B-55, N6127V, was manufactured by the Beechcraft Company. An Airworthiness Certificate issued by the FAA March 15, 1965, indicated the date of manufacture was March 13, 1965. The aircraft had accumulated 489 hours flying time as of March 2, 1967. The last periodic inspection was accomplished April 27, 1966, the last 100-hour inspection September 21, 1966, and the last 25-hour inspection February 27, 1967.

The Beechcraft was equipped with two Continental IO-470-L engines which were installed on the aircraft at the time of delivery. The engines were equipped with Hartzell PHC-A3VF-2B propellers that were also installed at delivery. The aircraft records indicated there was no malfunctioning or inoperative equipment aboard the aircraft when it left Detroit March 9, 1967. The aircraft was equipped with the required navigational and communications equipment and instrumentation for instrument flight. This equipment included an operational transponder and automatic pilot as well as dual, rotating anti-collision lights.

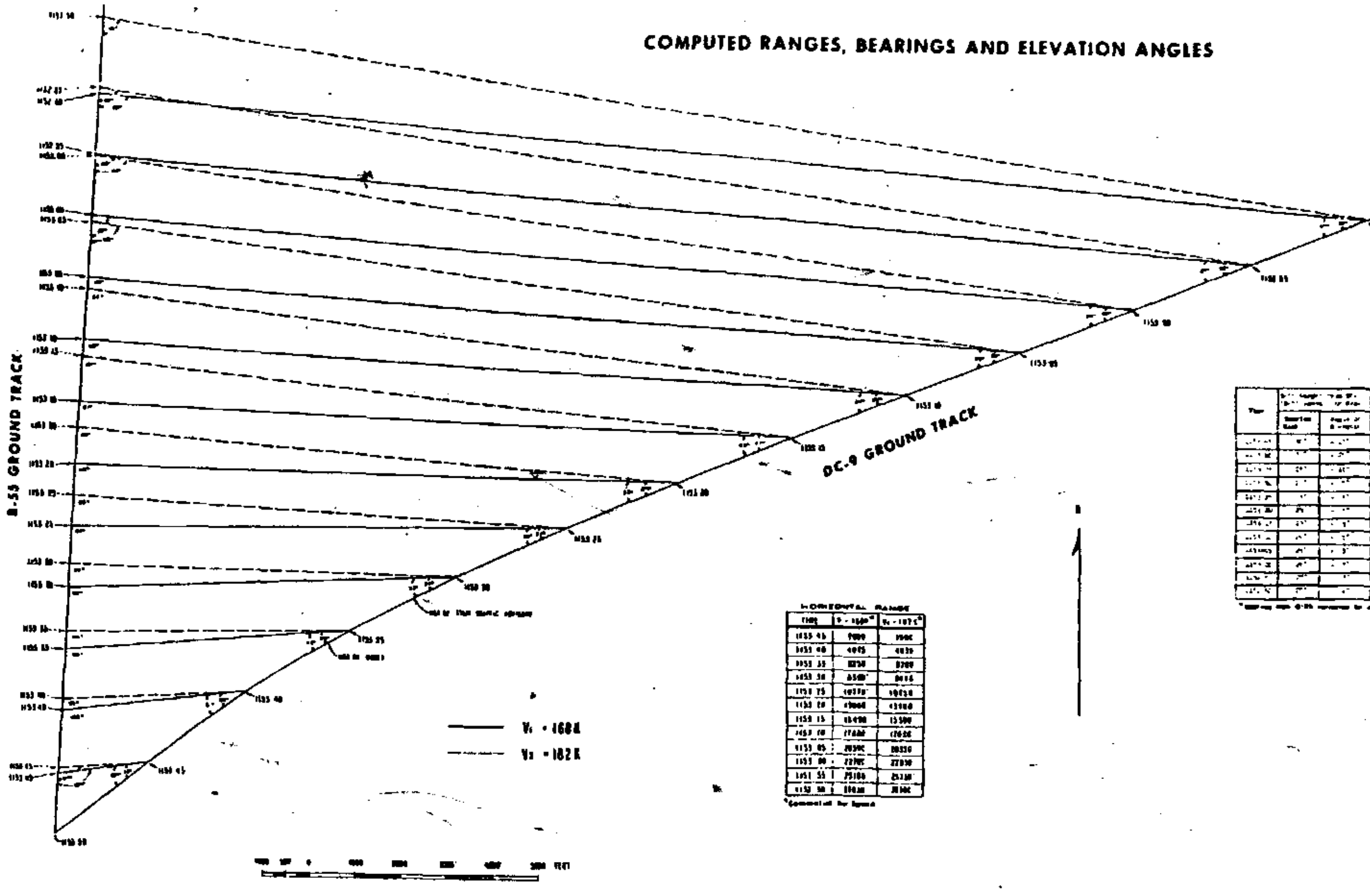
The last recorded maintenance on the pitot-static system was accomplished on June 24, 1966, when a loose "B" nut behind the copilot seat was tightened. The last recorded instrument maintenance was accomplished February 2, 1967, when a directional gyro was removed and replaced. The aircraft records indicated that all applicable FAA Airworthiness Directives had been accomplished.

The gross weight of the Beechcraft was computed to be 4,472.9 pounds at takeoff from Detroit and 4,306 pounds at the time of the collision. The c.g. was computed to be within limits throughout the flight.

The DC-9 was serviced with Jet A turbine fuel and the Beechcraft was serviced with 100 octane gasoline.

ATTACHMENT I

COMPUTED RANGES, BEARINGS AND ELEVATION ANGLES



HORIZONTAL RANGE

TIME	[illegible]	[illegible]
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1153 40	[illegible]	[illegible]
1153 35	[illegible]	[illegible]
1153 30	[illegible]	[illegible]
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1153 15	[illegible]	[illegible]
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1153 05	[illegible]	[illegible]
1153 00	[illegible]	[illegible]
1152 55	[illegible]	[illegible]
1152 50	[illegible]	[illegible]

NATIONAL TRANSPORTATION SAFETY BOARD
DEPARTMENT OF TRANSPORTATION
WASHINGTON D.C.

TWA DC-9, N1063T/TANN COMPANY
BEECHCRAFT B-55 N6127V
IN FLIGHT COLLISION NEAR URBANA, OHIO
MARCH 9, 1967

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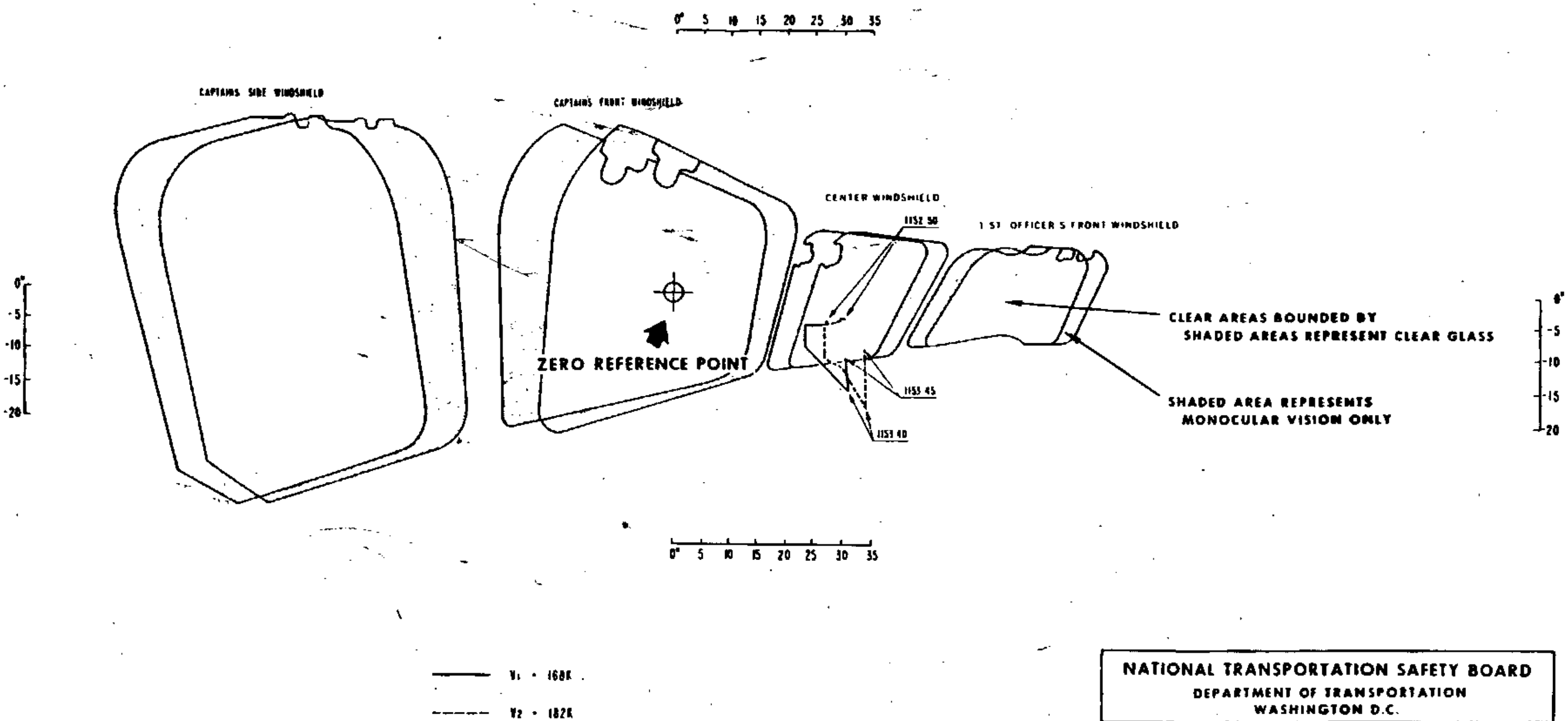
ATTACHMENT 2
PAGE 1

CALCULATED DC-9 PILOT'S VIEW



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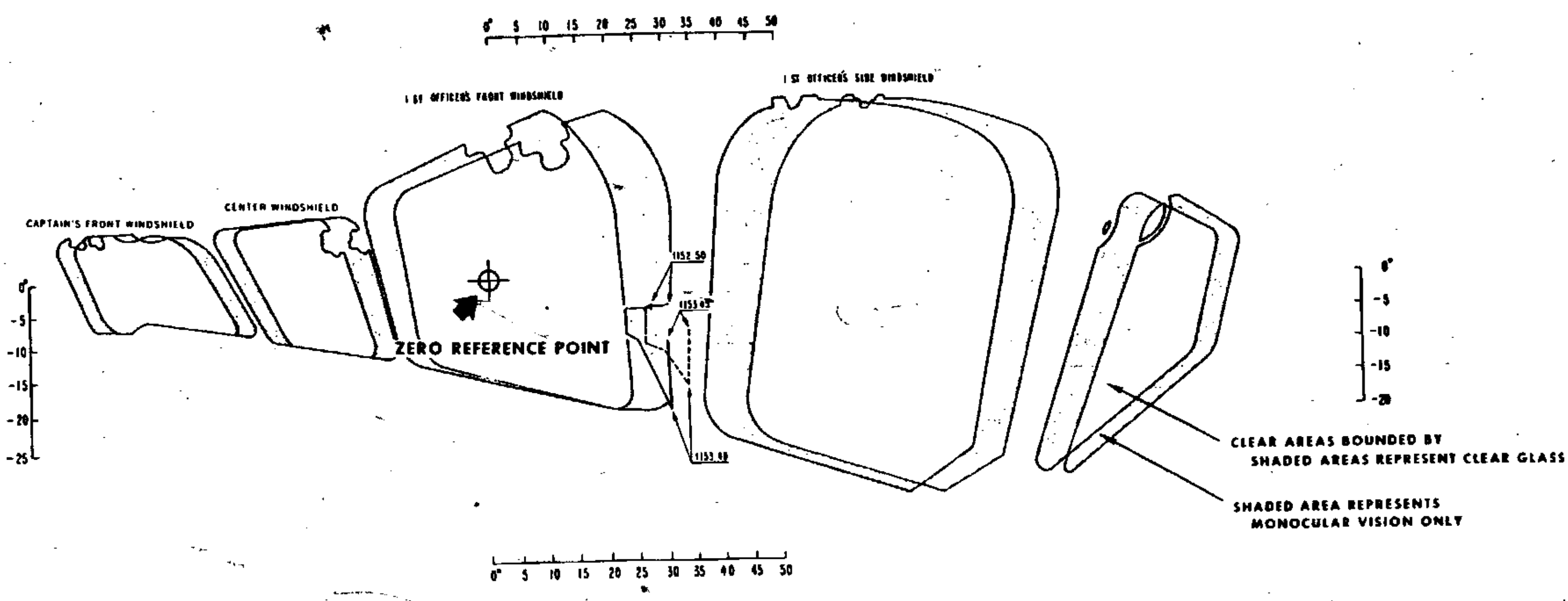
BEECHCRAFT B-55 N6127V
INFLIGHT COLLISION NEAR URBANA, OHIO
MARCH 9, 1967

CALCULATED DC-9 1st OFFICER VIEW



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BEECHCRAFT B-55 N6127V
IN FLIGHT COLLISION NEAR URBANA, OHIO
MARCH 9, 1967

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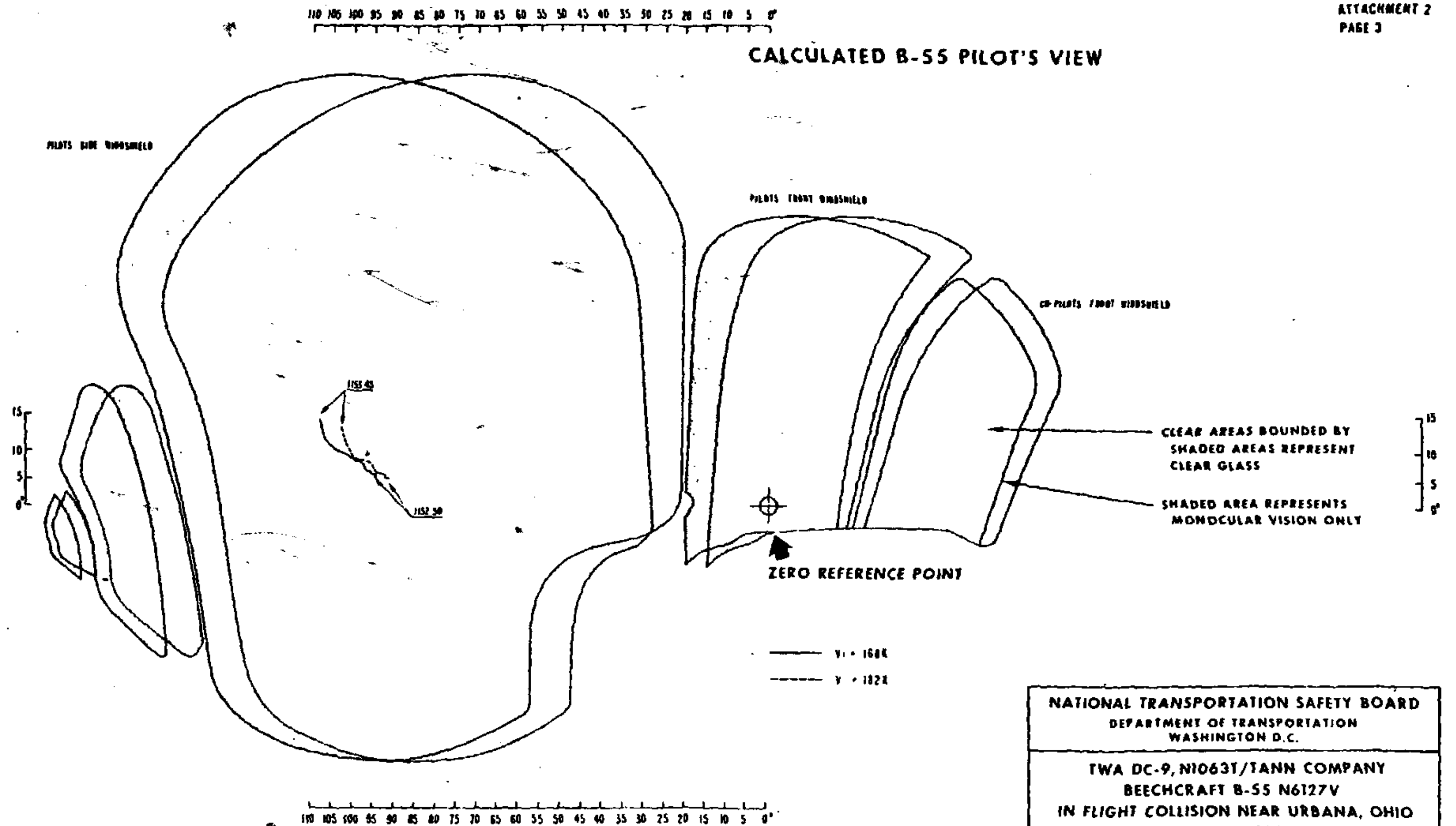
CALCULATED B-55 PILOT'S VIEW



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TWA DC-9, N1063T/TANN COMPANY
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