SA-405

File 1-0011

AIRCRAFT ACCIDENT REPORT

Adopted: July 8, 1969

NORTH CENTRAL AIRLINES, INC.

CONVAIR 580, N4634S

HOME AIRMOTIVE, INC.,

CESSNA 150, N8742S

MIDAIR COLLISION NEAR

MILWAUKEE, WISCONSIN

AUGUST 4, 1968

NATIONAL TRANSPORTATION SAFETY BOARD
DEPARTMENT OF TRANSPORTATION
WASHINGTON D.C. 20591

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SYNOPSIS

At 0948 c.d.t., on August 4, 1968, North Central Airlines Flight 261, a Convair 580, N4634S, and a Home Airmotive, Inc., Cessna 150, N8742S, collided approximately 11.5 miles southwest of General Mitchell Airport, Milwaukee, Wisconsin, at an altitude of 2,700 feet. All major components of the Cessna fell to the ground, with the exception of the cabin section with its three occupants and the attached landing gear, which were embedded in the Convair's forward baggage compartment. Damage sustained by the Convair was extensive, but controlled flight was maintained by the captain and a successful landing was accomplished at General Mitchell Field at 0954.

The three occupants of the Cessna were killed in the accident, and the first officer on the Convair sustained serious injuries. The captain, stewardess, additional crewmember, and eight passengers on board the Convair were not injured.

The Cessna 150, rented by a private pilot from Home Airmotive, Inc., departed Mitchell Field, Lombard, Illinois, about 0900 on a flight to Sheboygan, Wisconsin. The flight was conducted under Visual Flight Rules without a filed flight plan, and there was no known radio contact with any ground station during the flight. Evidence indicated that the Cessna was on an approximate heading of 314° when the collision occurred.

North Central Airlines Flight 261 departed O'Hare International Airport, Chicago, Illinois, at 0934 on an

Instrument Flight Rules flight plan to Milwaukee. At the time of the collision, the crew was in radio and radar contact with Milwaukee Approach Control, and the flight had been cleared to descend to 2,600 feet on a vector heading of 350° for an intercept with the Instrument Landing System localizer course serving Runway 7R.

During the 2 minutes prior to the collision, Flight 261 was issued three consecutive radar traffic advisories which described a target as "twelve thirty, four miles, northbound" then "one o'clock, three miles, northbound," and, finally, "one o'clock, a mile and a half, north-northwest bound." The Convair flightcrew searched for this target but were unable to sight it until immediately prior to impact when it was too late to take evasive action. Their detection efforts were hampered by a dense concentration of insect smears on the forward windshield and direct vision windows, which had accumulated at a heavy rate during the flight.

The surface weather observation made at 0920 at General Mitchell Field indicated that the visibility was 3 miles in haze and smoke.

The Board determines that the probable cause of this accident was the inability of the Convair 580 flightcrew to detect the Cessna 150 visually in sufficient time to take evasive action, despite having been provided with three radar traffic advisories concerning the latter aircraft. Visual detection capabilities were substantially reduced by the heavy accumulation of insect smears on the forward windshield and direct vision windows of the Convair. Visibility was further reduced by haze, smoke and sun glare, and by the inconspicuous color and lack of relative motion of the Cessna. Under these circumstances, the crew of the Convair should have requested a radar avoidance vector.

1. INVESTIGATION

1.1 History of the Flight

At 0948 c.d.t., 1/ on August 4, 1968, North Central Airlines Flight 261, a Convair 580, 2/ N4634S, and a Cessna 150, N8742S, owned by Home Airmotive, Inc., and rented to a private pilot, were involved in a midair collision which occurred approximately 11.5 miles southwest of General Mitchell Field, Milwaukee, Wisconsin, at an altitude of 2,700 feet. (See Attachment 1.) The Cessna was destroyed and its three occupants received fatal injuries. The Convair was damaged extensively, but its crew was able to maintain controlled flight and a successful landing was accomplished at General Mitchell Field. The first officer on the Convair sustained serious injuries while the captain, additional crewmember, stewardess and eight passengers were not injured.

North Central Flight 261 was a regularly scheduled passenger flight between O'Hare International Airport, Chicago, Illinois, and Manitowoc, Wisconsin, with an en route stop at General Mitchell Field in Milwaukee. The flight departed O'Hare Field at 0934, 9 minutes behind schedule, with an Instrument Flight Rules (IFR) clearance to Wind Lake Intersection via radar vectors direct. Departure instructions were to maintain runway heading (320°) and climb to 5,000 feet.

The first officer was operating the controls from his right seat position on this particular flight in accordance with the general airline practice of rotating flight segments between the pilots. The captain was handling the radio transmissions.

During climbout, the flight encountered an unusually heavy accumulation of insect strikes on the windshield. The captain compared the situation to a "snow shower" in

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1/ All times herein are central daylight based on the 24-hour clock.

2/ Although the technically correct designation for N4634S is Allison Prop-Jet Convair 340, this type of aircraft is most commonly referred to as a Convair 580, which is the terminology used throughout this report.

which "ice was accumulating on the windshield at an enormous rate." In view of the insect problem, the flight requested, and subsequently was granted, clearance to 7,000 feet. The captain stated that the insect accumulation continued at 7,000 feet, but at a lesser rate than was experienced at lower altitudes.

Flight 261 was handed off from O'Hare Departure Control to the Chicago Air Route Traffic Control Center, which cleared the flight to Wind Lake Intersection, via Victor Airway 479, at 7,000 feet. The Center, in turn, transferred control of Flight 261 to Milwaukee Approach Control, which located the radar position of the flight at or near the centerline of Victor 479.

After establishing radio contact at 0943:58, Approach Control cleared Flight 261 to "fly heading three five zero, descend and maintain . . . two thousand six hundred for a vector to the runway seven right ILS landing straight in."3/ During the 2-minute period prior to the collision, Approach Control transmitted three radar traffic advisories to Flight 261 which provided azimuth, range, and movement information on two unidentified aircraft ahead of the flight. One of these targets was consecutively described as "twelve thirty, four miles, northbound, slow moving" (0946:24), then "one o'clock, three miles, northbound" (0947:02), and finally "northbound target, one o'clock, mile and a half, north-northwest bound" (0947:35).

The captain and first officer on Flight 261 stated that they searched in the direction of the traffic advisories provided by Approach Control, but were unable to sight any of the reported targets. They stated that the forward visibility during this period was restricted considerably, due to the insect accumulation on the windshields as well as to the haze and smoke which increased in density throughout the descent. In addition, they stated that the position of the sun was such as to create a glare or halo effect in combination with the haze, particularly when looking to the right of the nose of the aircraft.

The captain estimated that the visibility through his side window was 1 to 2 miles based on his sighting of

3/ The communications between Milwaukee Approach Control and Flight 261 are set forth in full in the Communications Section.

Wind Lake, which, along with Muskego Lake, was detected by him shortly after receiving the 0946:24 advisory. Both the captain and the first officer described visibility through the front windshield and direct vision windows as extremely limited.

Both of the Convair pilots stated that they caught a glimpse of the Cessna just prior to impact. The first officer reported that he first saw the other aircraft at the 1:30 position, but that he "wouldn't even estimate the distance. It was close, very close .... a matter of ... yards." However, he was able to identify the type and color of the aircraft, as well as the fact that it was closing on an intercept angle of approximately 30°. He further stated that the proximity of the other aircraft precluded any evasive action. Following the momentary glimpse of the Cessna, his next recollection was the sound of impact.

Two passengers, who were seated on the right side of the Convair, stated that shortly prior to the collision they caught sight of a small aircraft which was ahead and to the right of the Convair and flying toward them at nearly a right angle. They lost sight of this aircraft, and moments later impact occurred.

There were two ground witnesses to the collision, both of whom were located in a barnyard slightly southeast of the collision point. They initially observed the larger plane flying in a northerly heading, with the small plane approaching the larger one on a converging angle of approximately 60 to 90°. They stated that the two aircraft flew straight towards each other, with no sign of any evasive maneuver. One of them continued to watch the two aircraft until they collided, after which the "large airplane jolted and made a sight left turn and then continued flying north." The other witness looked away when the two aircraft were still about three-quarters of a mile apart, heard the sound of collision several seconds later, and then looked back and saw pieces of aircraft falling to the surface. Shortly after the collision, he saw another light aircraft about 2 miles northeast of his position, flying in a southeasterly direction.

The radar controller who was handling Flight 261 at the time of the collision stated that he issued traffic advisories on targets that he considered might be a factor

for that flight. With respect to the three advisories reporting a "northbound" or "north-northwest bound" aircraft, the controller described the track of this target as paralleling the track of Flight 261 until the third advisory, when the former turned toward the latter. The controller could not recall what happened to this target after it turned toward the track of Flight 261.

The next advisory, which described a target "One o'clock, two and a half miles, just made a left turn, southbound, slow moving," was issued at 0948:32, or 7 seconds after the collision, although the controller was unaware of this at the time. The controller then observed this target appear to merge with the target of Flight 261, and, about the same time, the secondary, or transponder, target of Flight 261 disappeared from the radarscope. The primary target of Flight 261 was then observed in a right turn to the northeast.

Immediately following impact, the captain took control of the aircraft. The right engine was shut down, and the captain gradually added power to the left engine and turned in the direction of the airport. In evaluating the damage to the aircraft, he determined that electrical power (including communications) had been lost, and put the electrical system on an emergency basis.

After reaching the airport, the captain decided to circle the tower. He checked to assure that the hydraulic pressure was up and, when he was east of the tower, placed the landing gear handle to the "down" position. As an emergency measure, he also blew out the gear up latches with the emergency gear extension compressed air charge. He looked at the tower and noticed that he was being given a green light. He also noticed the shadow of the aircraft on the ground, indicating that the gear was down.

The captain continued to circle the tower to the north and then to the west, and finally came in for a no-flap landing on Runway 1, touching down at what tower personnel estimated to be about 0954. After landing, the gear remained extended, and the captain reversed the left engine propeller. The brakes operated normally, and the captain was able to taxi the aircraft to the north pier ramp without assistance.

The Cessna 150, N8742S, was rented on the morning of August 4, 1968, from Home Airmotive, Inc., Mitchell Field, Lombard, Illinois, by a private pilot for the purpose of transporting himself and two others to Sheboygan, Wisconsin. He mentioned that he would be returning that same day, late in the afternoon. He gave no indication of the route he intended to fly. The investigation did not disclose any record that the pilot filed a flight plan with a Federal Aviation Administration (FAA) facility, nor was one required.

The manager of Home Airmotive, Inc., observed that the private pilot who rented the Cessna had some sectional and instrument charts in his possession; however, he could not tell whether these included the radio facility charts for the area of the intended flight. The only phase of the preflight in which the manager participated was the calculation of the fuel load, which had to be adjusted downward because of the third person being carried on the flight. He estimated that the Cessna departed around 0900, in Visual Flight Rules (VFR) conditions.

The Home Airmotive manager described the radio-navigation equipment on board N8742S as consisting primarily of a NAVCOM 300, which allows the pilot to receive VOR and ILS frequencies and to transmit and receive voice communications on a separate frequency at the same time. The manager also described the color of the aircraft as follows: fuselage - 50 percent white, 50 percent red; wing area - totally white; rudder and elevator - 90 percent white, 10 percent red.

The accident occurred in daylight conditions at a location, based on the position of the Cessna wreckage, of latitude $42^{o}50'$ north, and longitude $88^{o}6'$ west.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	1 (Cessna 150)	2 (Cessna 150)	0
Nonfatal	1 (Convair 580)	0	0
None	3 (Convair 580)	8 (Convair 580)	

1.3 Damage to Aircraft

The Convair 580 was extensively damaged in the area from the radome aft to, and including, the right engine and propeller. The right side of the cockpit and forward baggage compartment were crushed inward by impact forces.

The Cessna 150 was destroyed by the collision. Portions of the cabin section and the attached landing gear were embedded in the Convair 580, while the remainder of the Cessna aircraft fell in pieces to the ground.

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 detailed crew information, see Appendix A.)

1.6 Aircraft Information

Both aircraft were properly certificated and had been maintained in accordance with existing requirements.

The weight and center of gravity of each aircraft were calculated and found to have been within limits. The Convair 580 had been serviced with Jet A fuel and the Cessna was serviced with 80-octane aviation gasoline.

For detailed information, see Appendix B.

1.7 Meteorological Information

The following surface weather observations were taken at General Mitchell Field on the morning of the accident:

0920, Special high, thin broken, visibility 3 miles in haze and smoke, wind from 030° at 3 knots, altimeter setting 30.13 inches.

0955, High, thin broken, visibility 6 miles in haze and smoke, temperature 79°F., dew point 70°F., wind from 070° at 3 knots, altimeter setting 30.13 inches.

The Tel Autograph record for General Mitchell Field indicated that the tower visibility was reported as 4 miles at 0949. 4/

4/ The Tel Autograph is basically a means of instantaneously transmitting weather information between various locations at an airport.

Winds-aloft observations made at 0700 for 3,000 feet m.s.l. were 305° at 4 knots (Green Bay, Wisconsin) and 270° at 21 knots (Peoria, Illinois).

The aviation terminal forecasts for Milwaukee and Green Bay issued by the Chicago Weather Bureau Forecast Center at 0545, valid 0600-1800, were as follows:

Milwaukee

0600-1000, Clear, visibility 3 miles in haze, variable to partial obscuration, visibility 1/2 mile in ground fog and haze until 0900.

1000-1800, 30,000 feet thin broken, visibility 5 miles in haze, occasional 4,000 feet scattered, 10,000 feet scattered.

Green Bay

0600-1100, 30,000 feet thin broken, chance of visibility 2 miles, ground fog until 0800.

1100-1800, 4,000 feet scattered, 30,000 feet thin broken.

A self-help weather briefing display was available to the crew of Flight 261 at O'Hare Field. In addition, company personnel attached pertinent 0800 sequence weather reports and pertinent Weather Bureau terminal forecasts to the dispatch release which was supplied to the captain.

There was no record of either the captain of Flight 261 or the pilot of Cessna 150, N8742S, having been briefed by personnel at the O'Hare Weather Bureau office. Nor was there any record indicating that Joliet Flight Service Station had been contacted by the pilot of N8742S on August 4, 1968. 5/

Shortly after the 0920 surface observation was made at General Mitchell Field, this weather information, which included a visibility value of 3 miles with haze and smoke,

5/ There is a direct telephone line from the Home Airmotive office, where the Cessna 150 was rented, to Joliet Flight Service Station.

was broadcast on the Milwaukee ILS frequency of 110.7 MHz. 6/ The Convair 580 captain stated that he heard this report during the approach. The Cessna 150 was equipped with radio/navigation equipment which, if appropriately tuned, also could have received this information. In addition, a general aviation pilot who had flown some 120-130 hours with the Cessna pilot, mostly on cross-country flights, reported that the latter was familiar with how weather information could be obtained from ground stations.

One of the two ground witnesses to the collision stated that the visibility in the area was very good, while the other reported that the weather was smoky and hazy. The passengers on Flight 261 generally reported that, during the period just prior to the collision, the weather was hazy and smoky with occasional thin clouds. Several of them stated that they could see the ground only intermittently.

The additional crewmember on Flight 261, who was seated in the front right section of the passenger compartment, stated that immediately following the collision, he opened up the window curtain, at which time he noticed that the horizontal in-flight visibility was approximately 3 miles.

General Mitchell Tower personnel visually sighted Flight 261 when it was approximately 4 miles southwest of the field. In addition, a private pilot, who took off from General Mitchell Field shortly after Flight 261 landed, reported that at a point 4 miles southwest of the field, at an altitude of 2,000 feet, the visibility was approximately 5 to 6 miles with some haze present.

The National Almanac Office reported that on August 4, 1968, at 0948, for an observer at 2,700 feet above mean sea level at latitude 42°49' north and longitude 88°07' west, the apparent altitude of the sun was 43° and the true azimuth was 107° measured from north through east.

1.8 Aids to Navigation

Following the accident, ground checks were conducted on pertinent facility equipment in accordance with prescribed

6/ The automated continuous broadcast of weather data, along with information regarding runways and approaches in use, is known an Automatic Terminal Information Service (ATIS).

certification procedures. The General Mitchell Tower's radar and associated equipment were found to be operating within established tolerances.

On the morning of the accident, all navigation aids in the Milwaukee terminal area were reported to be operating satisfactorily. Post accident ground check reports of Milwaukee VOR and Timmerman TVOR navigational aids revealed no operational discrepancies.

On August 6, 1968, a special flight check of the Milwaukee Airport Surveillance radar equipment was conducted with a Cessna 150 in the area of the collision to determine adequacy of facility performance. The flight check report disclosed that facility performance was satisfactory. However, one item of significant interest was revealed. The report shows that the primary target return of the flight check aircraft weakened and disappeared from the radar display for a brief period of time when the aircraft was flown on headings tangential to the antenna. The magnetic bearing from the radar antenna to the position of the Cessna wreckage was approximately 230°. The tangential heading at that point would therefore be either 320° or 140°.

The loss of a primary radar target of an aircraft on a heading tangential to the antenna is an expected or known fact concerning the limitations of radar. Target loss is related to the Moving Target Indicator (MTI) circuitry's cancellation effects on stationary objects. The target range must be less than the range setting of the MTI gate control, in addition to the target track's being tangent to the antenna. The tangential course problem does not pertain to secondary radar, and thus transponder returns are not affected.

1.9 Communications

The communications recorded between North Central Airlines Flight 261 (NO. 261) and Milwaukee Approach Control (MKE) were as follows:

Time	Source	Content
0943:58	NO. 261	Milwaukee Approach North Central 261 with you.
0944:01	MKE	North Central 261 Milwaukee Approach squawk zero four hundred fly heading three five zero descend and maintain three thousand - ah - make that altitude two thousand six hundred for a vector to the runway seven right ILS landing straight in. Advise when you are out of five thousand and the wind is zero two zero degrees at three altimeter three zero one two.
0944:22	NO. 261	OK. We'll do all that.
0944:25	MKE	261 radar contact traffic at eleven o'clock and a mile and a half southbound. Slow moving pass just off your left side on his present heading.
0944:31	NO. 261	OK.

(At 0945:48, NO. 261 reported over company radio that they were in range and gave a fuel report. They also stated that "we'll have to have the windows cleaned.")

0945:53	MKE	North Central 261, your altitude now?
0945:56	NO. 261	We're just out of thirty five.
0945:59	MKE	Out of thirty five. Roger.
0946:24	MKE	North Central 261 traffic at twelve thirty four miles northbound slow moving additional traffic at - ah - eleven thirty and three miles eastbound.
0946:33	NO. 261	OK.
0947:02	MKE	261 both targets now at - ah - one o'clock two miles eastbound and three miles northbound.

Time	Source	Content
0947:11	NO. 261	261 no contact.
0947:35	MKE	261 the one eastbound is no longer a factor the northbound target is at one o'clock and a mile and a half north northwest bound.
0947:42	NO. 261	OK.
0947:44	NO. 261	Got so many bugs on the window we can hardly see out of here.
0947:48	MKE	You'll have to stop at a filling station.
0947:51	NO. 261	Yeah, we made an appointment.
0948:32	MKE	261 traffic at one o'clock and two and a half miles just made a left turn southbound slow moving.

The cockpit voice recorder ceased functioning at 0948:25, thus indicating that Flight 261 did not receive the advisory transmitted by the approach controller at 0948:32. After receiving no acknowledgment for this advisory, the controller made several unsuccessful attempts to contact the aircraft. He then alerted the local controller in the tower cab that radio contact had been lost. The local controller's attempts to contact Flight 261 by radio were also unavailing.

The investigation failed to disclose any record of the pilot of Cessna 150, N8742S, having communicated via radio with any ground facility or with any other aircraft.

Post-accident examination revealed that the communications equipment at General Mitchell Field was operating satisfactorily.

1.10 Aerodrome and Ground Facilities

Not involved in this accident.

1.11 Flight Recorders

Flight 261 was equipped with a United Data Control Model F-542 flight data recorder, S/N 2202. Examination

of the flight record medium disclosed that the airspeed parameter did not function at any time during the flight, while the heading parameter ceased functioning approximately 14 minutes after lift-off. The vertical acceleration and altitude parameters functioned throughout the flight.

A data graph was prepared covering the time period from approximately 11 minutes after lift-off until the 21-minute, 10-second mark, when the aircraft touched down. A composite of the three functioning parameters indicates that impact occurred at a point in time 13 minutes and 24 seconds after lift-off.

The altitude trace shows that the aircraft was descending through 3,375 feet m.s.l. at the 11-minute mark, and continued this descent until reaching approximately 2,585 feet at a point 12 minutes and 48 seconds after lift-off. The aircraft then maintained this altitude for 6 seconds, after which it commenced a climb, reaching 2,700 feet at the 13-minute, 24-second mark. The altitude trace then dropped to 2,500 feet in 2 seconds, after which it rose to 2,775 feet in another 3 seconds. The trace then indicates that the aircraft descended to 2,225 feet in 20 seconds, after which it continued descending in a slightly erratic manner throughout the remainder of the flight.

The heading trace shows that the indicated magnetic heading of the aircraft varied from 355° to 358° during the several minutes prior to impact. The heading at impact was 356°, after which the aircraft veered slightly to the left to a heading of 353°. The heading parameter ceased functioning 36 seconds after impact.

The vertical acceleration trace contained only minor excursions during the several minutes prior to impact. At the 13-minute, 24-second mark, this trace rose vertically from ∕ 1.0 g to ∕ 1.3 g's, then dropped to ∕ .6 g's in 3 seconds, after which it rose to ∕ 1.2 g's in 8 seconds. Throughout the remainder of the flight, this trace indicated erratic excursions which were of a slightly greater magnitude than those shown during the period prior to impact.

Flight 261 was also equipped with a United Control Model V-557 cockpit voice recorder (CVR), S/N 1800. The

CVR was undamaged in any respect, and the tape was removed and a re-recording prepared therefrom. A transcription was prepared covering the period from 0943:58, when Flight 261 initially contacted Milwaukee Approach Control, until the recording ended at 0948:25.

Apart from the air/ground communications set forth hereinbefore in the Communications section 7/, the CVR also recorded the intra-cockpit conversation between the captain and the first officer. This conversation consisted primarily of a sporadic discussion of extraneous matters unrelated to the operation of the aircraft, which commenced at 0946:45 and continued intermittently during the remaining 1 minute and 40 seconds of the recording. At no time during this intra-cockpit conversation was any mention made of the traffic advisories which were being issued to Flight 261 by Milwaukee Approach control.

Neither a flight data recorder nor a cockpit voice recorder was required or installed on the Cessna aircraft.

1.12 Wreckage

The force of the impact between the two aircraft embedded a portion of the Cessna 150 cabin, containing both cockpit seats and a small auxiliary seat, into the upper forward baggage compartment of the Convair 580. Also embedded in this same area of the Convair were both main landing gear struts and the complete right wheel and fender assembly of the Cessna.

The main part of the Cessna was thrown free of the Convair at impact and was recovered from a beet field approximately 11 miles southwest of General Mitchell Field. Portions of the Cessna wings, fuselage, empennage, and engine were scattered along a north-south line approximately 2,000 feet long and 400 feet wide.

The right side of the Convair was extensively damaged from the radome aft to approximately Fuselage Station 210,

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7/ The investigation disclosed that all of the air-to-ground transmissions emanating from Flight 261 were made by the captain, with the single exception of the report that the flight was out of 3,500 feet. This report was made by the first officer, apparently because the captain was talking on the company radio at that time.

which is roughly in line with the propeller planes. The major part of this area was crushed inward by impact forces. The first officer's windshield, direct vision window, and sliding side window were shattered. The area to the right of the first officer's control column, from below the floor up to and including the first officer's console and the right side of his instrument panel, were crushed inward and severely buckled and distorted. Damage in this area limited elevator down travel to 2° and displaced a rudder pulley, causing the rudder control to become slack. The electrical panel circuit breaker panel and the door to the upper forward baggage compartment were crushed inward.

There was a series of compression wrinkles on the left side of the Convair fuselage between Fuselage Stations 281 and 317. These wrinkles extended from window No. 3 (emergency exit) downward and forward to the floor line between window No. 1 and window No. 2, and thence aft and downward to the fuselage lower centerline.

The right engine and propeller on the Convair were extensively damaged. The engine air inlet was blocked at the inlet guide vane area by pieces of metal from the Cessna. This foreign material also damaged the compressor first-stage vanes and blades. The engine reduction gearbox was found decoupled from the power section. The propeller spinner assembly was damaged, and the nose section and island frontal area were crushed. The four propeller blades exhibited varying degrees of damage, including gouges, lacerations, distortion and bending.

The NAV-COM unit was recovered from the wreckage of the Cessna. It was examined internally and found to be tuned to 116.4 MHz in the NAV tuning section 8/ and nearest to the 112.6 MHz position in the COM tuning section. The course selected on the Omni Bearing Indicator was 332°.

Because of an electrical power loss, none of the radio equipment on the Convair functioned subsequent to impact. The No. 1 and No. 2 VOR receivers were both tuned to 110.7 MHz, the frequency of the Milwaukee ILS. The No. 1 VHF COM was set to 123.8 MHz (Milwaukee Approach Control) while the No. 2 VHF COM was set to 130.9 MHz.

Examination of the cockpit instrumentation on the Convair 580 revealed that the barometric pressure setting

8/ 116.4 MHz is the frequency of the Milwaukee VOR station.

on the first officer's altimeter was 30.10 in. Hg. The compass card on the first officer's Radio Magnetic Indicator (RMI) indicated 355°, while the compass card on the first officer's course director indicated a heading of 351°. The heading select bug on the latter system was set to 351°.

The captain's altimeter indicated a barometric pressure of 30.12 in. Hg. The compass cards on his RMI and course director indicated headings of 352° and 355°, respectively.

Horizontal scratch marks were observed on the trailing edge of the Cessna left wing near the tip and near the base of the Convair windshield center post. The measured angles between these marks and the longitudinal axis of each aircraft were 64° for the Cessna and 22° for the Convair. Vertical scratch marks and paint smears on the Convair pilot's forward windshield formed an angle of 6° with the vertical axis of that aircraft.

1.13 Fire

Neither aircraft exhibited any evidence of fire.

1.14 Survival Aspects

The accident was nonsurvivable insofar as the three occupants of the Cessna 150 were concerned. The fatal injuries sustained by these persons appeared to have resulted from forces applied from the posterior aspects of the bodies through the backs of their seats. They were recovered in their seats, which were facing forward in proper sequence, in the upper forward baggage compartment on the right side of the Convair.

The bones in the Convair first officer's lower right leg were crushed at impact. His leg injuries also resulted in a substantial amount of bleeding, which he partially quelled by applying his uniform necktie as a tourniquet. Damage to the right side of the cockpit caused the first officer to be trapped in his seat until assistance was rendered on the ground following landing. The remaining 11 occupants of the Convair were uninjured and were able to deplane unassisted via the main passenger stairway.

Toxicological studies conducted on the three occupants of the Cessna revealed no evidence of carbon monoxide,

elevated lactic acid or ethyl alcohol concentrations. The only trace of drugs was a therapeutic level of Chlor-Trimeton, an antihistaminic basic drug, found in the body of one of the two passengers.

A review of the medical records of the three flight personnel involved, as well as the post-mortem examination of the Cessna pilot, did not reveal any pre-existing disease or incapacitating condition which would have compromised the safe operation of either aircraft.

1.15 Tests and Research

Cockpit Visibility Study

A cockpit visibility study was conducted by the Safety Board to determine the physical limitations on visibility from the flight crew seats in each of the aircraft involved in the collision. As a necessary adjunct of such a study, the flightpath of each aircraft was reconstructed in order to determine if the physical limitations would hinder the crews in their detection and observation of the other airplane.

The heading and altitude data for the Convair 580 were taken from the flight recorder readout, while the airspeed of 190 knots was based on the recollection of the first officer and captain. Since comparable sources did not exist in regard to the Cessna, its flightpath parameters were derived from the best information available. On the basis of known data (heading and speed of the Convair, plus the angles of the horizontal scratch marks on each aircraft to their respective longitudinal axes), a vector diagram was constructed, which indicated that the Cessna was on a heading of 314° and flying at a speed of 80 knots at impact. This diagram also showed that the collision angle between the two aircraft was 42°, or 40° if drift from reported winds is included, and the rate of closure at impact was 143 knots. It was assumed that the Cessna was flown at a constant altitude prior to impact.

On the basis of the foregoing data, the ground track for each aircraft was tabulated for the 2-minute period prior to the collision. (See Attachment 2). The course of the Convair during this period remained constant, while

the Cessna track as plotted took into account the heading change of that aircraft as observed by the radar controller. From these ground tracks, ranges and bearings between the two aircraft were calculated on an incremental basis. These calculations indicated that, at a point 2 minutes prior to the collision, the range between the two aircraft was 27,300 feet. The range closed to 14,850 feet at the 1-minute mark, after which the closure rate remained steady at 250 feet/second until impact. The relative bearing from the Convair to the Cessna increased gradually from 15° to 22°, where it remained constant during the final minute. The relative bearing from the Cessna to the Convair varied from 198° at the 2-minute mark to 244° at the 1-minute mark, after which it remained constant until impact.

In order to determine the physical limitations to vision from each cockpit, binocular photographs were taken of a Cessna 150 and a Convair 580 by the FAA's National Aviation Facilities Experimental Center. These photographs were taken with the camera lens mounted in a position corresponding to the normal eye position of a person sitting in the flight crewmember seats on each of the two aircraft. Superimposed on each binocular photograph was the visual position of the other aircraft during the period prior to impact. These positions were based on the bearing and inclination of the target from the reference eye position of the viewing flight crewmember.

The above studies thus indicated whether each aircraft had cockpit window configurations which would have restricted vision to the point target source of the other aircraft. From the normal eye position of the Convair captain, the Cessna would have been partially obscured by the center windshield during the minute prior to impact. 9/ With respect to the Convair first officer, the Cessna would have appeared in the left, middle portion of his direct vision window during this final minute. The Convair would not have appeared in any of the Cessna windshield or windows from the Cessna pilot's normal eye position during the final 2 minutes. From the Cessna copilot's position, the Convair would have appeared briefly during this period in the upper right portion of the rear window of the Cessna.

9/ The Cessna target was situated with respect to this post so as to be visible to only the left eye of the captain.

As noted previously, the paths of the target aircraft plotted on the windshields were based on fixed eye reference positions. If the crewmembers had shifted their head positions, these paths would have changed. It should also be noted that the cockpit visibility study does not take into account any of the other restrictions to visibility such as haze, smoke, sun glare, or insect smears.

Insect Information

In order to determine as precisely as possible the extent of the insect accumulation, a detailed examination was made of the captain's forward windshield, direct vision window, and sliding side window on the Convair. 10/ There was an average of 12 insect strikes per square inch on the forward windshield, with the greatest concentration being adjacent to the center post. The average diameter of the opaque portion of the strike marks was found to be approximately .050 to .075 inches. When the translucent or jell-like part of the smears was included, the average diameter of each mark increased to about .125 to .250 inches, resulting in an overall smear coverage of roughly 20 percent of the windshield. The number of insect strikes per given area on the direct vision window was only slightly less than that on the forward windshield. However, there was considerably less insect body fluid splattered on the DV window, with the result that the overall restriction to visibility caused by the insect smears was not as great as that which existed on the forward windshield.

The sliding side window exhibited only an occasional insect strike, which would have had no measurable adverse effect on in-flight visibility.

Insect remains scraped from the forward portions of the two aircraft were submitted to the Curator of Insects at the Milwaukee Public Museum for examination and indentification. Although these remains were finely fragmented, microscopic examination indicated that plant lice, plant hoppers, leaf hoppers, and midges were among the types of insects which had collided with the two aircraft in flight.

10/ The windshield and windows on the first officer's side of the Convair were too shattered to permit a meaningful examination in this regard. Neither the windshield nor the windows of the Cessna were recovered.

All of the insects recognizable from among the fragmented material belong to groups that are known to occur and have been collected at the 3,000- to 5,000 foot levels of altitude. Approximately 180 different species of insects have been collected in the air, 5,000 feet above the ground surface.

The phenomenon of insect swarms at altitude requires an unusual combination of meteorological and behavioral conditions. There must be a superabundance of a certain "buoyant" species of insects, 11/ which are subject to the same stimuli and which tend to respond in the same manner (i.e., by concerted aerial activity). In addition, there must be present in the area ascending air currents or updrafts, capable of lifting the mass of insects to abnormal altitudes. Although insect swarms at altitude are difficult to predict, the aforedescribed conditions necessary to such occurrences are generally most prevalent during the summer months.

Whenever an insect collides with the windshield of an aircraft, the nontransparent, straw-colored exoskeleton portion of the insect is fragmented and body fluid or insect blood is splattered. Although this fluid is basically colorless and translucent, its deposit on a windshield in substantial quantities creates a frosted-glass or prismatic effect which can seriously impair and distort visibility.

1.16 Other Pertinent Information

Federal Aviation Regulations

Part 91.67 of the Federal Aviation Regulations (FAR) reads, in pertinent part, as follows:

> 91.67 Right-of-way rules; except water operations
>
> (a) General. When weather conditions permit, regardless of whether an operation is conducted under Instrument Flight Rules or Visual Flight Rules, vigilance shall be maintained by each person operating an

11/ Contrary to common belief, insects found at altitude are not "strong flyers," but generally are wingless or weak flying insects which are relatively buoyant due to their light weight.

aircraft so as to see and avoid other aircraft in compliance with this section. When a rule of this section gives another aircraft the right of way, he shall give way to that aircraft and may not pass over, under, or ahead of it, unless well clear.

* * * * *

(c) Converging. When aircraft of the same category are converging at approximately the same altitude (except head-on, or nearly so) the aircraft to the other's right has the right of way.

* * * * *

(e) Overtaking. Each aircraft that is being overtaken has the right of way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear.

Air Traffic Control Procedures

The FAA handbook which prescribes air traffic control procedures for personnel providing terminal air traffic control services contains the following instructions pertaining to traffic advisories: 12/

815. Application

Apply merging target procedures to all radar-identified scheduled air carrier aircraft in all airspace environments except while they are in a holding pattern.

816. Traffic Information

Issue radar traffic information to the 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.

12/ Terminal Air Traffic Control, 7110.8, October 1, 1967; Section 17, Merging Target Procedures.

217. Avoidance Vectors

a. If the pilot requests and as an additional service, vector his aircraft to avoid merging with the target of previously issued traffic so that the targets do not touch.

b. If unable to vector, inform the pilot.

Another section of the handbook provides that the provision of additional services (such as avoidance vectors) is not mandatory, but rather is within the complete discretion of the controller as to whether he believes he is in a position to provide them. 13/

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

This was essentially an operational accident, and the search for the causal factors was concentrated in that phase of the investigation. From an analytical point of view, the basic elements significant to the collision were (1) the operation of the Cessna, (2) the operation of the Convair, and (3) the actions of Milwaukee Approach Control.

Operation of the Cessna

On the basis of the available evidence, it appears that the operation of the Cessna 150 was carried out in accordance with existing FAA regulations governing the conduct of a VFR flight from point to point. Since the flight was being conducted below a level 3,000 feet above the surface, there was no requirement that the Cessna be flown at a particular altitude or on a particular heading. 14/ Furthermore, there is no requirement that a pilot conducting a cross-country flight under VFR conditions either file a flight plan or make radio contact before or during the flight with any FAA facility.

The only aspect of the Cessna operation to which any degree of uncertainty might be ascribed is whether its flight, particularly in the later stages, was in fact conducted under VFR conditions. Since there apparently were

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13/ Chapter 5, Section 15, Note 775.

14/ See section 91.109 of the FAR.

no clouds of any magnitude along the final portion of the Cessna flightpath, the foregoing question may be further reduced to whether the forward horizontal in-flight visibility in the collision area was 3 miles or more.

The ground visibility at Mitchell Field, which is about 11-1/2 miles northeast of the collision point, was observed to be 3 miles at 0920, 4 miles at 0949, and 6 miles at 0955. With respect to in-flight visibility, the additional crewmember seated in the passenger compartment stated that the horizontal visibility out of the right-hand side of the Convair was about 3 miles when he looked out the window immediately after the collision. In addition, the captain estimated the visibility out the left side of the Convair was about 2 miles, based on the distance at which he sighted Wind Lake. However, the captain also testified that he saw Muskego Lake as well as Wind Lake when he was looking for traffic subsequent to the advisory issued at 0946:24. Based on an indicated airspeed of 192 knots, the time between that advisory and the collision, and the fact that the collision point was about 1 mile east of Wind Lake and 2 miles south of Muskego Lake, it would appear that the slant range visibility toward the north-northwest was 5 to 6 miles. Furthermore, it would be expected that the visibility out the left side of the Convair would be greater than the visibility out the right side, since the latter would be reduced by sun glare. Finally, a small plane pilot flying in an area 4 miles southwest of Mitchell Field shortly after the accident at an altitude of 2,000 feet estimated the visibility was 5 to 6 miles.

One of the reported restrictions to visibility at Mitchell Field was smoke, the source of which was the power-plants to the northeast and southeast of the field. However, since the surface winds from the northeast were light and the winds aloft were stronger and generally from the west, the visibility would have improved to the west and southwest of the airport.

From the foregoing, it appears that the flight visibility in the collision area, particularly forward along the Cessna's flightpath, was at least 3 miles and probably closer to 5 miles. Furthermore, there was nothing in the pertinent weather reports which would have caused a pilot

to conclude that conditions were below VFR minimums. Although Milwaukee was reporting 2-1/2 miles visibility when the Cessna departed Chicago, the forecast called for VFR conditions after 0900. In addition, if the pilot had tuned in the ATIS broadcast from Milwaukee at any time subsequent to 0920, he would have learned that the visibility was 3 miles. In this connection, it should be noted that, although the Cessna's radio was tuned to the VOR station at the time of the collision, it is possible that the pilot previously was listening on the ILS frequency over which the ATIS reports are broadcast. He was familiar with obtaining weather information while airborne from previous cross-country flights, and had in his possession charts from which he likely could have obtained the Milwaukee ATIS frequency.

The available evidence also indicates that the Cessna was tracking inbound to the Milwaukee VOR station at the time of the collision. The navigation receiver in the aircraft was set on the Milwaukee VOR frequency and the course selected on the Omni Bearing Indicator was 332°, which would have been the approximate inbound course to the station. Furthermore, the heading change from north toward a northwest course, observed by the radar controller shortly before the collision, could be taken as an indication that the Cessna pilot had been navigating along Victor Airway 479, had drifted to the right of the centerline of that airway, perhaps by overshooting Wind Lake Intersection, and then corrected his heading back to the left. In any event, it appears that it was the intent of the Cessna pilot to circumnavigate the Milwaukee terminal area to the west before proceeding directly to Sheboygan.

During the period preceding the collision, it is likely that the attention of the Cessna pilot would have been primarily focused forward in the direction of his flightpath. Even if the pilot visually "cleared" the area to his left prior to commencing his north-to-northwest heading change, he would not be expected to continue his scan back to the 7 o'clock position, which would have been the relative location of the Convair. In any event, the cockpit visibility study demonstrates that, during the final 2 minutes of flight, the Convair would at no time have appeared in the clear glass area from the pilot's seat of the Cessna, and would have appeared only briefly in the rear

window of the Cessna from the copilot's seat. Accordingly, the Board concludes that it would have been physically impossible for the Cessna pilot, and only remotely possible for the person sitting in the copilot's seat, to have detected the Convair visually prior to the collision.

Operation of the Convair

Since the Convair was overtaking the Cessna from the rear, as well as converging from the left, the applicable regulations specify on two separate counts that the Cessna had the right-of-way while the Convair was required to give way, notwithstanding the fact that the Convair was being operated under an IFR flight plan. However, these rules only apply "when weather conditions permit" the crew operating an aircraft to "see and avoid" the other plane. Thus, the question is whether the Convair flightcrew, taking into consideration all of the various restrictions to visibility which existed at that time, should have been able to detect the Cessna visually in sufficient time to take evasive action.

The Convair flightcrew was alerted to the presence of another aircraft through the provision of three radar traffic advisories representing the target of the Cessna during the 2-minute period prior to the collision. There is no reason to doubt the accuracy of these advisories, which described a target ahead and slightly to the right of the Convair tracking northbound, and then north-northwest bound as the range decreased from 4 miles to 1-1/2 miles. Since each of the three advisories was given in conjunction with a second target which was eastbound, it is possible that the Convair crew may have experienced some difficulty in visualizing the track of the Cessna (i.e., that it was flying a course parallel to that of the Convair, and then turned toward the Convair track). However, the Convair crew stated that they received and understood all of the advisories, including the "north-northwest bound" portion of the third advisory.

The Convair pilots also stated that they searched intently in the areas indicated by the advisories but were unable to detect the Cessna until the collision was unavoidable. The cockpit workload during the period preceding the collision was not inordinately heavy. Neither of the

pilots was engaged in any duties connected with checklists. The captain was handling the communications with the controller, which primarily concerned the traffic advisories, but there was no reason why he could not have continued his scan even while transmitting or receiving on the radio.

The first officer, who was operating the flight controls, stated that he interspersed his scan outside the cockpit with glances at the instruments to assure that he was maintaining the proper speed, heading, and rate of descent. Since the first officer was relatively new both to the aircraft and to the carrier, it would be expected that he might tend to devote a disproportionate amount of his attention inside the cockpit to assure that the approach was accomplished in an exemplary manner. On the other hand, the fact that he allowed the aircraft to climb back to 2,700 feet after leveling off just below the clearance altitude of 2,600 feet, as well as being 6° off his assigned heading, indicates that, during the period immediately prior to the collision, his attention might have been focused away from the instrument panel, perhaps outside the aircraft. It should also be noted that the first officer had no conscious recollection of leveling off, but rather believed the aircraft was still in a descent when the collision occurred.

The extraneous conversation carried on in the cockpit prior to impact may have had a distracting influence on the pilots' outside vigilance. Moreover, there was no mention during this conversation of the pilots' success or failure to sight the reported traffic, which might be construed as a reflection of a lack of effort in that regard. On the other hand, both pilots testified that they maintained a diligent outside scan during this period, and their testimony in this regard is compatible with the jumbled and intermittent nature of the conversation reflected by the cockpit voice recorder.

With respect to the physical limitations imposed by the cockpit structure, the visibility study indicates that, during the 1-minute period prior to impact, the target of the Cessna would have appeared, with reference to the Convair captain, in that portion of the pilot's front windshield which,

because of the relative position of the target and the center post, is only visible to the left eye. With reference to the Convair's first officer, the Cessna target would have appeared in his direct vision window near the post separating it from the front windshield. However, this study was based purely on the reference-eye position of each of the two crewmembers' seats and thus, if a pilot moved his head, the location of the target in the windshield would also shift. In this connection, the fact that the aircraft climbed 100 feet above the clearance altitude during the 30 seconds prior to collision might be an indication that the first officer was unconsciously applying back pressure on the yoke as a result of leaning forward to the alert position to scan for the reported traffic. In the alert position, the first officer's line of sight to the point target source would have been partially obscured by the post between the forward windshield and his direct vision window.

In attempting to determine the capability of the Convair crew to detect the Cessna, another factor which must be considered is the size of detail that the eye is capable of resolving. This is measured by determining the smallest visual angle subtended by the viewed object, expressed in minutes of arc, that can be resolved. According to a recent study, 15/ the probability of detection for targets which subtend a visual angle in excess of 1.4 minutes of arc is 100 percent in clear visibility. Based on a target width of 20 feet, 16/ the Cessna would have subtended an angle of 6 minutes at a point in time 1 minute before the collision, an angle of 10 minutes at 30 seconds prior to the collision, and an angle of 20 minutes at 15 seconds before impact. The calculations indicate that, under ideal visibility conditions, the limits of target detection were well within the probability range, even as early as 1 minute prior to impact.

Even though the evidence indicates that the Cessna would have appeared in the clear glass area of the Convair

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15/ Collision Avoidance Study, May 22, 1966, Lockheed California Company, Burbank, California.

16/ As viewed from the Convair, the Cessna would have presented a profile approximately 20 feet wide.

windshield as a target of sufficient size to be resolved by the eye, there were a number of factors which would have substantially impaired the capability of the Convair crew to detect the smaller aircraft. The conspicuity of a target depends not only on its size but also on its color, relative motion, and brightness contrast. The Cessna was predominately white with a lesser surface area painted red, a color scheme which is rated low on the scale of conspicuity. In regard to relative motion, the bearing of the Cessna from the Convair changed only 7° between 2 minutes and 1 minute prior to impact, and remained constant during the final minute. In addition, the brightness contrast between the Cessna and background against which it was viewed would have been considerably diminished by the atmospheric conditions described below.

The detectability of a target is also affected by the characteristics of the atmosphere through which the target is viewed, in that any contamination of the atmosphere would make the target more difficult to detect. In the area of the collision, such contamination was present in the form of both haze and smoke. The visibility restriction caused by these contaminants was heightened, with respect to a viewer looking to the right of the Convair's nose, by the glare or halo effect produced by the reflection of the sun off the individual particles of smoke and moisture.

The most significant restriction to visibility from the Convair cockpit was the unusually dense concentration of insect smears on the forward windshield and direct vision windows. Although the windshield and window on the first officer's side were destroyed, and thus not available for inspection, it is reasonable to assume that the same degree of smear concentration existed on his side as that described hereinbefore with respect to the captain's side. 17/

The fact that the insect deposits were the most densely concentrated near the windshield center post, where they constituted an almost complete obstruction to vision, is of particular significance because that was the area of the windshield in which the Cessna target would have appeared to the Convair captain, even if he had leaned forward to the alert position to scan for the reported traffic. If the point target source of the Cessna would have been

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17/ See Tests and Research section.

obstructed by either the opaque or translucent portion of one of the insect deposits, it would have been almost impossible to have detected the Cessna.

Apart from the obstruction effect, the insect smears would also have made it extremely difficult for the eyes of the Convair pilots to focus on a distant object such as the Cessna. Even though a concerted effort was made to search visually beyond the windshield, the eyes of the pilots would have tended to focus on the insect smears as the only discernible objects in view. For example, a horizontal scan by the first officer across the front windshield and direct vision window would have brought his eyes in contact with roughly 80 insect smears, while a vertical scan would have encountered about 26 smears. Accordingly, even if the Cessna target had appeared in an area not obstructed by an insect deposit, its lack of relative motion, coupled with the eye fixation on the smears, would have made it difficult to distinguish.

In view of the foregoing, the Board concludes that the combined effect of the various limitations on the visual detection capabilities of the Convair flightcrew -- namely, smoke, haze, sun glare, the inconspicuous color and lack of relative motion of the Cessna, and the heavy accumulation of insect smears on the Convair windshield and windows -- would have made it difficult for them to have sighted the Cessna in sufficient time to take evasive action. Although visual detection in time to avoid the collision would have been possible, but not probable, it is further concluded that the Convair crew's inability to do so was more a product of the above limitations than of a lack of vigilance on their part.

The substantial restrictions to forward visibility previously discussed raise the further question of whether the Convair crew, under all the circumstances, should have requested an avoidance vector around the traffic described in the radar advisories. Normally, if a flightcrew is unable to effect visual contact with reported traffic under VFR conditions, they can reasonably assume that the other aircraft is at a different altitude. In this instance, however, the Convair crew apparently believed that their forward visibility was so reduced as to render their

detection efforts almost completely ineffectual. 18/ At the same time, they should have been aware that the reported traffic could have been a VFR no-flight-plan aircraft operating legally at their altitude in view of the known facts that (1) the ATIS was broadcasting a visibility at Milwaukee of 3 miles, and (2) the traffic was "slow moving." It could therefore be urged that the Convair crew should have sought the assistance of the radar controller in avoiding such traffic.

The Convair crew apparently believed that the circumstances did not warrant a request for an avoidance vector. Since the first two advisories regarding the Cessna described a target to the right of the Convair on a northbound heading, compared to the assigned 350° heading of the Convair, the crew might have believed adequate course separation was present. However, a target described as "northbound" could be on a heading anywhere from 348-1/2° to 011-1/2°. This has particular significance since the Convair in fact was on a heading of 356°. Accordingly, a converging course situation could have existed.

In any event, the convergent nature of the track of the reported target should have become clearly apparent from the third advisory, when the heading of this target shifted from north to north-northwest. Indeed, the pilots stated that they became particularly concerned at this point. The pilots might have believed that, in view of the range of the traffic described in the third advisory (1-1/2 miles), there was insufficient time within which to request, receive, and effectuate an avoidance vector. This advisory was transmitted commencing 50 seconds prior to impact, and acknowledged by Flight 261 43 seconds before the collision. Even allowing for a period of 5 to 10 seconds of unsuccessfully searching for the target prior to making the request, it appears there would have been sufficient time remaining for an effective avoidance vector. Since the controller had been observing both targets for several minutes, and because he had a relatively light workload, it would have taken him only a minimum of time to calculate the direction change on the part of the Convair necessary to avoid a merger of these targets. Once this change was transmitted to the Convair, it would have taken only a matter

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18/ The Convair crew variously described the forward visibility as "practically nil," "almost useless," "we can hardly see out of here," and "95 percent" and "6 or 7 times" less than side visibility.

of seconds for the crew to react and initiate the change, and for the movement of aircraft controls to take effect.

It should also be mentioned, however, that the controller does not recall what happened to the Cessna target after it made the turn toward the north-northwest. As discussed hereinafter, primary target loss due to tangential effect might have occurred. If this in fact happened, and the Cessna target had no longer been visible on the radarscope when an avoidance vector were requested, the controller would have been extremely hesitant about providing the vector.

On the basis of the foregoing, and from the vantage point of hindsight, the Board concludes that if the Convair crew had requested an avoidance vector shortly after receiving the third advisory, and if the Cessna target was still on the radarscope when the vector request was made to the controller, an avoidance vector could probably have been issued and effectuated in sufficient time to avoid the collision.

The Board is aware that the Convair crew's not requesting an avoidance vector in this instance is indicative of the attitude of airline pilots in general toward such vectors. Avoidance vectors have fallen into a state of almost complete disuse, as evidenced by reports from both pilots and controllers that requests for such vectors are becoming increasingly rare. The pilots apparently believe that avoidance vectors have a greater potential for harm than for good. It is pointed out, for example, that deviation from an assigned course to avoid traffic which is probably at a different altitude in the first place may bring the vectored aircraft into conflict with other unknown traffic. Furthermore, an avoidance vector is only effective if the reported traffic maintains its course, whereas it is possible that such traffic could so alter its course as to become convergent with the new course of the vectored aircraft.

The pilot's attitude on this matter is understandable to a large degree, and the Board recognizes that in many situations avoidance vectors are impractical. Thus, when making an approach in an area which is even moderately congested, avoidance vectors would result in a continuous exercise in "dodging", which would probably gain the flight

little in terms of effective traffic avoidance. Moreover, the limitations of radar equipment oftentimes make it difficult for a controller to track the primary target of a light aircraft with the degree of precision necessary to allow him to provide an effective vector around it.

Nonetheless, the Board believes that there are situations, albeit occasional, in which an avoidance vector could be both safe and effective. For example, in a situation where conditions are reported to be VFR yet visual detection capabilities are limited, where there is no other conflicting traffic, and where the range of the converging traffic is sufficient to allow adequate time for an effective vector -- when all of these circumstances are present, a request for a vector might be appropriate as the last available means of preventing a midair collision. The Board recognizes that the pilot must reach a decision on this question on the basis of only a few seconds' consideration of a number of factors. However, if he has an open mind on the matter and is thoroughly familiar with all of the facets, both pro and con, of avoidance vectors, he will be in the best position possible to make a sound decision.

Again in retrospect, there were other actions, apart from requesting a vector, which the Convair crew might have taken to enhance their chances of detecting and/or avoiding the reported traffic. For example, gentle "S" turns would have imparted a relative motion to the Cessna target as it appeared in the Convair windshield, thus making it more readily detectable. A slight turn to the left might also have enabled the first officer to view the area of reported traffic through the side window which was almost completely free of insect smears. Although such turns would have constituted a minor deviation from an ATC clearance, they most likely would have been justified as an "emergency" measure under the applicable regulations. 19/

Milwaukee Approach Control

The investigation disclosed that the Milwaukee Approach Control radar controller handling Flight 261 acted in compliance with his prescribed duties. The vector and altitude clearance provided to the flight,

19/ Section 91.75 of the FAR

following the hand-off from Chicago Center, were consistent with the normal means of guiding air carrier aircraft on an IFR flight plan toward an ILS approach to Runway 7R, the active runway at Mitchell Field.

In accordance with applicable procedures, the controller issued to Flight 261 traffic information concerning all targets of unknown altitude which were likely to merge with the target of the Convair, as well as targets which were in close proximity to it. It should be emphasized that radar controllers are required to provide avoidance vectors around unknown targets only at the request of the pilot, and even then only if the controller, within his discretion, believes that he is in a position to provide the vector. In this instance, there was no request for a vector.

The circumstances surrounding this accident could be taken as providing good cause to doubt the advisability of a system whereby the pilot, rather than the radar controller, has the responsibility for initiating the avoidance vector process. Placing the burden on the controller to issue such a vector without requiring a request therefor from the pilot, however, has been tested in the past and found unworkable. In 1966, following a request from the Air Line Pilots Association (ALPA), and in coordination with the Air Transport Association (ATA), the FAA initiated a month-long evaluation of its capability to provide a special radar service designed to prevent merging of airline flight radar blips with those of other radar targets unless altitude separation existed. Basically, the program called for avoidance vectoring, unless the pilot requested not to be vectored (i.e., the avoidance steers were provided as a service rather than as mandatory instructions).

During the test period, many of the pilots given avoidance steers either preferred not to follow them or requested that none be issued. Of particular concern were the instances where pilots did not comply with vectors provided for IFR separation because they had mistaken them for avoidance steers issued as part of the test program. In view of the foregoing, the trial procedure was abandoned, again in coordination with ALPA and ATA, and the system eventually evolved to that in effect at the present time.

In light of the above experience, and until altitude information in regard to unknown traffic becomes a known factor, the Board believes the procedures currently in effect represent the most practical approach to the avoidance vector process.

The apparent disappearance of the Cessna target from the radar scope following its turn toward the north-northwest probably resulted from the tangential effect described hereinbefore in the Aids to Navigation section. The heading tangential to the radar antenna in the collision area is 320°, which is between the north-northwest heading last observed by the controller and the 314° heading which the Cessna was calculated to have been on at the time of impact. Even if the Cessna passed through the area of tangential effect prior to the collision, its reappearing target might have been so close to the Convair target as to have been indistinguishable. To place the phenomenon of tangential effect in proper perspective, it should be noted that this problem is not unusual but rather is a radar equipment limitation with which controllers are familiar and for which they usually can compensate. For example, if the controller is working an aircraft which becomes tangential, he can either change its heading or move the MTI gate control in.

The traffic which was given to Flight 261 7 seconds after the collision, and which was observed to merge with the Convair shortly thereafter, obviously could not have been the Cessna. Rather, this target, which a ground witness also observed flying in the area of the collision shortly after impact, represented a separate aircraft which was never identified.

Finally, the disappearance of the secondary target of the Convair from the radarscope shortly after the collision is traceable to the captain's placing the electrical system on emergency -- an action which would have de-energized the transponder.

2.2 Conclusions

(a) Findings

1. Both aircraft were properly certificated and in an airworthy condition.

2. Both flightcrews were properly certificated and qualified to conduct their respective flights.

3. There is no evidence of any failure or malfunction of either aircraft or any component thereof prior to the collision.

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

5. The Cessna pilot was not in radio contact with any FAA facility and no such contact was required.

6. The available evidence indicates that the Cessna was tracking inbound toward the Milwaukee VOR station along Victor Airway 479.

7. The Convair was in radio and radar contact with Milwaukee Approach Control, which had cleared the flight to descend to 2,600 feet on a vector heading of 350° for an intercept with the ILS localizer course serving Runway 7R at General Mitchell Field.

8. The radar controller provided the Convair with three traffic advisories concerning the Cessna, which consecutively described the target as "twelve thirty, four miles, northbound, slow moving" (2 minutes before impact), then "one o'clock, three miles, northbound" (83 seconds before impact), and finally "one o'clock, a mile and a half, north-northwest bound" (50 seconds before impact).

9. The Convair flightcrew acknowledged and understood the traffic advisories, but were unable to detect the Cessna visually until it was too late to take evasive action.

10. VFR conditions prevailed in the area of the collision; there were no clouds which obstructed visibility between the two aircraft, but flight visibility was reduced to approximately 3 to 5 miles due to smoke, haze, and sun glare.

11. There was a heavy accumulation of insect smears (approximately 12 per square inch) on the front windshield and direct vision windows of the Convair.

12. During the minute prior to the collision, the relative bearing from the Convair to the Cessna was 022°, while the relative bearing from the Cessna to the Convair was 244°.

13. From the reference-eye position of the Convair captain, the target of the Cessna would have appeared in the pilot's front windshield, partially obstructed by the center post; from the reference-eye position of the first officer, it would have appeared in his direct vision window.

14. The target of the Convair would not have appeared in any clear glass area from the pilot's seat of the Cessna, and would have appeared only briefly in the rear window from the co-pilot's seat.

15. At impact, the Convair was on a heading of 356° and the Cessna was on a heading of 314°, thus forming a convergence angle of 42°.

16. The indicated airspeed of the Convair was approximately 190 knots, while that of the Cessna was calculated to be 80 knots. The rate of closure between the two aircraft was 143 knots.

17. The collision occurred at an altitude of 2,700 feet, with both aircraft basically in a straight and level attitude.

18. Neither aircraft attempted any evasive maneuver prior to the collision.

19. There was no way the Cessna pilot could have been warned of the fact that his intended flightpath would intersect that of the Convair.

20. As the aircraft being overtaken from the left, the Cessna had the right of way; accordingly, the Convair was required to give way by seeing and avoiding the Cessna, weather conditions permitting.

21. The inability of the Convair crew to sight the Cessna in time to avoid the collision was more a product of the substantial limitations on their visual detection capabilities than lack of outside vigilance.

22. In view of the situation confronting the Convair crew, they should have requested a radar avoidance vector.

(b) Probable Cause

The Board determines that the probable cause of this accident was the inability of the Convair 580 flightcrew to detect the Cessna 150 visually in sufficient time to take evasive action, despite having been provided with three radar traffic advisories concerning the latter aircraft. Visual detection capabilities were substantially reduced by the heavy accumulation of insect smears on the forward windshield and direct vision windows of the Convair. Visibility was further reduced by haze, smoke and sun glare, and by the inconspicuous color and lack of relative motion of the Cessna. Under these circumstances, the crew of the Convair should have requested a radar avoidance vector.

3. RECOMMENDATIONS AND CORRECTIVE MEASURES

The subject accident is part of the general midair collision problem which is becoming of increased concern to the Safety Board as well as to all members of the aviation community. An in-depth study of the dimensions of this problem has recently been completed by the Board, and a report will be published in the near future outlining the relevant factors and causal areas. Included in this report will be a series of recommendations designed to lower the midair collision accident rate.

A number of these accidents in recent years have involved a collision in a terminal area between an air carrier aircraft, on an IFR flight plan, and a general aviation aircraft, operating under VFR without a flight plan. These circumstances are evident again in the subject accident, and the recommendations set forth below are directed at preventing a recurrence of this type of collision.

Traffic Separation in Terminal Areas

The control service and traffic separation provided by the Air Traffic Control system currently in effect are almost wholly predicated upon "known" traffic. Accordingly, when unknown traffic is mixed with known traffic, as frequently occurs in terminal areas, ATC cannot assure an appropriate level of safety. Even when the unknown traffic is observed on radar, its altitude is unknown, and therefore separation in the final analysis falls back on visual detection, which in this instance proved to be inadequate.

It therefore follows that separation of "known" and "unknown" traffic operations, to the broadest extent practicable, is desirable from a safety viewpoint. One possible solution would be the designation of larger segments of the navigable airspace as positive control areas to include terminal areas. This would require, however, that both the pilots and their aircraft operating in such areas meet certain standards in terms of qualifications and equipment. We recognize that such a measure would have an adverse impact on many of the airspace users for a variety of reasons, not the least of which would be economic.

With specific reference to the Milwaukee terminal area, the mix of unknown and known traffic could be reduced by a restructuring of Victor Airway 479. This airway, along which both of the aircraft involved in the collision were or had been navigating, is the first overland airway west of the Lake Michigan shoreline. For pilots who are adverse to over-water flights because of equipment limitations or other reasons, V 479 is the most convenient means of navigation for north and south bound flights between Chicago, on the one hand, and Milwaukee and points north of Milwaukee, on the other hand.

Complicating this situation is the fact that V 479 crosses the transition area for the approach to Runway 7R at General Mitchell Field in such a manner that an aircraft navigating on the airway becomes tangential to the radar at that point. In addition, flight training involving small aircraft is generally conducted in the quadrant southwest of the field. The final outcome is that an air carrier aircraft making an approach to Runway 7R must fly through an area containing a substantial amount of unknown traffic, some of whose primary radar targets may be lost due to tangential effect. This situation not only aggravates

the radar controller's separation problems, but also increases the workload of air carrier pilots who must depend on the "see and be seen" concept.

In view of the foregoing, the Board recommends that the FAA take under consideration the relocation to the west of V 479 between OBK (Northbrook) and MKE in the manner depicted on Attachment 1. We believe that such a measure would enhance traffic separation in a critical approach area without unduly disrupting the safe and orderly flow of traffic navigating on that airway.

"See and be Seen" Concept

In view of the incapability of the air traffic control system to provide positive separation between all aircraft at all times, and until some system with that capability is put into effect, the "see and be seen" concept will remain the basic means of collision avoidance. Notwithstanding the substantial limitations of this concept, many of which were factors in the subject accident, the Board urges, as it has repeatedly, that all users of the airspace make every effort to achieve the maximum benefit from visual detection. No less than constant vigilance on the part of both pilots and controllers is required, particularly in terminal areas where there is apt to be a mixture of large high-speed aircraft and small, relatively low-speed, aircraft. At the same time, the Board recognizes the difficult burden placed on airline crews of balancing such outside vigilance with the frequent, but necessary, diversion of their attention to cockpit duties, such as assuring maintenance of proper altitudes.

The Board notes with some concern that, in the majority of recent collisions involving an air carrier, the large aircraft was being flown by a relatively inexperienced first officer while the small aircraft was converging from the right. In view of the natural tendency of a pilot in such circumstances to become somewhat preoccupied with operating the aircraft, maximum outside vigilance may have been compromised. While on-line training and a safe level of outside vigilance are not incompatible, the Board urges that in such situations, and particularly when traffic advisories have been received, both pilots coordinate their efforts to assure that the designated areas are thoroughly scanned.

Finally, and as an extension of our comments in the Analysis section, the Board recommends that air carriers emphasize, both during training and operations, the entire spectrum of situations in which the use of an avoidance vector would be advisable. It is only through the judicious utilization of such vectors, based on a thorough understanding of their advantages and disadvantages, that the "see and be seen" concept can be supplemented to the fullest extent by bringing into play, when appropriate, the last available means of collision avoidance.

Windshield Cleaning

The insect accumulation which was such a substantial factor in this accident was both unpreventable and uncorrectable, considering available equipment and procedures. Following departure from Chicago with a clean windshield, the Convair was not equipped with any means of preventing the insect accumulation or, once it occurred, of removing the smears. Although the aircraft was equipped with a liquid rain repellent which can be discharged onto the windshield, its use would only have served to aggravate the problem.

The Board recognizes that the insect problem encountered on this flight may represent only an isolated occurrence. Indeed, the investigation disclosed that there is a dearth of evidence on the dimensions of this particular hazard. Accordingly, the first step which should be taken is a comprehensive survey by air carriers of their pilots with a view toward defining the extent of the problem. If a problem of sizable proportions is found to exist, then specific remedial measures can be explored.

The first point which should be stressed is the importance of having a clean windshield at the commencement of a flight. It is therefore recommended that inspection forms include a windshield cleaning requirement at all maintenance stations as well as a mandatory cleaning and sign-off of any dirty windshield complaint made by a flightcrew.

With respect to in-flight measures, one device which might be studied would be a deflector located forward of the windshield which would deflect the airflow containing the insects away from the windshield. A more practical system, particularly since it could be utilized subsequent

to the insect strikes, would involve in-flight window washing. The Board is aware that one air carrier is conducting experiments to develop a rain repellent chemical that also has detergent or cleaning qualities for use in the present rain repellent systems. Another system which might be adaptable for use on other aircraft is the windshield washer being installed on the B-747. On the other hand, while built-in washing systems may prove to be extremely useful during flight, we are not convinced that they would provide a completely adequate substitute for manual windshield cleaning on the ground.

Collision Avoidance Systems

During the course of the investigation, the Board was brought up to date on the activities of the Collision Prevention Advisory Group (COPAG), which is comprised of representatives from Government agencies and civil aviation associations 20/ and whose primary concern is with airborne systems designed to prevent midair collisions. The efforts of COPAG are primarily concentrated in three areas:

> (1) conspicuity enhancement (generally through exterior paint and lighting), (2) Pilot Warning Instruments (PWI), and (3) Collision Avoidance Systems (CAS).

PWI is an instrument whose function is to warn a pilot of the proximity of another aircraft and provide him with suitable information to assist him in evaluating a collision threat. CAS is more comprehensive in that it performs all of the necessary functions, such that its output is a signal indicating an appropriate avoidance maneuver at a suitable time. PWI is self-contained, while CAS is a cooperative system which requires that all participating aircraft be equipped with devices capable of exchanging information with each other.

With respect to the current stage of development, PWI equipment is being fabricated and flight tests should be held this year. Users have made known their need for devices costing $1,000 to $2,000. Two versions of CAS will

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20/ To avoid any of the problems associated with self-interest, the composition of COPAG does not include any companies or organizations involved in the design, development or fabrication of any equipment.

be flight-tested starting in the summer of 1969. The estimated cost of a complete CAS is $30,000 to $50,000, with a lower cost of possibly $8,000 for limited equipment that might be used by executive aircraft.

The Board is of the view that the CAS and PWI systems will provide a substantial contribution to collision avoidance, and therefore urges that their development be continued toward a successful conclusion as expeditiously as possible. With respect to CAS, which appears to be the system receiving the most attention at this point, one of the most critical factors is the cost of the airborne equipment. If this cost is beyond the means of most of the general aviation community, the overall ability of the system to prevent collisions between large aircraft and small aircraft will be drastically reduced. The subject accident, for example, could have been prevented by CAS only if the Cessna had been equipped with a device capable of transmitting warning signals to the fully equipped Convair. Accordingly, it is hoped that some such "minimum" device can be developed at a cost which will foster its widespread installation on small aircraft.

Finally, it should be emphasized that CAS, even when developed to its most sophisticated level, is designed to supplement, rather than replace, the Air Traffic Control system. It is therefore critical to the maximum effectiveness of both systems that the developmental efforts in each be fully coordinated. To this end, the FAA is investigating, in part by a planned 6-month flight test program, the interaction between the maneuvers that would be engendered by a collision avoidance system and the Air Traffic Control system in order to optimize their relationship.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOHN H. REED
Chairman

/s/ OSCAR M. LAUREL
Member

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

APPENDIX A

CREW INFORMATION 1/

Crew of North Central Flight 261

Captain Ted Baum, aged 42, was employed by North Central Airlines on April 17, 1957. He held airline transport pilot certificate No. 1256343 with type ratings for the DC-3, Convair 240/340/440, Allison Convair 340/440, (Convair 580), and commercial privileges airplane multi/single engine land. His last first-class medical certificate was dated July 23, 1968, and was issued with no limitations.

Captain Baum had a total of 12,163 flying hours, of which 364 hours were in the Convair 580. He had flown 55 hours in the last 30 days. In the 24-hour period preceding the accident, he had 6:27 hours of duty time and rest period of 17:33 hours.

Captain Baum received his initial rating check in the Convair 580 on July 12, 1967, and his initial Convair 580 line check on July 23, 1967. His last proficiency check in the Convair 580 was dated May 6, 1968, while his most recent line check (in the Convair 440) occurred on November 19, 1967.

First Officer John A. Mazur, aged 30, was employed by North Central Airlines on April 8, 1968. He held commercial pilot certificate No. 1555450, with airplane multi/single engine land and instrument ratings. His last second-class medical certificate was dated December 5, 1967, and was issued with no limitations.

Mr. Mazur had a total of 2,400 flying hours, of which 25 hours were in the Convair 580. He completed his first officer qualification training on July 22, 1968. He received his last line check (in the Convair 440) on May 1, 1968. In the 24-hour period preceding the accident, he had 4:25 hours duty time and 19:35 hours rest period.

The stewardess, Miss Sharon Lynn Ann Moenssens, was employed by North Central Airlines on June 10, 1968, and completed her training on July 12, 1968.

1/ All crew information was compiled as of the date of accident.

Cessna Pilot

Ricky Lynn Stenberg, aged 19, received his private pilot certificate on September 12, 1967. He held certificate No. 1785679 with an airplane single engine land rating. He had a total of 183:35 hours flying time, of which 3:05 hours were in the Cessna 150. He was given a check in the Cessna 150 on November 8 and 13, 1967, and found competent to solo that aircraft.

APPENDIX B

AIRCRAFT INFORMATION 1/

Convair 580

Aircraft N4634S, S/N 176, was manufactured on April 20, 1958, as a Convair 340. The aircraft was purchased by North Central Airlines on February 18, 1965, and its conversion to a Convair 580 was completed on May 15, 1967. The total time on the airframe was 25,219 hours, of which 3,238 hours were logged subsequent to the conversion. Time since the last maintenance check was 64 hours.

The aircraft was equipped with Allison engines and Aeroproducts propellers, whose histories were as follows:

Position	Installation	Serial No.	Overhaul
Eng. 1	May 30, 1967	501633	3238
2	September 16, 1967	501640	2281
Prop. 1	June 6, 1968	1002	2516
2	September 16, 1967	P1048	2281

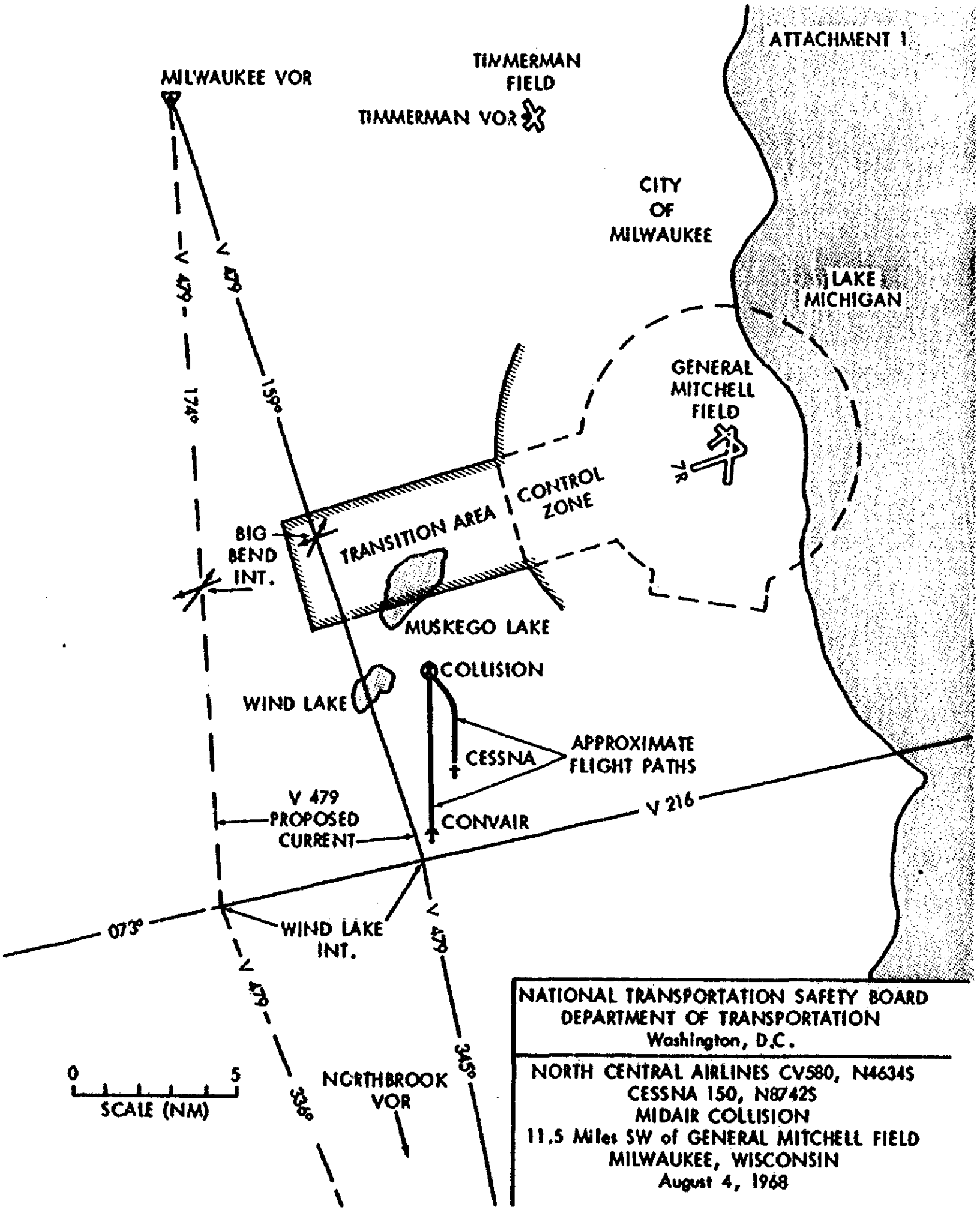
Cessna 150

Cessna 150, N8742S, received a certificate of airworthiness on September 20, 1965. The aircraft was owned by Home Airmotive, Inc., and had accumulated a total airframe time of 2,138 hours as of July 29, 1968.

N8742S was equipped with a Continental O-200A engine, S/N 61326-5A, and a McCauley 1A100 propeller, S/N 48743. The total time on the engine was 2,138 hours as of July 29, 1968.

1/ Except where otherwise noted, all aircraft information was compiled as of the date of the accident.

ATTACHMENT 1



NATIONAL TRANSPORTATION SAFETY BOARD
DEPARTMENT OF TRANSPORTATION
Washington, D.C.

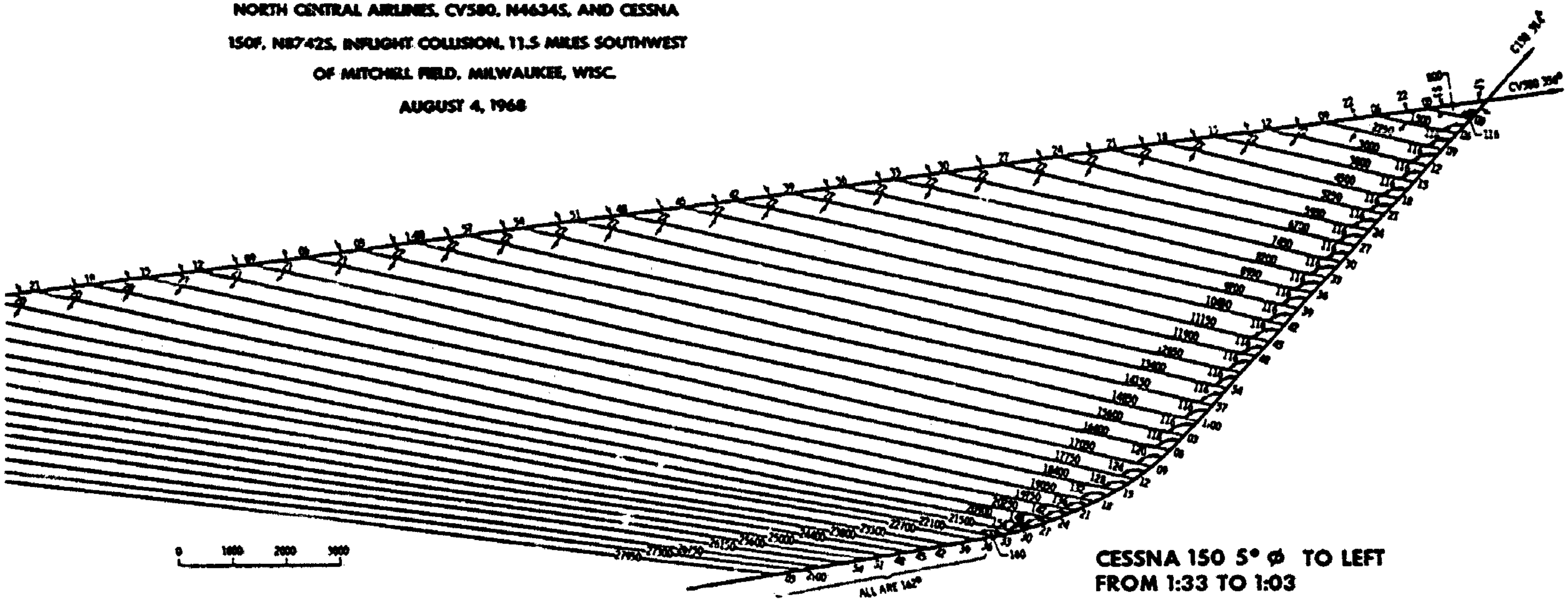
NORTH CENTRAL AIRLINES CV580, N4634S
CESSNA 150, N8742S
MIDAIR COLLISION
11.5 Miles SW of GENERAL MITCHELL FIELD
MILWAUKEE, WISCONSIN
August 4, 1968

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

ATTACHMENT 2

NORTH CENTRAL AIRLINES, CV580, N4634S, AND CESSNA 150F, N8742S, INFLIGHT COLLISION, 11.5 MILES SOUTHWEST OF MITCHELL FIELD, MILWAUKEE, WISC.

AUGUST 4, 1968



CESSNA 150 5° ϕ TO LEFT
FROM 1:33 TO 1:03

15