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AIRCRAFT ACCIDENT REPORT

North Central Airlines, Inc..
Allison Convair **340/440(CV-580)**, N90858
and
Air ,Wisconsin Inc., DHC-6, N4043B
near Appleton, Wisconsin
June 29, 1972

Adopted: April 25, 1973

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D.C. 20591
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16. Abstract A North Central Airlines Allison Convair 3401440 (CV-580) and an Air Wisconsin DHC-6, N4043B, collided over Lake Winnebago near Appleton, Wisconsin, at approximately 1037 c.d.t., June 29, 1972. The two passengers and three crewmembers aboard the CV-580 and the six passengers and two crewmembers aboard the DHC-6 were fatally injured. Both aircraft were destroyed as a result of the in-flight collision and the subsequent water impact. Both aircraft were proceeding in accordance with visual flight rules and were within minutes of landing at their respective destinations. Visual meteorological conditions existed at the time and place of the accident. The National Transportation Safety Board determines that the probable cause of this accident was the failure of both flightcrews to detect visually the other aircraft in sufficient time to initiate evasive action. The Board is unable to determine why each crew failed to see and avoid the other aircraft; however, the Board believes that the ability of both crews to detect the other aircraft in time to avoid a collision was reduced because of atmospheric conditions and human visual limitations.					
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 AND
 AIR WISCONSIN INCORPORATED, DHC-6, N4043B
 NEAR APPLETON, WISCONSIN
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SYNOPSIS

A North Central Airlines Allison Convair 340/440 (CV-580) and an Air Wisconsin Incorporated DHC-6 collided over Lake Winnebago near Appleton, Wisconsin, at approximately 1037 central daylight time, June 29, 1972. The two passengers and three crewmembers aboard the CV-580 and the six passengers and two crewmembers aboard the DHC-6 were fatally injured. Both aircraft were destroyed as a result of the in-flight collision and the subsequent water impact.

Both flights were operating in accordance with visual flight rules and were within minutes of landing at their respective destinations. Visual meteorological conditions existed in the accident area.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of both flightcrews to detect visually the other aircraft in sufficient time to initiate evasive action. The Board is unable to determine why each crew failed to see and avoid the other aircraft; however, the Board believes that the ability of both crews to detect the other aircraft in time to avoid a collision was reduced because of atmospheric conditions and human visual limitations.

1. INVESTIGATION

1.1 Histry of the Flights

North Central Airlines, Inc., Flight 290, an Allison Convair 3401440 (commonly known as a CV-580), N90858, was a regularly scheduled passenger flight between Houghton, Michigan, and Chicago, Illinois, with intermediate stops at Ironwood, Michigan, and Green Bay, Oshkosh, and Milwaukee, Wisconsin.

On June 29, 1972, the Houghton-to-Green Bay portion of Flight 290 was cancelled because of adverse weather conditions in northern Michigan. Consequently, Flight 290 originated at Green Bay on the day of the accident. Because of this change in the flight schedule, a replacement flightcrew was required and was sent to Green Bay from Chicago.

At approximately 1026:28 ^{1/}, CV-580 called Green Bay ground control and stated, "... ready to taxi, like to go VFR ^{2/} to Oshkosh." The flight was cleared to taxi and was given the Green Bay altimeter setting.

At 1028:14, Green Bay tower requested a clarification of the crew's intentions by asking, "... VFR or IFR ^{3/} ?" The crew replied, "VFR".

At approximately 1030, the flight departed from Green Bay and climbed to 2,500 feet. ^{4/} The flight then proceeded on an approximate course to Oshkosh.

At 1035, the CV-580 made an "in range" call to the company office at Oshkosh, stating that this landing would be accomplished with 8,400 pounds of fuel remaining.

At 1035:46 the flight made its initial contact with Oshkosh tower stating, "...we're about, seven northeast, two thousand five hundred, VFR." The tower acknowledged the transmission from NC290 and gave the crew the latest weather, altimeter setting, and runway information at the airport.

At 1036:11, the crew requested clearance to land on Runway 27. The controller confirmed the runway and cleared the flight for landing.

At 1036:16, the crew acknowledged the landing clearance. This was the last known radio transmission from the flight.

^{1/} All times used herein are central daylight, based on the 24-hour clock.

^{2/} VFR = Visual flight rules.

^{3/} IFR = Instrument flight rules.

^{4/} All altitudes herein are measured above mean sea level, unless otherwise indicated.

Air Wisconsin Incorporated, Flight 671, A DeHavilland DHC-6 Twin Otter, N4043B, was a regularly scheduled passenger flight between Chicago and Appleton, Wisconsin, with an intermediate stop at Sheboygan, Wisconsin.

The flight departed from Chicago at 0928 in accordance with an IFR flight plan. Prior to their arrival at Sheboygan, the flightcrew cancelled the IFR flight plan and continued VFR to Sheboygan.

At 1023, 13 minutes later than scheduled, the flight departed from Sheboygan. The flightcrew did not reopen the filed IFR flight plan prior to their departure from Sheboygan but rather elected to proceed VFR direct to Appleton.

At approximately 1030, the crew contacted the company office at Appleton on the company radio frequency and reported that it would be landing at 1044 with 300 pounds of fuel remaining. This is the last known radio contact with the flight.

The in-flight collision occurred at 1036:47 at an altitude of approximately 2,500 feet. The collision point, as established by witness statements and wreckage location, was over Lake Winnebago, 6 nautical miles south of Appleton, Wisconsin, and 2.5 nautical miles east of Neenah, Wisconsin. (Latitude 44°11'N., longitude 88°24'W.)²
The accident occurred in hazy sunlight below a scattered cloud layer.

#1. Straight line courses drawn from each flight's departure point to its respective destination intersect approximately at the collision point. (See Appendix D.)

Of the 38 eyewitnesses who were interviewed, 8 observed both aircraft just prior to and at the time of the collision. Two witnesses stated that the DHC-6 might have initiated a turn, moments before the collision.

Explosion and fire followed the in-flight collision and both aircraft fell into Lake Winnebago.

1.2 Injuries to Persons

<u>Injuries</u>	<u>Crew</u>	<u>Passengers</u>	<u>Other</u>
Fatal	*5	*8	0
Nonfatal	0	0	0
None	0	0	

* Includes persons on both aircraft.

1.3 Damage to Aircraft

Both aircraft were destroyed as a result of the in-flight collision and subsequent water impact.

1.4 Other Damage

None.

1.5 Crew Information

The crewmembers of both aircraft were certificated and qualified for the operations involved. (See Appendix B for detailed information.)

1.6 Aircraft Information

Both aircraft were certificated and maintained in accordance with existing regulations. (See Appendix C for detailed information.)

1.7 Meteorological Information

Both the 0700 and the 1000 surface weather charts for the accident area showed, in part, a low-pressure area centered over southeastern lower Michigan and northwestern Ohio with a frontal system extending south and southwestward from the low center.

The 0700, 850 millibar chart (approximately 5,000 feet) showed, in part, a broad low-pressure area over the Great Lakes area, with the center located over north central Indiana.

Official surface weather observations from the accident area were as follows:

★ Appleton, Wisconsin (7 miles northwest of the accident site)
-1000 - Scattered clouds at 2,000 feet, visibility 6 miles in haze, temperature 75° F, wind from 360° at 10 knots.

1100 - Local observation, scattered clouds at 3,000 feet, thin broken clouds at 15,000 feet, visibility 5 miles in haze, temperature 80° F, wind from 360° at 10 knots.

Oshkosh, Wisconsin (13 miles south of the accident site.)
1000 - Scattered clouds at 1,200 feet, scattered

clouds at 8,000 feet, visibility 6 miles in haze, temperature 70° F., dew point 62° F., wind 360° at 10 knots.
1100 - Scattered clouds at 1,500 feet, visibility 6 miles in haze, temperature 74° F., dew point 60° F., wind 360° at 10 knots.

Statements of other pilots who were flying in the area before, during, and after the time of the accident, generally confirmed the reported weather. Most of these pilots stated that the top of the haze layer was at approximately 3,500 feet and that visibility was at least 5 miles but diminished rapidly when they turned toward the sun. The flightcrew of the CV-580 would have had to look toward the sun in order to see the DHC-6.

A review of the National Weather Service weather radar observations from Neenah, Wisconsin, indicated that there were no weather echoes over Wisconsin at the time of the accident.

The Green Bay, Wisconsin (30 miles northeast of the accident site) 0700 radiosonde ascent showed an isothermal layer from the surface to near 1,500 feet and conditionally unstable air above that altitude. Winds aloft observations taken on this ascent showed the wind direction and velocity between 2,000 and 3,000 feet to be from the northeast at 5 knots. Later ascents showed no change in wind direction and a slight increase in its velocity.

1.8 Aids to Navigation

Not applicable to this accident.

1.9 Communications

There was no indication that either flight had experienced any difficulties with communications.

1.10 Aerodrome and Ground Facilities

Not applicable to this accident.

1.11 Flight Recorders

The CV-580 was equipped with a Sundstrand, United Control Data Division flight data recorder, Model FA-542, S/N 3833, and a cockpit voice recorder.

The flight data recorder unit was found in relatively good condition in the wreckage of the tail section. There was no evidence of exposure to fire, heat, or smoke. Both the magazine and the foil medium were undamaged. All traces were operable at the time of the accident.

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A C

The aircraft was straight and level on a heading of 182° magnetic, at an altitude of 2,500 feet and 254 knots indicated airspeed (KIAS) when all the traces stopped. There was no indication of abnormal g forces.

The cockpit voice recorder was not recovered.

No flight data or voice recorders were required or installed in the DHC-6.

1.12 Aircraft Wreckage

The wreckage of the two aircraft was scattered over an area of the lake bottom approximately 1 mile long and one-half mile wide. The area was oriented generally north to south, with the major portions of the DHC-6 to the north and the major portions of the CV-580 to the south.

An estimated 50 to 60 percent of the wreckage of each aircraft was salvaged. Recovery operations were extremely difficult and hazardous, even though the average water depth in the area was only 16 feet. Four feet of mud and silt covered the lake bottom and underwater visibility was reduced to approximately 6 inches because of algae, rough water, and silted water runoff from recently flooded rivers and farm land.

1.13 Fire

Ground witnesses observed an explosion and fire at the time of the in-flight collision. These observations were corroborated during the inspection of the recovered portions of both aircraft as follows:

(a) CV-580

Indications of fuel splatter burning and sooting were in evidence, starting approximately midway along the right exterior side of the fuselage. From this point aft to the vertical stabilizer, the fire damage and sooting became progressively more severe. No evidence of fire was found on the interior fuselage surfaces.

Portions of the empennage showed fire damage on the upper section of the left rudder hinge shroud, and fuel splatter burning and sooting were found on both sides of the vertical stabilizer spars.

(b) DHC-6

The upper and lower panels of the left wing showed the effects of fire; the damage to the lower panel was more severe. The fire damage varied progressively from severe skin and stringer quilting, with wing panel embrittlement and distortion at the wing root, to light sooting at the wingtip.

Most of the fuselage sections which were recovered showed signs of fire and explosion damage. The cockpit area showed internal and external paint blistering and sooting. Interior and exterior fire damage was more severe toward the aft section of the aircraft; the left rear side showed the most severe fire damage.

1.14 Survival Aspects

This was a nonsurvivable accident.

1.15 Tests and Research

Two heading-indicating instruments from the DHC-6 were recovered and examined. An Allen Aircraft Radio, Inc., radio magnetic indicator (RMI), type 2105B-6, from the captain's instrument panel, showed impact marks on the back of the dial equivalent to a magnetic heading of 3220. The first officer's directional gyro, type 200-4, manufactured by Aviation Instrument Manufacturing Corporation, was found broken and mechanically locked on a heading of 325° magnetic.

Binocular photographs, taken from the cockpit of a CV-580 (Appendix E) and a DHC-6 (Appendix F), were prepared by the Federal Aviation Administration National Aviation Facility Experimental Center. These photographs were used as an aid in determining whether the cockpit structure of either aircraft might have interfered with the detection of the other aircraft.

The collision track of each aircraft was reconstructed, using flight data recorder information from the CV-580 and estimates of heading, altitude, and airspeed of the DHC-6. Appendix G illustrates the reconstructed flight track as well as the collision angle, closure rate, and visual sight lines from each aircraft.

1.16 Other Information

~~Neither air carrier had a formal training program regarding visual scanning, nor did the Federal Aviation Administration (FAA) require such a program. However, both carriers involved in this accident had been actively engaged, through the use of bulletins~~

and crew information items, in keeping their crewmembers aware of the "see and avoid" concept and of the importance of vigilance during VFR flight.

The status of the FAA Pilot Warning Indicator (PWI) and Collision Avoidance System (CAS) programs was examined to learn when these devices might be available for general use. Research is being conducted on these systems and the goals, achievements and trends of these programs, as of March 1973, are attached as Appendix H. Testimony indicates that the present target date for national standards for these programs is 1976.

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

Both aircraft were properly certificated and maintained in accordance with existing regulations and established maintenance procedures. The gross weight and center of gravity of both aircraft were within established limits, and each aircraft was properly equipped for the intended flight.

Examination of the recovered sections of the wreckage, which included portions of both airframes, portions of both aircraft control systems, an engine from each aircraft, one propeller from the DHC-6, and other components from both aircraft, revealed no evidence of structural failure, malfunction, or other abnormality prior to the in-flight collision.

Both crews were properly certificated and qualified for their flights. No evidence was discovered to suggest pilot impairment or incapacitation. Both pilots of the CV-580 were required to wear corrective glasses while executing the privileges of their airman certificates. No evidence could be found to establish compliance or noncompliance with this restriction.

In view of the foregoing, the areas of primary causal concern were those involving the operational and human factors aspects of each flight during a finite time interval prior to the collision.

★ The decision by both flightcrews to conduct their flights under visual flight rules, rather than under instrument flight rules, appears to have been influenced by the expectation that some savings of time, fuel, and flightcrew workload would result. By operating in accordance with visual flight rules, both aircraft were able to proceed directly to their respective destinations at low altitudes without delay. The investigative findings and hearing testimony, indicate that the savings would have been minimal. Both flights

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had computer-stored IFR flight plans available, the activation of which could have been accomplished with little loss of time and would have resulted in minor mileage increases. In addition, the choice of VFR flight instead of IFR flight and the election by both crews not to request either radar or flight advisory assistance from the Chicago Air Route Traffic Control Center (ARTCC), deprived both flights of the protection afforded to aircraft that operate in accordance with IFR procedures. ~~Had both aircraft been operating in accordance with instrument flight rules, they would have been afforded collision avoidance radar advisories and altitude separation. If only one aircraft had been IFR, it could have been given radar separation from other known IFR traffic and probably would have been given advisories regarding unidentified traffic in its vicinity. The aircraft under IFR clearance would have had an assigned altitude (i.e., 4,000, 6,000 feet) and VFR aircraft should have flown below 3,000 feet or at a proper hemispheric altitude (i.e., 4,500, 6,500 feet). Thus, altitude separation could have been maintained effectively.~~ *Recommendation*

In the absence of cockpit voice recorders, certain assumptions were made in order to reconstruct possible crew activities immediately preceding the collision. These assumptions were based on testimony of witnesses, on examination of the CV-580 flight recorder data, and on known radio transmissions from each aircraft.

Following is an approximation of in-flight, crew activities just prior to the collision:

CV-580 Flightcrew

Between 1034 and 1035, the first officer contacted the North Central Station at Oshkosh to report in-range. At about 1035:45, he contacted Oshkosh Tower. Correlating Flight Recorder data with the transmission to the Oshkosh Tower, the following reconstruction is possible for the CV-580:

<u>Time Prior to Collision</u> (Seconds)	<u>Event</u> (Radio transmission from Flight 290)
84.5	"Oshkosh Tower, North Central 290" (2-second duration) (1035:45)
80.5	2-½ " second pause
78	"Yeah, we're about, seven northeast. Two thousand five hundred, VFR" (4-second duration)

<u>Time Prior to Collision</u> (Seconds)	<u>Event</u> (Radio transmission from Flight 290)
74	16-second pause
58	"OK, we'll take two seven" (2-second duration)
56	2-second pause
54	"Cleared to land" (1-second duration) (1036:15) (last transmission)
53	Start heading change from 200°
30	Completed 18° heading change
	Flight 290 remained on a heading of approximately 182°, a speed of 254 KIAS, and an altitude of 2,500 feet for the final 30 seconds.

Testimony received during the public hearing and examination of the flight recorder data indicate that the heading change was accomplished by use of the autopilot. It is assumed that the captain, during the heading change to the left, was occupied with monitoring the heading change on the RMI as the aircraft banked into the turn and simultaneously made command inputs to the autopilot. He probably devoted some attention to scanning visually to his left in the direction of the turn. It is further assumed that he cleared the area to the left during the initial portion of the turn and spent progressively less time searching to the left as the turn was completed and his attention was shifted to monitor the aircraft heading indicators and the aircraft position relative to the airport at Oshkosh.

The in-range checklist probably would have been started sometime after the new heading was established. Procedurally, the signal for the first officer to start these checks is the completion of preliminary checks by the captain. These preliminary checks require the captain to look outboard to check the hydraulic fluid levels and then look inboard toward the center control pedestal to check the antiskid system. Because the captain would have been occupied with the aforementioned tasks associated with the heading change, it does not appear likely that he would have been also occupied with pre-in-range check items at the same time. Checking the hydraulic fluid level the antiskid system takes approximately 5 to 8 seconds.

Two possibilities regarding the accomplishment of the in-range check were considered:

- (a) The checklist was started and completed up to item No. 3, (Item No. 4, "BYPASS-DOWN," was not yet accomplished and the hydraulic bypass handle was found in the "UP" position.)
- (b) The in-range checks were not started at the time of the collision.

Considering the first possibility, approximately 15 to 18 seconds would be required by the captain to complete his preparatory checks and by the flightcrew to perform checklist items Nos. 1 through 3. It is possible that a longer period of time would have been required if the captain aided the first officer with the in-range checklist. The first officer had only been with North Central a month and had not flown before with the captain.

Two alternatives then follow: either the checks were begun immediately after taking up the new heading, or the checks were being conducted at the time of the collision.

The first alternative, that the checks began immediately after the turn, can be discounted because the turn was completed approximately 30 seconds prior to collision, and there would have been ample time to have completed all in-range checks, i.e., the "Bypass" handle would have been found in the down position.

The second alternative, that the checks were being accomplished at the time of the collision, appears more plausible. Calculating back from the time of the collision, 15 to 20 seconds are allocated to complete the checklist through item No. 3. During the first 5 to 8 seconds of this period, the captain would have been occupied with checking hydraulic and antiskid systems. This would have left him about 12 to 15 seconds for outside scanning. The first officer would have been preoccupied during these remaining seconds with the in-range checks.

Therefore, if the in-range checks were conducted at all, the crew probably would have been preoccupied with the checks at the time of the collision. The crew's ability to maintain outside vigilance would have been diminished during these checks. If the crew had not yet started the in-range checks, they would have had approximately 30 seconds to scan outside the cockpit from the time the airplane rolled out of the turn until the collision.

DHC-6 Flightcrew

At about 1030, the captain contacted Air Wisconsin's Appleton station to advise of his intended landing at about 1044 with 300 pounds of fuel. Without benefit of information from a flight data recorder or a cockpit voice recorder, certain assumptions were made regarding crew activities. Information received from other Air Wisconsin captains disclosed that a heading of about 325° magnetic, an airspeed of approximately 150 KIAS, and an altitude of 2,500 feet probably would have been flown on a direct VFR flight from Sheboygan to Appleton. About 8 minutes before landing and about 12 nautical miles from Appleton the nonflying pilot would normally have made the in-range call to the Air Wisconsin station at Appleton. Shortly thereafter he would have contacted the Appleton Tower for landing instructions. After he received the Appleton altimeter setting, he would have started the descent checklist. During this interval, or at about 9 nautical miles from Appleton, the DHC-6 would have been at an altitude of about 2,500 feet. Because the crew had not yet made the in-range call to Appleton Tower, it is likely that they had not yet begun the descent checklist. The Board is unable to determine what flightcrew activities would have prevented the crew from looking for other aircraft during the 30-second period before the collision.

A number of conditions present at the time of the collision, taken either individually or collectively, reduced the ability of each crew to detect the other aircraft and to take appropriate evasive action. The detection of a converging and potentially hazardous airborne target, the assessment of its speed, altitude, and closure rate, the completion of the decisionmaking process, and the initiation of a control input can require a minimum of 10 to 15 seconds. Testimony received at the public hearing, reconstruction of the probable flightpaths, and cockpit visibility photographs provided the basis for the following analysis::

(a) Sun Position - ~~The crew of the CV-580 would have had to look toward the sun in order to see the DHC-6.~~ The small size of the DHC-6 target, coupled with its location adjacent to the sun, adversely affected its detectability. On the other hand, sun position (relative to collision geometry) would have improved illumination of the CV-580 when viewed from the DHC-6. This would have been due to the reflection of sunlight from the white paint on the CV-580, causing the target to appear brighter than its background.

However, the effect of lowered target-to-background ratio from intervening haze (between the DHC-6 and the CV-580) cannot be determined. The Board believes that some lowering of the conspicuity of the CV-580 would result from the intervening haze.

- (b) Windshield Condition - The postcrash condition of the windshields of both aircraft prevented any determination of precollision material condition or cleanliness. ~~How-~~ever, some windshield obscuration from insect smears was undoubtedly present on both aircraft. The proximity of large bodies of water to each flight's point of departure and intended landing airport, the relatively low en route cruising altitudes used by both flights, and the time of the year, all tend to suggest conditions suitable for encountering insects in flight.
- (c) Haze - Since neither flightcrew refiled en route for an IFR clearance, it is concluded that each believed they had at least 3 miles in-flight visibility. Six miles' visibility was reported by trained ground observers, and in-flight visibility was reported to be approximately 5 miles, except that it was less, looking toward the sun. ~~When a target is viewed through intervening haze, fog, smog, etc.~~ *Conclusion* the ability to discern shape, form, size, and motion can be severely reduced. Additionally, when an aircraft is close enough for its color to be discerned, the color scheme can blend that aircraft into an ill-defined background. As previously mentioned, haze between the sun and the targets could cause both targets to be poorly illuminated. The density and color of the "haze" (size of moisture droplets and solid particulate matter suspended in the atmosphere) and the uniformity of the haze, could have affected the atmospheric light scatter. ~~The ability of a pilot to see an intruding aircraft passing between himself and the sun, when viewed through haze, can be severely affected.~~ The characteristics of the reported haze cannot be determined in this accident.
- (d) Conspicuity - When a target is large enough to be detected visually, the color of the target can have an effect on its detection. A relatively slow rate of closure can compound this problem. The colors of the CV-580 (basically white with a wide, longitudinal, gray-green stripe) and the colors of the DHC-6 (basically white with red and blue longitudinal stripes) could cause both airplanes to blend with the background. The red anticollision lights would have been diffused similarly by intervening haze and the attention-getting qualities almost totally negated. The CV-580 was equipped with high-intensity capacitance discharge lights in both wing tips. North Central Airlines recommended that these lights be used at all times in

flight unless the lights would affect safe operation of the aircraft; however, the use of these lights was not mandatory. There is no evidence to indicate whether or not these lights were used.

- (e) Type of Flight Plan. - Neither captain chose to activate prestored IFR flight plans; consequently, both aircraft were operating in accordance with VFR. Neither captain requested radar in-flight advisories, even though these advisories probably could have been provided had they been requested. Chicago ARTCC had no knowledge of the intended flightpath of either aircraft or their en route locations at any point in time. The ARTCC would not have been able to identify or communicate with either aircraft if conflicting radar returns had been observed on their radarscopes. Considering the limitations inherent in the aforementioned VFR operations, it would have been prudent for one or both flights to operate under an IFR flight plan so that they could obtain ARTCC traffic advisories. While advisories in themselves are no guarantee that pilots will always see other traffic, the flightcrews are nevertheless alerted to a target and its relative bearing. With such information available, the search area is localized, and a warning is provided that a potentially dangerous threat could suddenly appear.

- ~~(f)~~ ~~Visibility from the CV-580~~ - Based upon analysis of cockpit visibility (Appendix E), at 1 minute prior to collision, the DHC-6 would have been approximately 29° to the left of the captain's and first officer's zero reference points. The target would have remained between approximately 16° and 14° during the final 30 seconds. A possibility exists that during the last 25 seconds, the DHC-6 could have been partially obscured by a windshield post immediately outboard of the captain's windshield. However, slight movement of the captain's head, neck, or torso could have eliminated such obscuration. The aircraft structure should not have obscured vision from the first officer's position during the final 30 seconds of flight.

- A- (g) Visibility from the DHC-6 - Based upon cockpit visibility analysis (Appendix F), the CV-580 would have moved from approximately 28° to 24° to the right of the captain's and the first officer's zero reference points during the period from 60 seconds to 30 seconds prior to impact. During the last 30 seconds, the location of the CV-580 would have remained constant at approximately the 24° bearing. Some obscuration might have been presented by the windshield wiper located in front of the first officer, who was occupying the left seat; however, slight movement of eyes, head, or torso would have permitted unobstructed

vision in the direction of the CV-580. Observation of the target would have been unobstructed from the captain's position in the right seat.


In summary, the following analysis illustrates the ability of each flightcrew to detect and avoid the other aircraft in this accident:



CV-580 Flightcrew - If the flightcrew were engaged in performing the in-range checks at the time of the collision, the captain would have had approximately 12 to 15 seconds to detect the DHC-6, assess the situation, decide on appropriate evasive maneuver (if he perceived a collision threat), and make the necessary control inputs. There is no evidence to suggest that this sequence was started or that it was completed before the collision occurred. If the flightcrew had not started the in-range checks, they could have had as much as 30 seconds after the turn was completed, to perform a search. (The target of the DHC-6 when a 6-mile visibility limit is considered, should have been of sufficient size to permit detection. However, when atmospheric haze, atmospheric light scatter, DHC-6 conspicuity, ratio of DHC-6 brightness to background brightness, and probable windshield smearing and spotting from insects are considered, it is not possible to determine when the DHC-6 would have presented a target which could have been interpreted as a threat. The smallness of the target and its position relative to the sun would have similarly hampered detection.) The bank angle of the CV-580 during the turn could have restricted the captain's view to the left (toward the DHC-6) for 23 seconds. The DHC-6 would have remained essentially 16° to 14° to the left of the captain's and the first officer's zero reference points during the final 30 seconds. If the DHC-6 were sighted during this time, the crew should have been alerted that a collision threat existed because the target would have remained on a fixed relative bearing.


DHC-6 Flightcrew - The flightcrew probably had not started the descent checks. Cockpit structure probably would not have interfered with sighting the CV-580. The CV-580 would have presented a target size significantly greater than the detection threshold prior to, during, and after the CV-580's turn. The CV-580 would have remained approximately 24° to

the right of the captain's and first officer's zero reference points for the final 30 seconds of flight. Sun position would have resulted in better illumination of the CV-580 as a target, and, at the low closure rates involved, the CV-580 should have had a higher probability of detection. However, the mitigating conditions described that reduced the fidelity of the DHC-6 target would similarly affect the fidelity of the target presented by the CV-580. The fixed bearing for the last 30 seconds would have severely limited the DHC-6 crew's ability to perceive target motion, speed, altitude and rate of closure. If the target were sighted during these 30 seconds, the fixed bearing should have alerted the DHC-6 crew that a collision threat existed.

 This accident is another example of the hazard of attempting to maintain visual separation when the in-flight visibility is restricted but above the minimum required for VFR flight. This accident again illustrates that care must be taken and outside vigilance must be maintained in order to implement the "see and avoid" concept to its fullest extent. Although less reliable as aircraft speeds increase, the "see and avoid" concept remains the primary collision avoidance technique used by pilots who operate in visual meteorological conditions. **3**

2.2 Conclusions

(a) Findings

- ① The flight crewmembers of both aircraft were properly certificated and qualified.
2. There was no evidence of crew incapacitation.
3. Both aircraft were properly certificated and maintained in accordance with existing regulations and approved procedures.
4. There were no known malfunctions of either aircraft prior to the in-flight collision, and both aircraft were properly equipped for flight.
-  5. Both aircraft were operating under visual flight rules in visual meteorological conditions. Surface visibility was restricted to about 5 miles in haze. The top of the haze layer was reported to be 3,500 feet.

6.

- The choice of VFR flight by both crews deprived them of the protection afforded to IFR aircraft by Air Traffic Control.
7. The CV-580 did not take evasive action.
 8. There is insufficient evidence to indicate that the DHC-6 took any evasive action.
 9. No positive determination could be made as to crew activities just prior to collision.
 10. The collision occurred at an altitude of approximately 2,500 feet.
 11. At 1 minute prior to the collision, the DHC-6 would have been approximately 29° to the left of the zero reference points of the CV-580 crew. The DHC-6 would have remained at approximately 16° to 14° to the left of both crewmen's zero reference points during the last 30 seconds of flight.
 12. At 1 minute prior to collision, the CV-580 would have been located approximately from 28° to 24° to the right of the DHC-6 captain's and first officer's zero reference points. For the last 30 seconds, the CV-580 would have remained approximately 24° right of the zero reference points of both pilots.
 13. The rate of closure was calculated to be 608 feet per second at 1 minute before the collision and increased to 688 feet per second during the last 5 seconds of flight.

(b) Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the failure of both flightcrews to detect visually the other aircraft in sufficient time to initiate evasive action. The Board is unable to determine why each crew failed to see and avoid the other aircraft; however, the Board believes that the ability of both crews to detect the other aircraft in time to avoid a collision was reduced because of atmospheric conditions and human visual limitations.

3. RECOMMENDATIONS

There is no approved, standardized method to train or grade pilots in the techniques of time sharing between scanning cockpit instruments and searching the surrounding airspace for other aircraft.

The Board believes that an audio-visual aid, developed by the Aircraft Owners and Pilots Association Air Safety Foundation Group could help pilots develop a better understanding of how to conduct a search for airborne targets and the necessity of improving their time sharing techniques. The presentation used in this aid does not dwell at length upon any recommended scanning technique, but it does draw the trainee's attention dramatically to the inherent difficulties involved in sighting other aircraft and, by so doing, it emphasizes the need for the attention and concentration required to improve the possibilities of visually sighting airborne targets.

On January 6, 1972, the Board made its third recommendation to the FAA concerning visual scan and time-sharing training. The FAA previously had proposed, in Notice of Proposed Rule Making (NPRM) No. 70-37, to develop a system to train pilots in methods to time-share visual outside searches and scanning of cockpit displays. The NPRM was withdrawn by the FAA on July 27, 1972, because a majority of the comments received from individuals and organizations within the aviation community did not favor the amendment. The Board then recommended that the FAA reconsider the withdrawal of the NPRM and that the rule making be reinstated. The FAA on November 28, 1972, advised the Board that the rule making had been premature and that additional research and development was required. They stated that such research and development was in progress and that if the results were fruitful, the rule making would be reinstated.

The Board, in Special Study Midair Collisions in U. S. Civil Aviation 1969 - 1970, June 7, 1972, recommended that the FAA require the daytime use of high-intensity white lights on all air carrier aircraft. The FAA responded on October 19, 1972, that "... An evaluation project was started on 7 April 1972 to pursue aircraft conspicuity research on a priority to substantiate rulemaking action on anticollision lights, strobe lights, and pilot warning instrument (PWI) application of the strobe lights" As we have previously noted, no determination could be made in this case regarding the use of the installed strobe lights on the CV-580. However, the Board continues to believe that the use of such lights in daytime operations would improve the conspicuity of aircraft and make them easier to detect by pilots of other aircraft.

The Board also noted, during the investigation of this accident, that there is no standardized flight check requirement with regard to the visual scan procedures used by a flightcrew when the flight is operating in visual meteorological conditions (VMC). This subject has been investigated in several collision accidents and to date, no satisfactory system has been reported to the Board.

The Board continues to be concerned with the overall midair collision problem. [As the Board has stated before, the midair collision hazard is one of the most urgent and serious problems confronting civil aviation in this decade.]

While the Board recognizes the continuing emphasis that the FAA is providing to resolve the midair collision problem, the Board considers that an even greater effort is needed to resolve the issues and arrive at a solution which will reduce the risk of midair collisions, especially as it relates to the wide bodied jet fleet.

In view of the above, the National Transportation Safety Board recommends that the Administrator, Federal Aviation Administration:

1. Develop and publish standards for visual search techniques to be used by instructors and check pilots on all training, certification, and proficiency check flights when pilots are operating in VMC (Safety Recommendation A-73-27).
2. Establish a requirement for pilots to be trained in the techniques of time sharing between visual scanning for airborne targets and cockpit duties (Safety Recommendation A-73-28).
3. Require that all pilots and flightcrew members training, certification, and proficiency check forms contain a specific item on scanning and time sharing (Safety Recommendation A-73-29).
4. Require that all pilots and flightcrew members be graded in scanning and time sharing techniques when training, certification, and proficiency check flights are conducted under VMC (Safety Recommendation A-73-30).
5. Advise the Board of the status of the FAA's evaluation project of April 7, 1972, on aircraft conspicuity research and, if that project has not been completed, take action to complete the project on a priority basis (Safety Recommendation A-73-31).
6. Expedite the development and issuance of national standards for systems to provide protection from midair collisions so that the industry can proceed without further delay to develop and market economically viable hardware (Safety Recommendation A-73-32).

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JOHN H. REED
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M THAYER
Member

/s/ ISABEL A. BURGESS
Member

/s/ WILLIAM R. HALEY
Member

April 25, 1973

INVESTIGATION AND HEARING

1. Investigation

The Safety Board received notification of this accident at approximately 1232 e.d.t., June 29, 1972, from the Federal Aviation Administration. An Investigation team was dispatched immediately to the scene of the accident. Working groups were established for Operations, Air Traffic Control, Witnesses, Weather, Human Factors, Structures and Powerplants Systems and Maintenance Records, Flight Data Recorder, and Cockpit Voice Recorder. Parties to the Field Investigation included the Federal Aviation Administration, North Central Airlines, Inc., Air Wisconsin Incorporated, Air Line Pilots Association, Northern Professional Pilot's Association, Detroit Diesel-Allison Division of the General Motors Corporation, and the DeHavilland Aircraft of Canada, Ltd. The on-scene investigation was completed on July 12, 1972.

2. Hearing

A public hearing was held at the Ramada Inn in Neenah, Wisconsin, from September 19 through September 20, 1972. Parties to the Hearing were: Federal Aviation Administration, North Central Airlines, Inc., Air Wisconsin Incorporated, Air Line Pilots Association, Northern Professional Pilot's Association, and Airline Transport Association.

3. Preliminary Report

A preliminary aircraft accident report summarizing the facts disclosed by the investigation was released by the Safety Board on August 30, 1972.

CREW INFORMATION

A. North Central Airlines, Inc.

Captain James T. Cuzzort, aged 50, was employed by North Central Airlines on June 25, 1956. He held Airline Transport Pilot Certificate (ATPC) NO. 119046 with aircraft multiengine land (AMEL), and aircraft single-engine land (ASEL) ratings. He was type rated in Douglas DC-3, Convair 240/340/440, and Allison Convair 340/440 (CV-580) aircraft. Captain Cuzzort possessed a first-class medical certificate, dated June 8, 1972, with the following limitation, "Holder shall wear correcting glasses while exercising the privileges of airman."

He completed his last proficiency check January 21, 1972, his last line check March 22, 1972, and his last recurrent ground training January 22, 1972. The captain had accumulated 15,688 hours flying time, of which 3,079 hours were in CV-580 aircraft. He had been upgraded to captain on October 1, 1959. Captain Cuzzort had flown 208 hours during the previous 90 days, and 65 hours during the previous 30 days. The captain had a rest period of 8 hours 19 minutes before reporting for duty. At the time of the accident he had been on duty 4 hours 25 minutes, of which 1 hour was flight time.

First Officer Alton O. Laabs, aged 31, was employed by North Central Airlines, Inc., on May 22, 1972. He held ATPC No. 1763807 with an AMEL rating, and commercial privileges in ASEL. First Officer Laabs possessed a first-class medical certificate, dated December 1, 1971, with the following limitation, "Holder shall wear corrective lenses while exercising the privileges of airman." He had accumulated 4,462 hours' flying time, of which 62 hours were in Allison Convair 340/440 (CV-580) type aircraft. He had flown 141 hours during the previous 90 days, and 47 hours during the previous 30 days. He had been off duty in excess of 24 hours before reporting for duty. At the time of the accident, he had been on duty 2 hours, of which 10 minutes were flight time.

Stewardess Frances M. Rabb, aged 21, was employed by North Central Airlines on April 28, 1972. Her company physical of February 21, 1972, contained no limitations.

B. Air Wisconsin Incorporated

Captain David L. Jacobs, aged 28, was hired by Air Wisconsin June 17, 1968. The captain held an ATPC No. 1502284 with an AMEL rating, and commercial privileges in ASEL. He possessed a first-class medical certificate, dated April 28, 1972, with no limitations. He completed his last two instrument checks on March 25, 1972, and September 13, 1971, in Beech 99 (BE99), and DeHavilland Twin Otter (DHC-6) aircraft, respectively. He

completed recurrent ground training on May 14, 1972. He had accumulated 6,556 hours' flying time, of which 3,412 hours were in DHC-6 aircraft. Captain Jacobs had flown 256 hours in the previous 90 days, and 83 hours during the previous 30 days. He had been flying as captain with the company since June 17, 1968. He had a rest period of 10 hours 45 minutes before reporting for duty. At the time of the accident, the captain had been on duty approximately 13 hours 20 minutes, of which approximately 7 hours 05 minutes were flight time.

First Officer Michael J. Gaffin, aged 29, was hired by the company April 1, 1969. He had an ATPC No. 1623126 with an AMEL rating, and commercial privileges in ASEL. He possessed a first-class medical certificate, dated July 12, 1971, with no limitations. He had completed instrument checks June 24, 1972, and June 31, 1971, in BE-99 and DHC-6 aircraft, respectively. Recurrent ground training had been completed May 7, 1972. First Officer Gaffin had been previously qualified as captain but was unable to fly in that capacity due to a reduction in force. He was qualified and current, however, to fly in the left seat in accordance with Air Wisconsin's operating procedures. He had accumulated 4,309 hours' flying time, of which 1,685 hours were in the DHC-6 aircraft. He had flown 254 hours during the previous 90 days, and 73 hours during the previous 30 days. He had been off duty in excess of 24 hours prior to reporting for duty. His duty and flight times for this series of flights were identical to those of the captain.

AIRCRAFT INFORMATION

Both aircraft involved were properly registered and certificated. An inspection of their records revealed the following:

Aircraft

North Central
Airlines, Inc.

Air Wisconsin
Incorporated

Make	Convair	DHC-6
Model	Allison Convair 340/440	Series 100
Registration No.	N90858	N4043B
Serial Number	83	13
Date of Manufacture	May 25, 1953	October 6, 1966
Total Aircraft Hours	45,905.2	15,664.8

Engines

Make	Allison	Pratt & Whitney
Model	501-D-13	PT6A-20
<u>Engine No.</u>	<u>Serial No.</u>	<u>Serial No.</u>
1	501-781	PCE-20909
2	501-763	PCE-22205

Hours Since Overhaul

No. 1	7,467	2,531.5
No. 2	7,555	3,258.5

Propellers

Make	Aeroproducts	Hartzell
Model	A644 1 FN-606A	NCB3TN-3B
Date of Manufacture	Unknown	Unknown

Serial Nos.

No. 1	P1058	BU-960
No. 2	P1190	BU-435
<u>Hours Since Overhaul</u> <u>or Reassembly</u>		
No. 1	2,670.0	2,521.4
No. 2	3,403.9	1,468.0

North Central Airlines, Inc.

Review of company maintenance records of N90858 indicated that all routine aircraft inspections had been properly conducted and recorded. All required special inspections, and airworthiness directives had been complied with on the aircraft. The aircraft received a periodic check, C, on May 25, 1972, and an intermediate check on June 25, 1972, at 45,884.7 hours. The daily flight log sheets from January 1, 1972, to June 27, 1972, were reviewed for discrepancies which might be related to navigation, cockpit visibility, or increased cockpit workload. No pertinent discrepancies were noted,

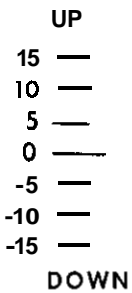
N90858 weighed 44,576 pounds at takeoff, which was below the minimum allowable takeoff gross weight of 53,600 pounds. The aircraft had been loaded in accordance with the company loading chart, and the center of gravity (c.g.) was within prescribed limits. The aircraft was operated by North Central Airlines, Inc., and leased from Systems Capitol Aircraft, Inc., who leased it from the Arlington Leasing Company, the registered owner.

Air Wisconsin Incorporated

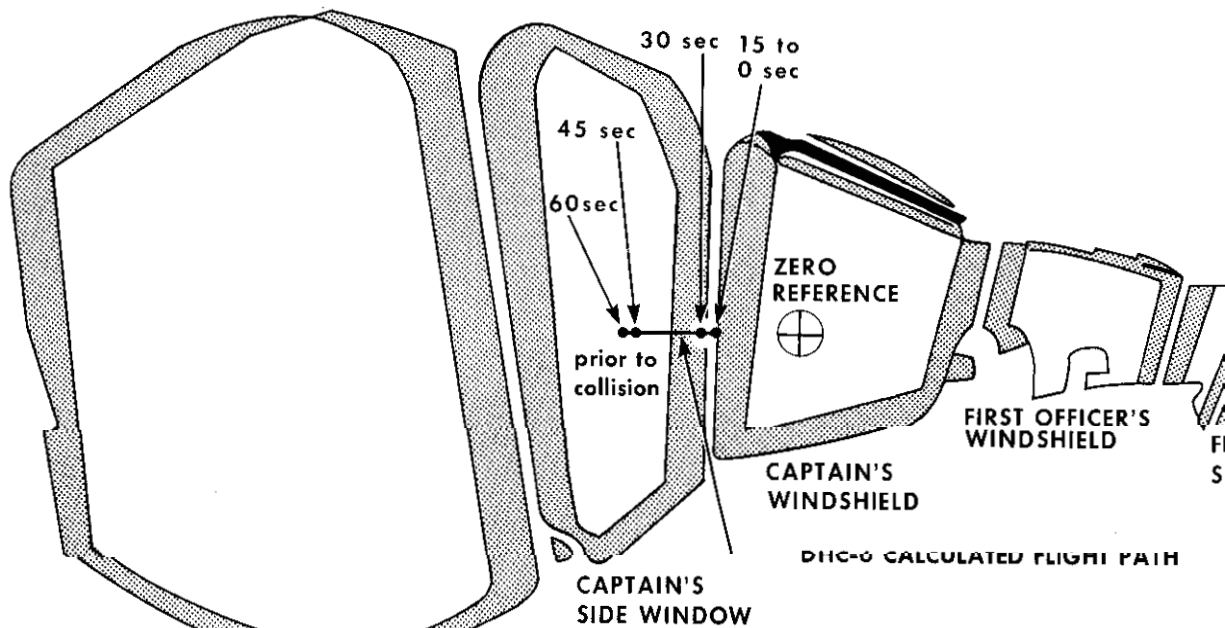
Review of company maintenance records of N4043B revealed that all routine aircraft inspections had been properly conducted and recorded. All required special inspections and airworthiness directives had been complied with. The aircraft had received a progressive inspection on June 20, 1972, at 15,587.8 hours. The daily flight log sheets from January 1, 1972, through June 28, 1972, were reviewed for discrepancies which might be related to navigation, cockpit visibility or increased cockpit workload. No pertinent discrepancies were noted.

N4043B weighed 8,704 pounds at takeoff. This was below the maximum allowable gross weight for takeoff of 11,579 pounds. The center of gravity was within the prescribed limits. The aircraft was owned and operated by Air Wisconsin Incorporated.

VERTICAL VISIBILITY ANGLE - DEGREES

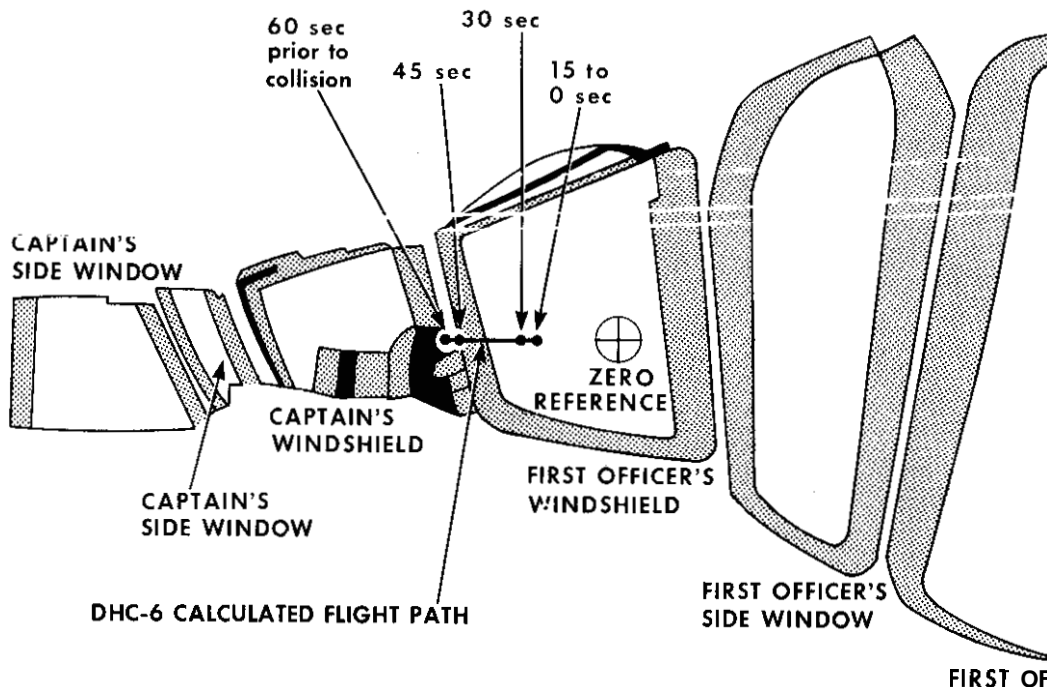
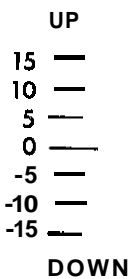


LATERAL VISIBILITY ANGLE - DEGREES
 403530252015 10 5 0 5 10152025303540
 LEFT RIGHT



CAPTAIN'S SIDE WINDOW

VERTICAL VISIBILITY ANGLE - DEGREES



DHC-6 CALCULATED FLIGHT PATH

FIRST OFFICER'S SIDE WINDOW

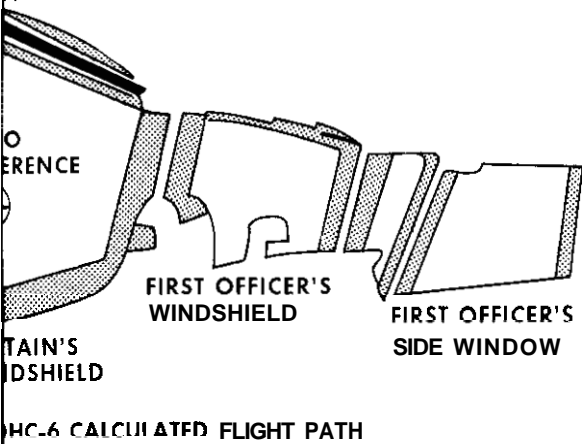
FIRST OF

LEFT RIGHT
 3530252015 10 5 0 5 101520253035
 LATERAL VISIBILITY ANGLE - DEGREES

APPENDIX E

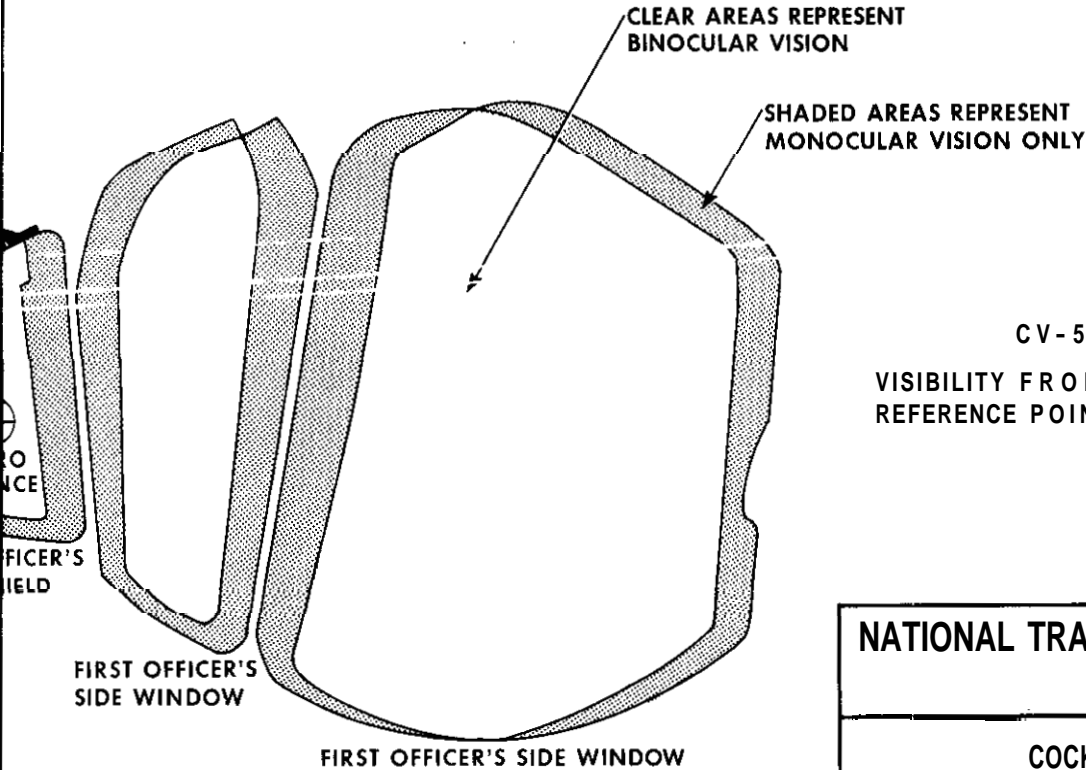
— 29 —

ANGLE - DEGREES
5 10 15 20 25 30 35 40
RIGHT



CV-580 LEFT SEAT

VISIBILITY FROM CAPTAIN'S DESIGN EYE
REFERENCE POINT



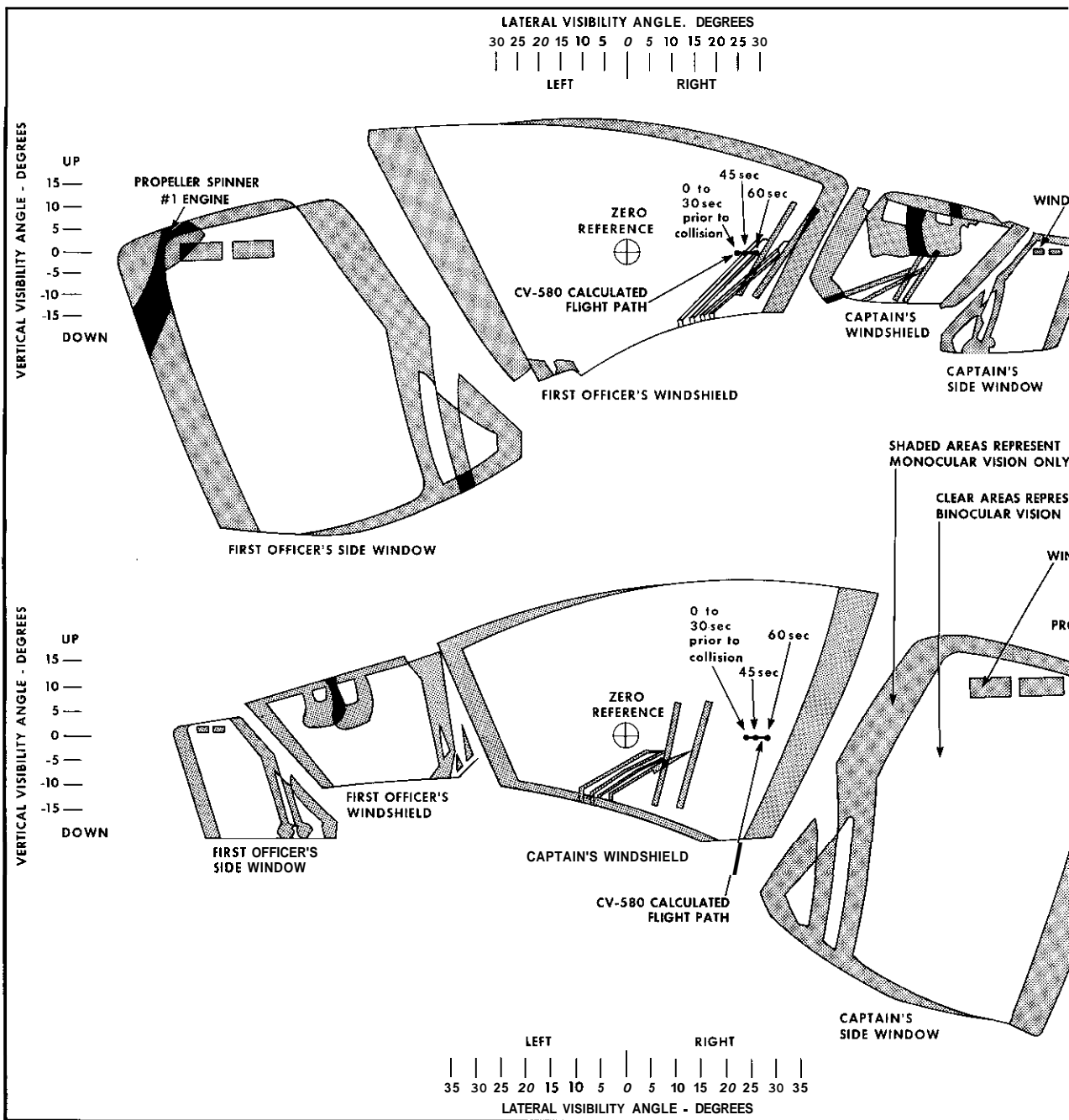
CV-580 RIGHT SEAT

VISIBILITY FROM FIRST OFFICER'S DESIGN EYE
REFERENCE POINT

RIGHT
5 10 15 20 25 30 35
ANGLE - DEGREES

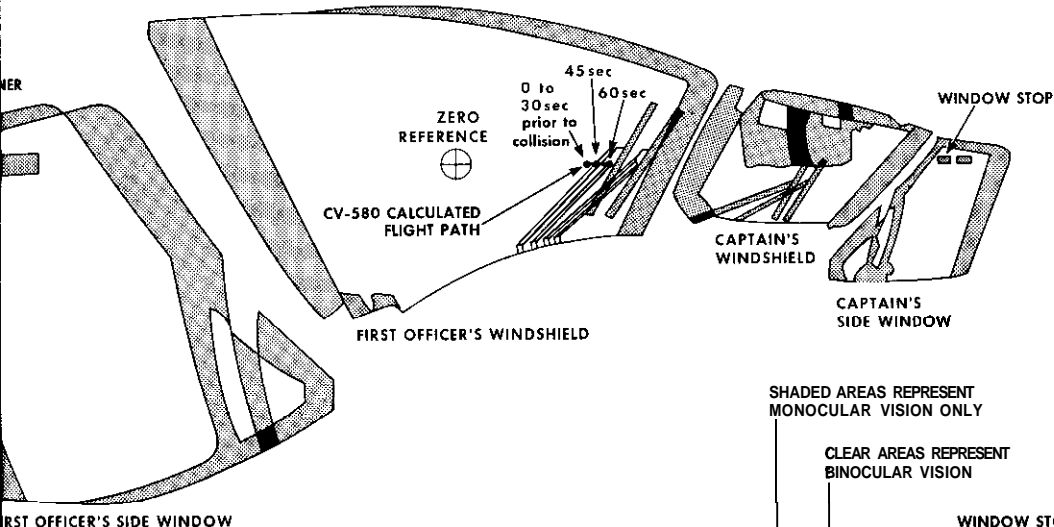
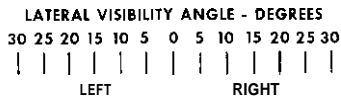
NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C.

COCKPIT VISIBILITY - CV-580
NORTH CENTRAL CV-580 AND AIR WISCONSIN DHC-6
NEAR APPLETDN, WISCONSIN
JUNE 29, 1972

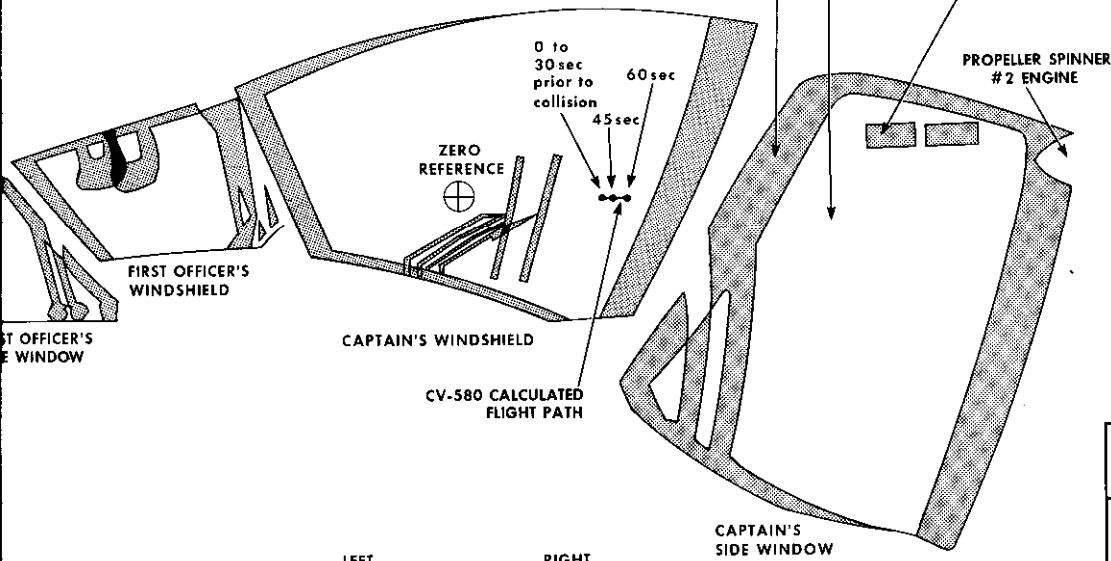


APPENDIX F

-31-



DHC-6 LEFT SEAT
 VISIBILITY FROM FIRST OFFICER'S PROBABLE
 EYE REFERENCE POINT
 FIRST OFFICER OCCUPIED LEFT SEAT



DHC-6 RIGHT SEAT
 VISIBILITY FROM CAPTAIN'S PROBABLE
 EYE REFERENCE POINT
 CAPTAIN OCCUPIED RIGHT SEAT

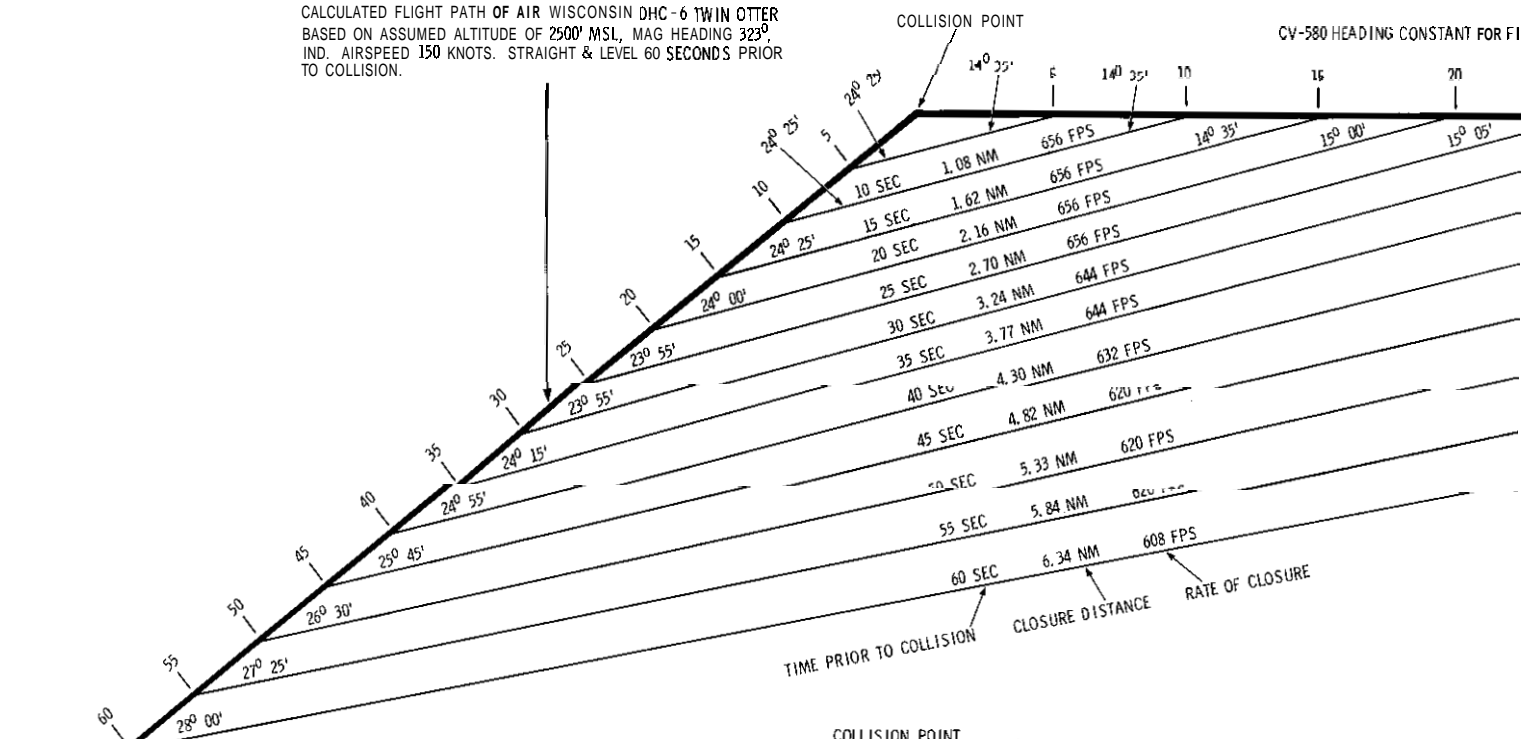


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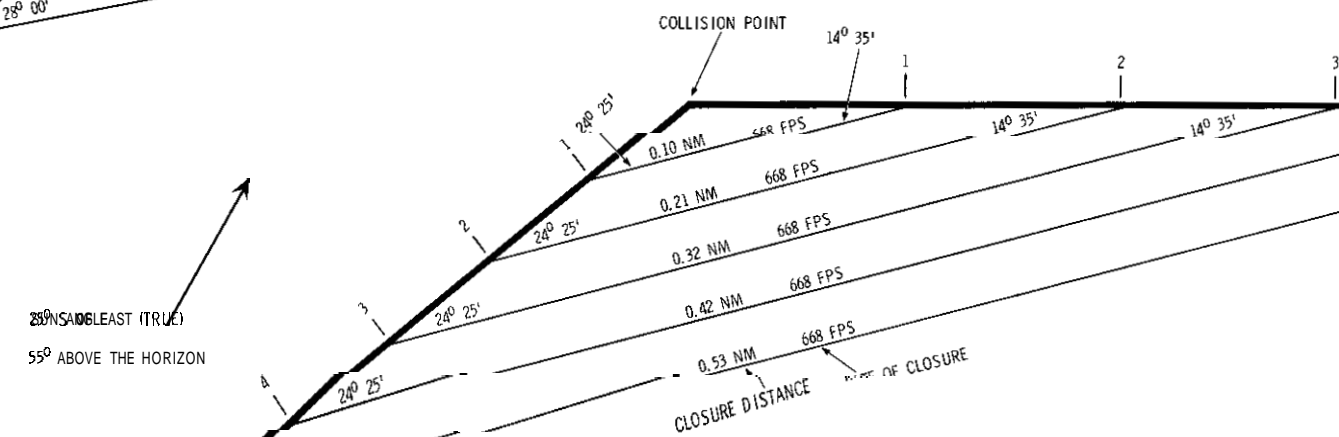
COCKPIT VISIBILITY - DHC-6
 NORTH CENTRAL CV-580 AND AIR WISCONSIN DHC-6
 NEAR APPLETON, WISCONSIN
 JUNE 29, 1972

CALCULATED FLIGHT PATHS FOR 60 SECONDS PRIOR TO COLLISION

CALCULATED FLIGHT PATH OF AIR WISCONSIN DHC-6 TWIN OTTER
 BASED ON ASSUMED ALTITUDE OF 2500' MSL, MAG HEADING 323°
 IND. AIRSPEED 150 KNOTS. STRAIGHT & LEVEL 60 SECONDS PRIOR
 TO COLLISION.



280° NS (TRUE)
 55° ABOVE THE HORIZON



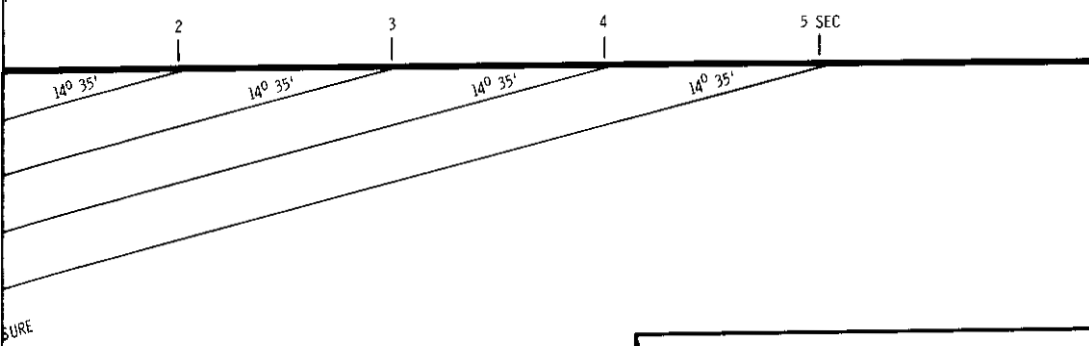
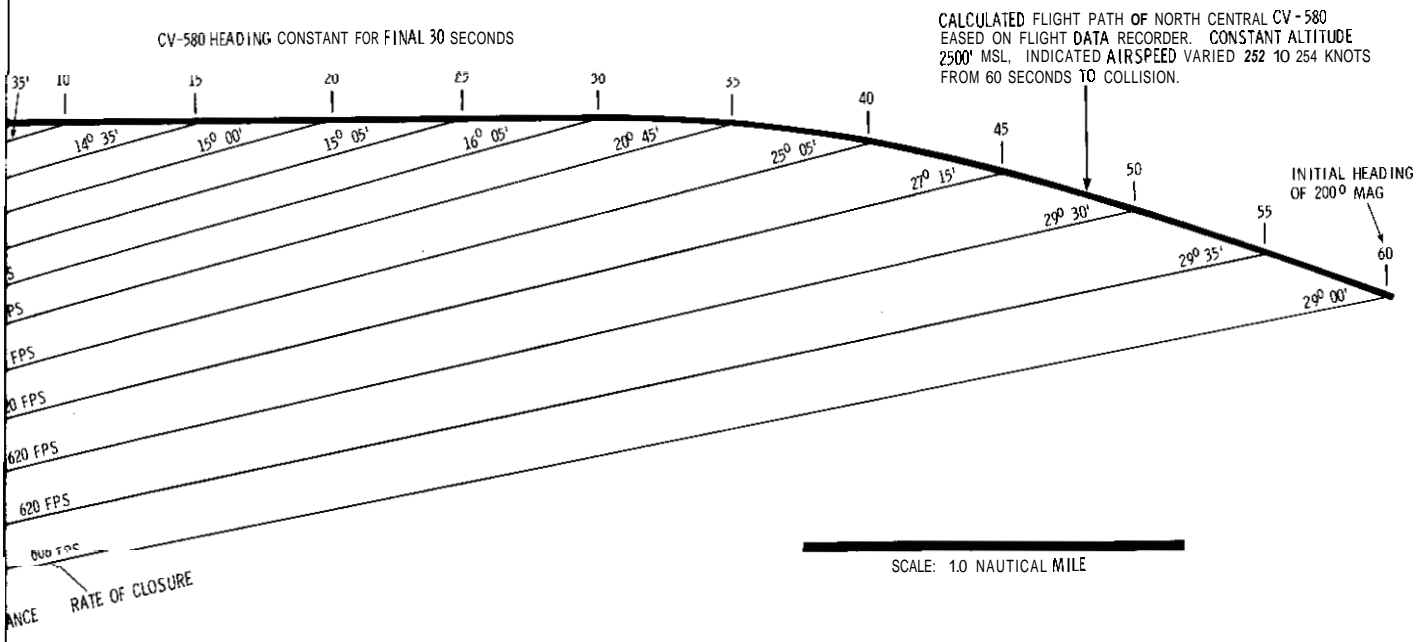
5 SECONDS PRIOR TO COLLISION

TN
VAR 1° E
MN

APPENDIX G

— 33 —

30 SECONDS PRIOR TO COLLISION



NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, O.C. 20591

CALCULATED FLIGHT PATH
NORTH CENTRAL CV-580 AND
AIR WISCONSIN DHC-6
NEAR APPLETON, WISCONSIN
JUNE 29, 1972

SUMMARY OF FAA PLANNING, RESEARCH, AND DEVELOPMENT OF THE COLLISION AVOIDANCE SYSTEM/PROXIMITY WARNING INDICATOR

Prooram Element	Sub-Program	Title
051		Proximity Warning Indicator (PWI)
	051 241	Visual Collision Prevention System
052		Collision Avoidance System (CAS)
	052 241	Airborne Collision Avoidance System
	052 620	CAS Spectrum Engineering

Objectives

The objectives are to:

1. Proceed towards a possible national standard for a Proximity Warning Indicator/Collision Avoidance System (PWI/CAS).
2. Consider all PWI and CAS desians and test and evaluate those which have real-promise.
3. Conduct the advanced tests and preimplementation activities for the Air Transport Association's CAS.
4. Conduct tests, electromaonetic compatibility analyses, and spectrum studies to ensure interference-free operation of the CAS.
5. Prepare a progress report on the above activities for delivery to Congress.

Discussion

The Collision Avoidance System/Proximity Warning Indicator Program includes the development of those aspects of transponderlinterrogator and infrared (IR) technologies related to PWIICAS. An in-depth analysis of the Army's **transponderlinterrogator** technique is being undertaken. The National Aviation Facilities Experimental Center (NAFEC) flight test report on the National Aeronautics and Space Administration (NASA)-initiated IR techniques has defined where further work on IR sensors and anticollision lights should be conducted. Other potential PWI concepts and technologies are uncertain at this time; however, efforts will continue to foster the development and evaluation of promising candidate systems.

In regard to collision avoidance system development, the Air Transportation Association's (ATA) successful testing of the ATA airborne CAS based on time-frequency technology and the first NAFEC ATCICAS interaction simulations indicate that the system has the potential for meeting airline operational requirements with an acceptable ATC interaction price in today's heaviest traffic levels. Further analysis and Simulation are required to determine whether air traffic control procedural and/or CAS logic changes will keep the interaction price within acceptable limits at future traffic levels and other conditions.

The FAA has recently awarded a study contract to determine how many ATA time-frequency (T-F) ground stations would be required versus various levels of coverage, should such a system be implemented. Also, the FAA will soon award a contract for the purchase, installation at NAFEC, and test of a complete T-F ground station and associated airborne equipment. Other CAS concepts such as those utilizing the ATCRBS or DABS are being studied and tested. The future CAS program is expected to be very dynamic and continually evolving because of the current rapid enhancement of the state-of-the-art in this field.

FY 1973 Highlights

1. A contractor was selected to deliver complete collision avoidance systems for flight test and evaluation during FY 1973 and 1974 at the Naval Air Development Center (NADC).
2. A contractor was selected for an analytical study to determine the number, location, and implementation priority of T-F CAS ground stations. should that method ultimately be selected. Completion is scheduled for late 1973.

FY 1974 Plans

1. Contracts mentioned above under FY 1973 Highlights will be completed and maximum use will be made of FAA-developed standard traffic models and other computer programs in evaluating candidate CAS systems.
2. A development model T-F CAS ground station and associated airborne equipments will be delivered for test and evaluation at NAFEC.
3. The NAFEC CASIATC interface and interaction simulations will be completed and the results evaluated and translated into impact on and/or changesto existing procedures.