NATIONAL TRANSPORTATION SAFETY BOARD

REPORT NUMBER: NTSB-AAR-70-15

AIRCRAFT ACCIDENT REPORT

ALLEGHENY AIRLINES, INC., DC-9, N988VJ AND A FORTH CORPORATION, PIPER PA-28, N7374J NEAR FAIRLAND, INDIANA SEPTEMBER 9, 1969

NATIONAL TRANSPORTATION SAFETY BOARD

Bureau of Aviation Safety

Washington, D. C. 20591

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SA-417 FILE NO. 1-0016

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ADOPTED: JULY 15, 1970

E R R A T U M

The following change should be made to the subject report:

Delete footnote 2/, page 6, Appendix D.

November 18, 1970

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DEPARTMENT OF TRANSPORTATION
AIRCRAFT ACCIDENT REPORT

Adopted: July 15, 1970

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SYNOPSIS

An Allegheny Airlines, Inc., DC-9, N988VJ, and a Forth Corporation, Piper PA-28, N7374J, collided in flight approximately 4 miles northwest of Fairland, Indiana, at approximately 1529 e.d.t., September 9, 1969. All 83 occupants, 78 passengers and four crewmembers, aboard the DC-9 and the pilot of the PA-28 were fatally injured. Both aircraft were destroyed by the collision and ground impact.

Allegheny 853 was under positive radar control of the Federal Aviation Administration's Indianapolis Approach Control, descending from 6,000 feet to an assigned altitude of 2,500 feet at the time of the collision. N7374J was being flown by a student pilot on a solo cross-country in accordance with a Visual Flight Rules (VFR) flight plan. The collision occurred at an altitude of approximately 3,550 feet.

The visibility in the area was at least 15 miles, but there was an intervening cloud condition which precluded the crew of either aircraft from sighting the other until a few seconds prior to collision.

Based in part upon this investigation, the Board has submitted recommendations to the FAA concerning establishment of minimum standards for radar reflectivity of small aircraft, and mandatory aircrew training programs on effective scanning patterns and procedures.

The Board also convened a public hearing on the Midair Collision Problem in general, which was attended by all segments of the aviation community. The material received at that hearing will be the subject of a separate report.

The Board determines the probable cause of this accident to be the deficiencies in the collision avoidance capability of the Air Traffic Control (ATC) system of the Federal Aviation Administration in a terminal area wherein there was mixed Instrument Flight Rules (IFR) and Visual Flight Rules (VFR) traffic. The deficiencies included the inadequacy of the see-and-avoid concept under the circumstances of this case; the technical limitations of radar in detecting all aircraft; and the absence of Federal Aviation Regulations which would provide a system of adequate separation of mixed VFR and IFR traffic in terminal areas.

1. INVESTIGATION

1.1 History of the Flight

Allegheny Airlines, Inc., Flight 853 (Allegheny 853), is a regularly scheduled flight from Boston, Massachusetts, to St. Louis, Missouri, with intermediate stops at Baltimore, Maryland, Cincinnati, Ohio, and Indianapolis, Indiana. On September 9, 1969, the flight departed Boston at 1200 1/ and proceeded routinely to Cincinnati. Departure, at 1515, was in accordance with an Instrument Flight Rules (IFR) clearance to Indianapolis via V-97 at an altitude of 10,000 feet. There were 78 passengers and four crewmembers aboard. At 1522:55, the Indianapolis Air Route Traffic Control Center (ARTCC) D-20 controller advised, "Allegheny eight fifty three is in radar contact, cross Shelbyville (VOR) at and maintain six thousand and your position now thirty-two miles (unintelligible) . . . southeast of Shelbyville." Approximately 3 minutes later, the flight reported leaving 10,000 feet, and during its descent, was instructed to contact Indianapolis Approach Control. At 1527:12, the approach control controller advised, "Allegheny eight five three roger, squawk ident heading two eight zero radar vector visual approach three one left." Allegheny 853 acknowledged the vector and was almost immediately instructed to descend to 2,500 feet. The flight acknowledged at 1527:29, "Eight five three cleared down two thousand five hundred and report reaching." This was the last recorded transmission from the flight.

Piper PA-28, N7374J, owned and operated by the Forth Corporation, was based at Brookside Airpark, approximately 20 miles northeast of Indianapolis. On September 9, 1969, the aircraft was leased to a student pilot, who was to complete a solo cross-country flight. Although the pilot had intended to fly to Purdue University Airport, deteriorating weather had prompted a change in plans, and he selected Bakalar AFB, approximately 40 miles south of Brookside. The preparation for the actual flight was checked by the general manager of the airpark, and a Visual Flight Rules (VFR) flight plan was filed indicating a cruising altitude of 3,500 feet. The general manager reported that the pilot was wearing glasses, had turned on the aircraft's rotating anti-collision beacon, and in a call on Brookside Unicom, acknowledged by the general manager, said that he would depart on Runway 36. No witness observed the actual takeoff, but the pilot advised the Indianapolis Flight Service Station at 1521 that he had departed Brookside, and requested activation of his flight plan. This was the last known communication with N7374J.

The D-20 controller in the ARTCC who handed off Allegheny 853 to approach control stated that the target was approximately 10 miles southeast of the Shelbyville VOR on V-97 at the time. He continued to observe

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

the target proceed to a point approximately 5 miles southeast of the Shelbyville VOR, execute a 45° left turn and proceed westbound for approximately 5 miles. At this point, he shifted his attention to other duties. He testified that he did not see any primary targets that were conflicting traffic for Allegheny 853.

The AR-1 controller, who assumed responsibility for Allegheny 853 in the approach control facility, was also assigned the functional duties of the AR-2 position. 2/ He stated that he observed the target of Allegheny 853 southeast of the Shelbyville VOR, heading approximately 300°. Following radar identification he, ". . . instructed him to turn left heading two eight zero degrees for radar vector for visual approach to runway three one left, descend and maintain two thousand five hundred feet and report level . . ." The flight acknowledged these instructions, and then the controller's attention was diverted to other duties, including a radar handoff on Allegheny 820 which was arriving from the southwest. At approximately the same time, 1531, he noticed that the target of Allegheny 853 had disappeared. At no time did he observe any conflicting traffic in the vicinity of the flight. The recorded communications between the AR-1 controller and other flights under his direction revealed that he issued several traffic advisories of primary radar targets in the vicinity of the flights he was controlling.

Statements were obtained from 22 witnesses in the area, eight of whom saw the collision. The statements indicate that there was a broken-to-scattered cloud cover in the area, but both aircraft were below the clouds and could be seen clearly at the time of the collision. Allegheny 853 was westbound and N7374J was heading southeasterly, and neither aircraft attempted a collision avoidance maneuver according to the witnesses.

There were many flights in the vicinity of Indianapolis at the approximate time of the accident. They all reported good visibility below the clouds, but varied in their estimates of the cloud base from 3,000 to 4,000 feet m.s.l. There were three aircraft utilizing the expanded radar service of approach control between 1500 and 1600 that reported operating VFR at 3,500 feet. One of these aircraft, N2666J, reported in the vicinity of Shelbyville approximately 10 minutes before the accident.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	4 (DC-9)	78	0
	1 (PA-28)	0	0
Nonfatal	0	0	0
None	0	0	

2/ The AR-1 position is responsible for traffic arriving from the east and AR-2 is responsible for traffic arriving from the west.

1.3 Damage to Aircraft

Both aircraft were destroyed by the collision and ground impact.

1.4 Other Damage

A few mobile homes in the vicinity of the main crash site were slightly damaged. The soybean crop, which was growing in the field where the DC-9 impacted, was destroyed.

1.5 Crew Information

The crews of both aircraft were properly certificated and qualified for the respective flights. (See Appendix B for details.)

1.6 Aircraft Information

Both aircraft were properly certificated and had been maintained in accordance with existing regulations. The weight and center of gravity of each were within the prescribed limits. The DC-9 was serviced with kerosene and the PA-28 with 80/87 aviation fuel. (See Appendix C for details.)

1.7 Meteorological Information

There were no fronts or low-pressure system centers in the vicinity of the accident. The 1540 Special surface weather observation at Indianapolis was ceiling measured 3,400 feet broken, 5,000 feet overcast, visibility 15 miles, wind 330° 12 knots, altimeter setting 30.08 inches. The 1557 surface observation at Bakalar AFB was, in part, ceiling estimated 2,800 feet broken, 8,000 feet broken, visibility 15 miles.

The aviation area forecast, issued by the Forecast Office at Chicago at 0845, indicated that excluding the extreme northern sections, the rest of Indiana would be clear, becoming 3,000 to 4,000 feet scattered variable to broken after 1200. For the northern half of Indiana, the forecast issued at 1445 called for 1,800 to 3,000 feet scattered variable to broken, ceiling 3,500 to 5,000 feet overcast variable to broken, tops 7,000 to 10,000 feet.

The aviation terminal forecast issued at 1245 for Indianapolis included the following for the period 1500 to 2000: ceiling 2,500 feet broken, 5,000 feet broken, wind 330° 12 knots, lower broken clouds variable to scattered.

The Dayton 2000 radiosonde ascent (below 12,000 feet) showed conditionally unstable air below approximately 6,800 feet, stable air from near 6,800 feet to 9,000 feet, and above 9,800 feet. The 800-foot band from 9,000 to 9,800 feet contained conditionally unstable air. The freezing level was 6,400 feet, but there was a 4° C. inversion from near 8,400 feet to 9,000 feet. The temperatures were above freezing from near 8,600 feet to 9,000 feet.

1.8 Aids to Navigation

Indianapolis ARTCC utilizes an ARSR-1E radar system for control of traffic. The antenna is located on the airport and rotates at six revolutions per minute. The D-20 sector controller has an RBDE-5 (television presentation) radar display equipment. At the time of the accident, the ARTCC radar was being operated on low power.

Indianapolis Approach Control utilizes an ASR-6 radar system with a maximum range of approximately 50 miles. The antenna site is also on the airport, approximately 1 mile from the ARSR-1E antenna. The ASR-6 antenna rotates at 15 revolutions per minute. The AR-1 controller uses a PPI 9-inch radarscope, but there are 14-inch TI-440 television displays at adjacent positions on either side of the AR-1 controller. The TI-440 is normally set at a 40-mile range, 10 miles greater than the PPI, and therefore is generally used to locate and identify handoffs from the ARTCC.

1.9 Communications

There were no reported difficulties with communications between either Allegheny 853 or N7374J and the respective ground stations contacted by each. The flights were not on the same frequencies.

1.10 Aerodrome and Ground Facilities

Not applicable.

1.11 Flight Recorders

Allegheny 853 was equipped with a United Control Data Division flight data recorder, Model FA-542, S/N 1667. The recorder unit was crushed and had to be cut open to remove the magazine, which was moderately deformed. The foil medium had been torn in half in the area of the last recorded traces, and the upper and lower edges were torn and crumpled in numerous places. The edges of the severed foil were matched, and a readout of the traces was made without difficulty. The aircraft was descending at approximately 2,400 feet per minute on a heading of 282° when the airspeed trace stopped at 13 minutes 48 seconds after lift-off and 1 second later, the altitude and vertical acceleration traces also became aberrant. The last values indicated, prior to the abnormalities, were +1.0 g, 282°, 256 knots, and 3,550 feet.

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Allegheny 853 was also equipped with a United Control Corporation cockpit voice recorder (CVR), Model V557, S/N 2107. The recorder was in operating condition throughout the flight, and although the protective casing separated at impact, leaving the tape cartridge exposed, the complete recording was satisfactory.

The CVR tape revealed that the crew had completed their "In Range" checklist preparatory to landing at Indianapolis, and were in the process of accomplishing other points of crew coordination when the following sequence occurred:

1529:13 Out of thirty-five for twenty-five (1929:14.3)
CAM-(2) 3/

1529:14.3 I'm Going Down (1929:15.9)
CAM-1

1529:15 Sound similar to objects striking metal
CAM

CAM Landing gear warning horn.

1529:17 Sound of possible stall vibration
CAM

The recording ended at 1529:27.1.

N7374J was not equipped with any flight recorders, and none was required by regulation.

1.12 Wreckage

The wreckage of the two aircraft, which was scattered over an area approximately 5,000 feet by 3,500 feet and oriented along a 107° to 287° centerline, was concentrated in two basic areas.

The DC-9 impact site was approximately 1,300 feet long and 700 feet wide. The aircraft struck the ground in an inverted, almost wings-level, nosedown attitude. It was relatively intact except for the parts which separated in the collision. The landing gear, flaps, and spoilers were retracted at impact, but the leading edge slats were extended.

The PA-28 and DC-9 horizontal stabilizer assemblies were located approximately 4,500 feet east of the DC-9. The PA-28 left wing, most of the fuselage, and the horizontal stabilizers were intact about 150 feet

3/ Abbreviations indicate source of intelligence, i.e., (CAM-(2) denotes the comment was probably from the first officer, CAM-1 denotes the captain, and CAM denotes the cockpit area microphone was the recording instrument.

east of the DC-9 horizontal stabilizer. The engine, vertical fin and rudder, part of the right wing, engine cowling, propeller, and metal from both aircraft were found in an area 700 feet south of the DC-9 horizontal stabilizer.

The wreckage of both aircraft was moved to Bakalar AFB where a two-dimensional layout was made to study the scratch and scuff marks and determine the principal points of impact and the impact geometry. The initial contact between the two aircraft occurred at the forward upper right side of the vertical fin, just below the horizontal stabilizer, of the DC-9, and the left forward side of the PA-28, just forward of the left wing root. The representative scratch and scuff marks on the DC-9 horizontal stabilizer (Attachment D), nearest the initial point of contact, were aligned at an angle of 22° to the longitudinal axis of the aircraft on the right stabilizer and 16° on the left stabilizer. The scratch and scuff marks on the right wing of the PA-28 (Attachment E) were generally aligned 50° to 60° with the longitudinal axis of the aircraft. A line of sight along the damage through the PA-28 fuselage was approximately 60° to the longitudinal axis of the aircraft. There was no indication of relative motion between the two aircraft in the vertical plane.

1.13 Fire

There was no evidence of in-flight or ground fire on any parts of either aircraft.

1.14 Survival Aspects

This was a nonsurvivable accident.

1.15 Tests and Research

A cockpit visibility study was conducted to determine the physical limitations to visibility from the crewmember seats in each aircraft, and what effect the flightpaths might have had. The flightpath of Allegheny 853 was based on the flight recorder data and, since there was no other source, the data for N7374J at the moment of impact was projected backward for 22.8 seconds prior to collision. The reconstruction (Attachment A) revealed that, at that time, the aircraft were 12,130 feet apart and Allegheny 853 was approximately 850 feet above N7374J. Allegheny 853 was 55° to the left of N7374J, and the relative bearing of N7374J to Allegheny 853 was 19° to the right. As the aircraft closed to a range of 5,430 feet, 10.2 seconds prior to collision, there was approximately 350 feet vertical separation. As Allegheny 853 descended through 3,800 feet altitude the range had decreased to 3,500 feet, 6.6 seconds before impact. At 2.4 seconds the range was 1,210 feet and Allegheny 853 was at 3,675 feet.

In order to determine the physical limitations to vision from each cockpit, binocular photographs were taken in a PA-28 and a DC-9. A dual lens camera was used to record a panoramic photograph of the window configuration as seen by the pilot when he turns his head from the extreme left to the extreme right. The photographs were taken using the design eye position for each crewmember. Attachments B and C portray the position of each aircraft in the field of vision of each crewmember, based on this fixed-eye reference. Naturally, any movement or deviation from such a position would have effected the position of the target in the window.

Flight tests of the ARTCC and approach control radar systems following the accident were conducted to determine whether they were capable of detecting a PA-28 in the vicinity of the accident. In each of the three flight checks, conducted on September 9, 10, and 15, both systems were capable of detecting the PA-28 after the aircraft had emerged from tangential blind speed effect, 4/ about 8 miles north of the accident site. However, none of the tests were conducted under meteorological conditions similar to those which existed at the time of the accident, particularly in terms of temperature inversions aloft.

1.16 Other

The aforementioned visibility study does not consider the effect of cloud cover or other conditions which reduce the pilot's ability to see and avoid other aircraft. In this connection, the Board reviewed the development of the "see and be seen" concept and a summary of that study is provided in Appendix D. The involvement of the concept in this accident is discussed in the analysis portion of this report.

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

This accident involved an intermix of high-speed aircraft and low-speed aircraft under the combined active and passive control of the air traffic control system within a terminal area. The complexity of operating such a system, in this instance, was increased by meteorological circumstances which reduced the safety features below an acceptable level.

Allegheny 853 was operating under the positive radar control of Indianapolis Approach Control from approximately 1527 until the time of the accident. The flight was being vectored along the same general

4/ The result of an aircraft's radial velocity, with respect to the antenna, decreasing to approximately 10 knots or less as the flightpath becomes tangent. The "moving target" circuit senses such returns as stationary targets and eliminates them from display on the radarscope. The aircraft speed, heading, radar cross section, and distances from the antenna will determine the duration of the effect.

route as all arrival traffic from the southeast for Runway 31L. The flight segment from Cincinnati is very short, but preparations for the landing at Indianapolis were smooth and efficient. During the final 50 seconds, Allegheny 853 was descending at approximately 2,460 feet per minute, and at an indicated airspeed which was gradually increasing from 236 to 256 knots. The descent to the 2,500-foot assigned altitude was probably made in part while the aircraft was in clouds, and in part under VFR conditions. During this interval the pilot of N7374J was proceeding in accordance with his previously filed VFR flight plan. According to his instructor, he was very much aware of the need to maintain a lookout for landmarks as well as other traffic. Based on the data available from the collision itself, he was doing an excellent job of conforming to his flight plan. It is impossible to determine the exact cloud cover, depth, or degree of stratification, but the preponderance of evidence indicates that there were two layers of clouds in the area. The lower, broken cloud base would have been at approximately 4,000 feet. Accordingly, the crew of Allegheny 853 would be unable to initiate a scan for unknown traffic until 14 seconds prior to reaching the collision point. Conversely, the pilot of N7374J would also be limited to 14 seconds in which to apply the "see and avoid" criterion of separation, since he would be unable to see Allegheny 853 until it emerged from the clouds.

In considering the amount of time to "see and be seen," in this instance, the Board notes that there is no fixed value to the amount of time that may be necessary for detection and avoidance of potentially conflicting traffic in VFR conditions. Further, the "fixity-of-bearing" criterion 5/, that is the primary basis on which a collision potential is assessed by visual means, may not be entirely adequate. In a study report titled "The Role of Exterior Lights in Mid-Air Collision Prevention," prepared for the FAA by the Applied Psychology Corporation in 1962, the problem is discussed as follows:

> "One commonly used premise underlying analysis of collision probability is that there exists some required 'warning time,' admittedly uncertain and variously estimated by different sources." Laufer (1955), in emphasizing the complexity of determining warning time, said that in "some exceptional cases a full minute or more may be required." He carries out his collision analysis for two warning times; 25 and 50 seconds. Another source (Honeywell Aeronautical Division, 1961) says, "Depending upon maneuverability of the aircraft, the desired minimum warning time generally accepted is 10 to 20 seconds." Stone (1954), thinking in terms of DC-7 aircraft, said ". . . we are now down to 15 seconds to avoid collision." Projector & Robinson (1958), referring to Laufer (1955), said that the

5/ Fixity-of-bearing -- when two aircraft are flying straight, constant speed courses (not necessarily level) toward a collision, the bearing to either aircraft remains constant in the field of view of the pilot of the other.

"required warning time probably lies between 25 and 50 seconds." Many illumination engineers have pointed out (Laufer, 1955; Projector & Robinson, 1958, for example) that the light intensities required to furnish the required warning times, as estimates, under the full range of VFR conditions, were so high as to be impracticable. It has thus been recognized that visual collision avoidance, with presently available techniques and equipment, has serious limitations when closing speeds are high or flight visibility is near the VFR minimum.

Calvert's (1958) analysis shows, however, that there are other more profound limitations. His analysis, although limited to the fixity-of-bearing criterion, has much broader implications, which apply generally to all avoidance techniques currently in use. Calvert bases his approach on how well a pilot can estimate the probability of collision and, in the event he undertakes an avoidance maneuver, how assured he can be that the maneuver he selects will eliminate or at least reduce the probability of collision. The analysis shows that the uncertainties inherent in the fixity-of-bearing criterion are so great that the pilot often cannot use it effectively. In many situations, including some with moderate-speed aircraft, the information he needs to use the fixity criterion properly is unavailable or inadequate. If he does undertake an avoidance maneuver with inadequate information, he cannot tell what effect it will have on the probability of collision. Once he has begun the maneuver, he is committed, but he no longer has the fixity criterion, nor can he know when to end the maneuver. Since the uncertainties increase with distance, very early warning is sometimes of little or no help to him.

Because of the limitations on when it may be applied at all, and the inherent uncertainties when it is applicable, the fixity-of-bearing criterion, it seems evident, will not suffice as a visual collision-avoidance technique. It is often useful for roughly determining that an aircraft is not on a collision course; in other cases it is not applicable at all, or cannot be relied on.

These and several other studies have resulted in a consensus that 15 seconds is the absolute minimum time for detection, evaluation, and evasive action if the collision is to be avoided. On this basis, neither the pilot of N7374J or the crew of Allegheny 853 would have had sufficient time to "see and avoid" the other aircraft, even if they had devoted virtually their entire attention outside the cockpit, scanning for other aircraft.

In this connection, it should be borne in mind that Allegheny Airlines procedures require a call by the pilot not flying the aircraft when the aircraft, during descent, passes through the altitude 1,000 feet above the clearance altitude. In this instance, the call was required at 3,500 feet and the first officer, who made the call about 2 seconds prior to the collision, would have been required to monitor the altimeter for a few hundred feet prior to reaching the altitude in order to note passage. The captain's ability, meanwhile, to observe the other aircraft from his position in the left seat was virtually nil. Accordingly, the Board believes that if the high rates of descent in the approach area to civil airports are to be continued, the airspace involved must be protected by positive air traffic control procedures.

With respect to the application of the "see and be seen" concept to this accident, history has shown that restrictions to visibility have had little to do with the cause of most midair collisions. Nearly all occurred in visibility conditions greater than 3 miles and most in visibility conditions greater than 5 miles. In the present case, the visibility was 15 miles. Accordingly, there is little likelihood of any significant improvement in safety by a simple requirement for increasing the present visibility minimums -- unless it would be to the extent that there would be fewer VFR flights and more IFR operations.

Speed restrictions, as currently imposed, offer a measure of collision avoidance capability. However, the operating characteristics of present and future jet aircraft appear to preclude speed restrictions to a level at which "see and avoid" can be relied upon, particularly where high descent rates are also involved. Of more than passing interest is the fact that in nearly all of the midair collisions, whether between military and civil aircraft, or between general aviation and airline aircraft, at least one of the aircraft was changing altitude. In many instances, one or both aircraft were turning. Under these conditions the pilot's ability to locate other traffic is diminished, and some of the normal frames of reference used to determine sight-line rates 6/ are reduced. This degrades the pilot's ability to see and avoid other aircraft.

If the situation is compounded by a circumstance in which one aircraft is descending in clouds at a high rate, and the other aircraft is operating in VFR conditions only 500 feet below the clouds, the pilot of the descending aircraft will not be able to search for conflicting traffic until he is clear of the clouds. Conversely, the pilot of the VFR aircraft will be unable to see the opposing traffic until it emerges from the clouds.

With today's jet aircraft, descent rates of 3,000 feet per minute into terminal areas are common. The total time available to search for, find, and avoid another aircraft is thereby reduced to 10 seconds in the mixed IFR/VFR operation, just described. Depending upon (1) the point in space that the pilot of the descending aircraft begins his

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6/ Sight-line rate is the observed angular velocity or relative motion of a target in a horizontal or vertical plane.

scan for other traffic, and (2) the direction in which the VFR pilot is looking at the moment the other aircraft emerges from the clouds, neither pilot may have time to complete the search, and collision will be unavoidable. It is the Board's conclusion, therefore, that the "see and be seen" concept of collision avoidance, which has been demonstrably deficient in the past, is now totally unacceptable in providing separation between aircraft during descents into terminal areas where high- and low-speed traffic is intermixed under IFR and VFR control.

One additional meteorological factor, which had a bearing on the accident in a less obvious way, was the temperature inversion with a base at 7,000 feet in the area of the accident. However, its detrimental effect on radar reception, because of anomalous propagation 7/, is well known.

The D-20 controller's workload at the time of the handoff was sufficiently light that even though he had no continuing responsibility for the aircraft, he continued watching it for several minutes. His testimony indicates that he must have observed Allegheny 853 until it was within a few miles of the accident site, and that at no time did he see any primary targets that would conflict with that of the flight.

The AR-1 controller was responsible for the flight for approximately the last 2-1/2 minutes only. During most of this period, he apparently spent most of the time attending to necessary duties other than following the target of Allegheny 853. He did not detect any traffic conflicting with the flight.

Radar has proven itself a safe and efficient tool for the positive control of air traffic. However, in this accident, it is believed that two independent radar systems failed to detect the presence of N7374J and, as a result, no warning was given to the crew of Allegheny 853 regarding the specific direction and distance of the hazard. Had the crew been provided with this information, their chances of seeing and avoiding the other aircraft below the cloud layer would have been enhanced.

The ARSR-1E radar at the Indianapolis ARTCC, serving the D-20 controller's position, was being operated on low power at the time of the accident to counteract the effects of anomalous propagation. This setting reduces the clutter from such atmospheric interference and improves transponder target display. Unfortunately, the reception of

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7/ A term applied to the return of radar energy from targets beyond the normal range of the radar station. These returns enter the receiver in phase with the returns of subsequent signals from closer targets, and appear as close-in targets. The target returns in this case were the result of "ducting" due to temperature inversion. The use of low power, that is the radar pulse transmitted, minimizes the effects of this phenomenon, but has an adverse effect on the controller's ability to detect certain real targets with low radar reflective properties.

primary target, with the small radar cross sections is also reduced proportionately. Expert testimony at the public hearing confirmed that a primary target, with the radar cross section of a PA-28, might not be detected at a distance of 20 miles from the antenna site under low-power operation. The Board concludes that under the conditions present at the time of the accident, the target of N7374J was not visible on the D-20 controller's radarscope.

The ASR-6 radar at the Indianapolis Approach Control, serving the AR-1 controller's position, was operating at normal power, with the Moving Target Indicator (MTI) 8/ set at approximately 20 to 25 miles. The various flight tests to determine the capability of the radar to detect N7374J as it proceeded along its intended flightpath have demonstrated that, in all probability, there was no usable target displayed from approximately 14 miles to 8 miles north of the crash site. The lack of reception in this area is attributed to the tangential blind speed effect, where the radial velocity between the target and the antenna falls below the detectable threshold. N7374J should have been emerging from this area at about the time the handoff of Allegheny 853 was effected. From this point to the crash site, the primary target of N7374J would normally have been visible for approximately 5 minutes on the AR-1 controller's radarscope. The controller stated he was scanning an area approximately 15 miles ahead of Allegheny 853, and there were no primary targets that represented conflicting traffic. However, no accurate correlation can be made between the time that he scanned and the specific location of N7374J. It is possible that the temperature inversion, which was affecting the ARTCC radar, also decreased the effectiveness of the approach control radar as well. Based on the conscientious attention that the AR-1 controller gave to providing radar traffic information to other aircraft under his control, the Board believes usable radar returns from N7374J were not presented on the radar display, at least not during the time that the controller was observing the radarscope.

The solution to the ineffectiveness of the radar in this instance appears to be the establishment of some minimum standard of reflective capability for all aircraft and the incorporation of some form of signal enhancement apparatus in all aircraft, as necessary, to meet the standard. This would insure target presentation on radar, and converging traffic advisories could be given. Additionally, the present controller-pilot relationship presumes sufficient time to transmit, acknowledge, detect, and avoid conflicting traffic. In high-density terminal areas where airspace and radio time are always at a premium, it appears that a saturation point has been reached during peak hours of operation. The recent Notice of Proposed Rule Making 69-41, Terminal Control Areas General, published by the FAA, was endorsed in principle by the Board as a first step in the direction of a safer and more efficient air traffic control system.

8/ An electronic device designed to improve the radar display by minimizing the presentation of stationary targets.

This discussion of the circumstances relating to this accident has established that each party involved was conforming to the requirements of a system intended to provide safe and compatible operation for all persons desiring to use the available airspace. Nonetheless, the accident occurred. It was recognition of the vast scope and far-reaching effects of this conclusion that prompted the Board to conduct a public hearing on the Midair Collision Problem. This hearing, before all five Board Members, was unprecedented, and will be the subject of a separate report and recommendations itself.

2.2 Conclusions

(a) Findings

1. Both aircraft were properly certificated and airworthy.
2. All flight crewmembers were properly certificated.
3. There was no malfunction of either aircraft prior to the collision.
4. Allegheny 853 was operating with an IFR clearance under positive radar control of Indianapolis Approach Control.
5. N7374J was operating with a VFR clearance and was not under positive control of any facility.
6. The AR-1 controller was properly certificated.
7. There were broken cloud layers in the vicinity of the accident, with bases at 4,100 and 6,000 feet.
8. Visibility below the clouds was in excess of 15 miles.
9. There was a temperature inversion at approximately 7,000 feet in the area of the accident.
10. The ARTCC radar failed to detect N7374J because of inadequate radar cross section of the aircraft and the low power selected to offset the effects of anomalous propagation from the inversion.
11. The approach control radar failed to detect N7374J initially because of the tangential blind speed. Subsequent lack of detection, within approximately 8 miles of the accident site or less, was due either to the effects of the inversion on target strength, or to the controller's attention to duties which precluded monitoring the radarscope.

12. The descent rate and airspeed of Allegheny 853, although generally in compliance with existing regulations, are considered to be slightly high in view of the present regulations which permit VFR aircraft operations only 500 feet below clouds in airport approach areas.

13. There was insufficient opportunity for either crew to reasonably be expected to see and avoid the other's aircraft.

(b) Probable Cause

The Board determines the probable cause of this accident to be the deficiencies in the collision avoidance capability of the Air Traffic Control (ATC) system of the Federal Aviation Administration in a terminal area wherein there was mixed Instrument Flight Rules (IFR) and Visual Flight Rules (VFR) traffic. The deficiencies included the inadequacy of the see-and-avoid concept under the circumstances of this case; the technical limitations of radar in detecting all aircraft; and the absence of Federal Aviation Regulations which would provide a system of adequate separation of mixed VFR and IFR traffic in terminal areas.

3. RECOMMENDATIONS

The Board issued 14 recommendations to help prevent midair collisions in its special accident prevention study "Midair Collisions in U. S. Civil Aviation - 1968" which was released in July 1969. Two months later, in a report on another midair collision between an IFR air carrier aircraft and a VFR light aircraft, the Board reiterated the need for improvement in the separation of traffic in terminal areas, increased pilot vigilance, and the expeditious development of a low-cost collision avoidance system or proximity warning indicator.

As a result of information developed in the investigation of both this, and the previously mentioned midair collision, the Board recommended that FAR Parts 21 and 23 be modified to require all aircraft weighing less than 12,500 pounds, manufactured after some appropriate date, to have a minimum radar cross section, or reflectability, suitable for detection as a primary radar return at distances of 125 to 150 miles from the antenna site. Further, a minimum level of radar cross section should be established for present aircraft to be permitted to operate in certain expanded radar service environments.

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

/s/ ISABEL A. BURGESS
Member

July 15, 1970.

INVESTIGATION AND HEARING

1. Investigation

The Board received notification of the accident at approximately 1550 on September 9, 1969, from the Federal Aviation Administration. An investigating team was immediately dispatched to the scene of the accident. Working groups were established for Operations, Witnesses, Air Traffic Control, Weather, Structures, Systems, Maintenance Records, Powerplants, and Flight Recorder. Interested parties included the Federal Aviation Administration, Allegheny Airlines, Forth Corporation, Douglas Aircraft Division, Air Line Pilots Association, Aircraft Owners and Pilots Association, Airline Transport Association, and Professional Air Traffic Controllers Organization. The on-scene investigation was completed on September 19, 1969.

2. Hearing

A public hearing was held at Indianapolis, Indiana, on October 8-10, 1969. Parties to the Investigation included Federal Aviation Administration, Allegheny Airlines, Inc., Forth Corporation, Air Transport Association, Aircraft Owners and Pilots Association, Air Line Pilots Association, Air Traffic Control Association, National Association of Government Employees, and Professional Air Traffic Controllers Organization.

3. Preliminary Reports

A summary of the testimony which was taken at the public hearing was published by the Board on November 6, 1969.

Crew Information

Captain James M. Elrod, aged 47, held airline transport pilot certificate No. 92684-41, with ratings in airplane single- and multiengine land, DC-3, CV 240/340/440, Allison Convair 340/440, and DC-9. He had accumulated 23,813 total flying hours, of which 900 were in the DC-9. His last proficiency check was completed February 21, 1969, and his FAA first-class medical certificate was dated August 4, 1969, with the limitation, "Holder shall possess correcting glasses for near vision while exercising the privileges of his airman certificate."

First Officer William E. Heckendorn, aged 26, held commercial pilot certificate No. 1601124, with ratings for airplane single- and multiengine land and instruments. He had accumulated 2,980 total flying hours, of which 651 were in the DC-9. He completed his last proficiency check on August 19, 1969, and his FAA first-class medical certificate was dated November 20, 1968, which was still currently valid as a second-class medical certificate at the time of the accident.

Hostess Barbara Petrucick, aged 31, was hired on April 11, 1960, and received her last recurrent training on April 9, 1969.

Hostess Patricia Perry, aged 29, was hired on August 22, 1961, and received her last recurrent training on March 12, 1969.

Pilot Robert W. Carey, aged 34, held a combination student pilot and medical certificate, No. AA-0835466, dated March 13, 1969. He was reported to have accumulated approximately 12 to 15 flying hours prior to commencing flight instruction at Brookside Airpark in March 1969.

Since that time he had accumulated 39 flying hours, all in the PA-28. He had completed his written examination for a private pilot certificate, and was preparing for the flight test. A limitation placed on his medical certificate stated, "Holder shall wear correcting glasses while exercising the privileges of his airman certificate."

The flight crew of Allegheny 853 arrived in Boston at 2219 on September 8, and were off duty until approximately 1100, 1 hour prior to scheduled departure, on September 9. The pilot of N7374J had been at home the evening of September 8; worked from 0800 until 1200 on September 9; and following a lunch at home, had gone to the airport for his flight.

Aircraft Information

N988VJ, a McDonnell Douglas DC-9, S/N 47211, had accumulated 3,170 total hours at the time of the accident flight. An airworthiness certificate had been issued to Allegheny Airlines, Inc., on August 7, 1968, and maintenance records documented the accomplishment of all necessary corrective action, inspection, and Airworthiness Directives. Pratt & Whitney JT8D-7 engines were installed as follows:

Position	Serial No.	Time Since Overhaul	Total Time
1	657339	---	3,169:58
2	657121	1,204:12	3,462:23

The records reflect that the takeoff gross weight was 98,589.5 pounds, which is less than the maximum allowable of 98,600 pounds. The center of gravity was computed to be 14.6 percent MAC, within the allowable limits of 7.54 to 30.2 percent MAC.

N7374J, a Piper Aircraft PA-28, S/N 28-24730, had accumulated 803 total hours on August 29, 1969, which was the date of the last 100-hour inspection. An airworthiness certificate had been issued to the Forth Corporation on July 26, 1968, and maintenance records revealed that the aircraft had been maintained in accordance with approved procedures and directives. The aircraft was equipped with a Lycoming O-320-E2A engine, S/N L23013-27A, and a Sensenich 74DM6-0-58 propeller, S/N K-26559. Both the engine and propeller were original equipment and had never been overhauled.

The "See and Be Seen" Concept

In the early development of aviation, aircraft were of necessity operated on a "see and be seen" basis. Federal regulations designed specifically to augment the "see and avoid" concept and minimize the midair collision potential were first issued in 1926 by the Secretary of Commerce. These were basically right-of-way rules, modeled after marine regulations, relating to movement of surface vessels on the water. They were based entirely on the premise that pilots would operate aircraft by visual reference to the ground and would be able to see and avoid other aircraft. For the most part, aircraft cruising speeds at that time were 100 miles per hour or less.

Early in 1930 it was recognized that the aircraft's ability to maneuver in three dimensions tended to present a collision potential that was not completely solvable by "see and be seen" procedures or the existing right-of-way rules. Accordingly, separation of aircraft in cruising flight was accomplished by the adoption of rules which required the use of discrete altitudes, based upon the direction of travel. By 1935 it was further recognized that pilots operating aircraft in restrictive meteorological conditions might not be able to see and avoid other aircraft. The Secretary of Commerce, therefore, authorized the airlines to establish a system of self-separation of airline aircraft operations in the vicinity of Cleveland, Ohio, Chicago, Illinois, and Newark, New Jersey.

In 1936, this was followed by Amendment No. 4 to Chapter 7 of Aeronautics Bulletin No. 7, which established Federal regulations governing all aircraft operations conducted by reference to instruments over designated airways. Aircraft cruising speeds had increased, by this time, to about 150 miles per hour. However, because passenger cabins were not pressurized, airline flights were operated at altitudes below 10,000 feet. Rates of descent were normally limited to about 500 feet per minute for passenger comfort. In the years immediately following passage of the Civil Aeronautics Act of 1938, considerable regulatory attention was given to the problems of providing separation between aircraft.

Rules relating to flight by visual means were expanded to prohibit flight within certain distances from clouds, and to prescribe minimum visibility conditions for flight in both controlled and noncontrolled airspace. However, the often expressed, fundamental basis of collision avoidance in VFR flight remained the "see and be seen" concept.

Doubts about the adequacy of the rules relating to "see and be seen" again appeared with the introduction into airline service in 1947 of such aircraft as the Lockheed Constellation, the Douglas DC-6, and others with pressurized cabins. Pressurization permitted high altitude operations and high rates of descent, without passenger discomfort. Operating speeds increased to approximately 250 miles per hour. These factors, and the continually growing numbers of aircraft in the U. S. Civil fleet, prompted recommendations from the airlines, the military, and the Civil Aeronautics Administration for increases in the VFR visibility minimums to 5 miles in controlled airspace, and for the expansion of positive air traffic control. Anti-collision lights were installed on airline aircraft to provide increased safety in nighttime operations.

In June 1956, the adequacy of the "see and avoid" philosophy was brought into sharp focus by the catastrophic midair collision of two airline aircraft, both operating in visual meteorological conditions.

In an appearance before the Subcommittee on Transportation and Communications of the House Committee on Interstate and Foreign Commerce, on September 11, 1956, the Deputy Director of the Bureau of Safety Regulation of the CAB discussed the adequacy of "see and be seen" as follows:

> "For many years it has become increasingly apparent that conditions other than weather conditions are being encountered which directly affect aircraft separation and of which account must be taken in the continued development of the air traffic rules. For instance, it appears that under certain circumstances the rate of closure of very high-speed aircraft is such that the total time in which an aircraft may be visible to a pilot of another aircraft is so short that pilots cannot be expected to insure separation between aircraft irrespective of the weather conditions in which they are flying. It is also apparent that the density of air traffic, particularly in the vicinity of certain major air terminals, has approached or is approaching serious proportions. Obviously, the greater (sic) number of aircraft movements within a given airspace the more difficult it is for a pilot to separate himself adequately from other aircraft regardless of the vigilance exercised."

Subsequent to this testimony, on February 6, 1957, Amendment 60-2 to the Civil Air Regulations was adopted. This provided, among other things, for the designation, at the discretion of the Administrator, of high-density air traffic zones around certain airports. Aircraft were to be limited to indicated airspeeds not to exceed 180 miles per hour (160 knots). Communication with, or otherwise permission from, the control tower was also required prior to entering the control zone. This amendment specified further that aircraft operating in a control zone without an ATC clearance must not be flown VFR beneath the cloud ceiling when the ceiling was less than 1,000 feet; or closer than 500 feet vertically under, 1,000 feet vertically over, or 2,000 feet horizontally from any cloud formation.

On April 30, 1957, Amendment 60-5 to Part 60 became effective and modified the cruising altitude rules to provide a better safety margin between aircraft in cruising flight. This amendment contained the following caveat:

> "Since the cruising rules in effect in Part 60 will not provide for separation between IFR aircraft at certain assigned altitudes and VFR aircraft operated in accordance with VFR cruising altitude rules, it remains the responsibility of all pilots operating in VFR weather conditions, even while cruising at an assigned altitude authorized by air traffic control, to maintain a vigilant watch so as to observe and avoid conflicting traffic."

Civil Air Regulation Draft Release No. 57-11, issued on May 23, 1957, contained an agenda for an air traffic conference to be held in June 1957. This agenda contained, among other things, proposals relating to weather minimums for VFR flight, the expansion of controlled airspace at high altitudes, and operations on, and within the vicinity of, airports. The agenda stated that the Bureau of Safety Regulations had received recommendations from the Civil Aeronautics Administration, the Army, Navy, Air Force, Air Transport Association, Air Traffic Controllers Association, and the Air Line Pilots Association advocating an increase in the minimum VFR criteria. These groups contended that the existing, prescribed minimums were inadequate in light of the high speeds of aircraft and the increasing volume of air traffic. Little attention was directed to the problems inherent in high descent rates, however, other than a recommendation by the Aircraft Owners and Pilots Association for a maximum rate of descent of 1,000 feet per minute at altitudes below 3,000 feet in all control zones around civil airports. This recommendation appears to have been dismissed from serious consideration, and other than its appearance as an agenda item, was not again mentioned in any subsequent regulatory action. Also largely ignored was the potential collision hazard inherent in a combination of high-speed descents for IFR traffic and the operation of VFR flights only 500 feet below cloud formations.

The diminishing validity of the "see and avoid" method of collision avoidance was recognized, as is evidenced by the several recommendations by the aviation industry and the aforementioned Deputy Director's statement to the Congress. However, operational capability for positive control, as a solution to the problem, did not exist without severe restrictions on the amount of air traffic that could use the airspace. This was not considered acceptable.

Subsequent to the June 1957 conference, the CAB issued Civil Air Regulations Draft Release No. 57-27 proposing changes to the regulations based upon comments received in response to the conference notice, and the discussions at the conference. On September 11, 1958, Civil Air Regulation Amendment 60-11 was adopted. This amendment increased the visibility requirement to 5 miles only for those aircraft operating above 24,000 feet m.s.l. The minimum distance below clouds remained at 500 feet. In discussing the reasons for not adopting more of the previously proposed regulation, the preamble to the amendment stated:

"It was clear from the comment received on the draft release that the lines were drawn sharply on this highly controversial issue of appropriate VFR weather minimums. Briefly stated, the airmen from the professional segments of aviation concurred with the proposal, although some thought that it did not go far enough, while the non-professional segments vigorously opposed any increases in the VFR minimums. Reasons given in support of the respective positions were essentially as received in earlier considerations of the problem, and which are detailed above. Persuasive arguments were advanced by the general aviation segment that no case could be made for the proposition that accidents would be reduced materially if VFR weather minimums were increased since accident statistics clearly showed that mid-air collisions were occurring in relatively clear weather. The Board has confirmed this through an extensive analysis of its civil accident and near collision statistics. One finding is particularly telling: 98 percent of all mid-air collisions in the past 10 years have occurred in weather conditions exceeding 3 miles in visibility - the other 2 percent have occurred in visibility conditions of about 3 miles.

"The position of the proponents of increased minimums, and the one pursued in the draft release, is, of course, valid. It is indisputable that some safety advantage would accrue were the minimums to be raised since fewer aircraft would be authorized to operate in given airspace and, accordingly, collision potential would be reduced.

"The question which the Board must decide is how much safety will be increased by raising the VFR weather minimums and at what price to the users of the airspace. Based on the evidence available, the Board concludes and the Administrator agrees that the advantages to be gained by adopting the VFR weather minimums rules as proposed are not sufficient to justify the impairment to the public right of freedom of transit in air commerce through the navigable airspace of the United States. Accordingly, with the exception of the one-half-mile rule discussed below, established VFR weather minimums will not be changed. This conclusion should be construed only as a finding that under existing conditions raising the VFR minimums for acrobatic flight and in high density areas will not materially

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assist in the separation of traffic in VFR conditions under the see and be seen principle. It does not mean that other measures should not be taken to give greater effect to this principle."

In early 1958, critical attention was again focused on the adequacy of the "see and be seen" concept of air traffic separation by two catastrophic midair collisions, which occurred within 29 days of each other, between two military and two airline aircraft. In both accidents, all four aircraft involved were operating in VFR weather conditions. Subsequent to these accidents, Special Civil Air Regulation SR-424 was adopted. This regulation, on an experimental basis, authorized the establishment of positive air traffic control over designated routes at altitudes between 17,000 and 35,000 feet m.s.l. With this exception, the regulations continued to place the burden for collision avoidance in VFR weather conditions on the pilot. However, in a growing recognition that the visibility criterion alone was insufficient, other recommendations were received by the FAA. Among these recommendations was one by the Aircraft Owners and Pilots Association in March 1959 that a speed restriction of 180 miles per hour be applied to all aircraft operating at altitudes of less than 2,000 feet above the ground, and that a maximum safe "see and be seen" speed be determined for en route operations.

The inadequacy of the "see and be seen" concept received further recognition in the 10 years between 1960 and 1970. Studies were conducted to determine the feasibility of devices in the cockpit to warn the pilots of potentially conflicting traffic. One such study 1/ concluded that a better chance of collision avoidance would be probable if the pilot were aware that potentially conflicting traffic was present, and knew approximately where to look for it. A distinction should be made here between a device described as a Pilot Warning Indicator (PWI) and a Collision Avoidance System (CAS). Early studies considered the feasibility of a PWI which would serve to alert a pilot to potentially conflicting traffic and identify the area in which he should look for the traffic. Most of the early proposals considered a "compatible" system in which detection was based upon the premise that all aircraft would be equipped with a receiver/transmitter. Later studies suggested that the detection capability should not be dependent upon transmitting capability of another aircraft, and that detection capability should be self-contained in each aircraft. This premise was expanded to include capability of the device to not only detect the presence of conflicting traffic, but to provide the pilot with instructions for the proper evasive maneuver, hence "Collision Avoidance System." This subject will be discussed in detail in the Board's forthcoming report on the Midair Collision Problem.

1/ A Study of Requirements for a Pilot Warning Instrument for Visual Airborne Collision Avoidance - Sperry Gyroscope Company, December 1963.

Further regulatory consideration of the midair collision problem in the past 10 years resulted in the lowering of the "floor" of the Continental Control area 2/ to 14,500 feet m.s.l. Visibility minimums have been increased to 5 miles for VFR flights above 10,000 feet m.s.l. Above 10,000 feet, the minimum distance below clouds was increased to 1,000 feet, and the horizontal distance to 1 mile. However, as of September 19, 1969, with respect to VFR operations in controlled airspace below 10,000 feet, the regulations remained essentially as they were in 1956.

Speed restrictions since 1957 however, were increased from 160 knots in the high-density airports to 200 knots for turbine-powered aircraft. A 250-knot maximum speed has been established for operations below 10,000 feet outside of airport air traffic areas. The Board believes that the original speed restriction of 160 knots was valid for the purpose of minimizing the collision potential at the busy terminals in 1957. The subsequent allowable increase to 200 knots in the airport traffic area, and the 250-knot speed allowed outside these areas, can be related only to the operational characteristics of the jet aircraft. In the process, the ability to achieve safety through the "see and be seen" concept has been diminished.

2/ An area in which all aircraft must be operated in accordance with IFR procedures, regardless of the meteorological conditions.

SEQUENTIAL

FRAMES

OF

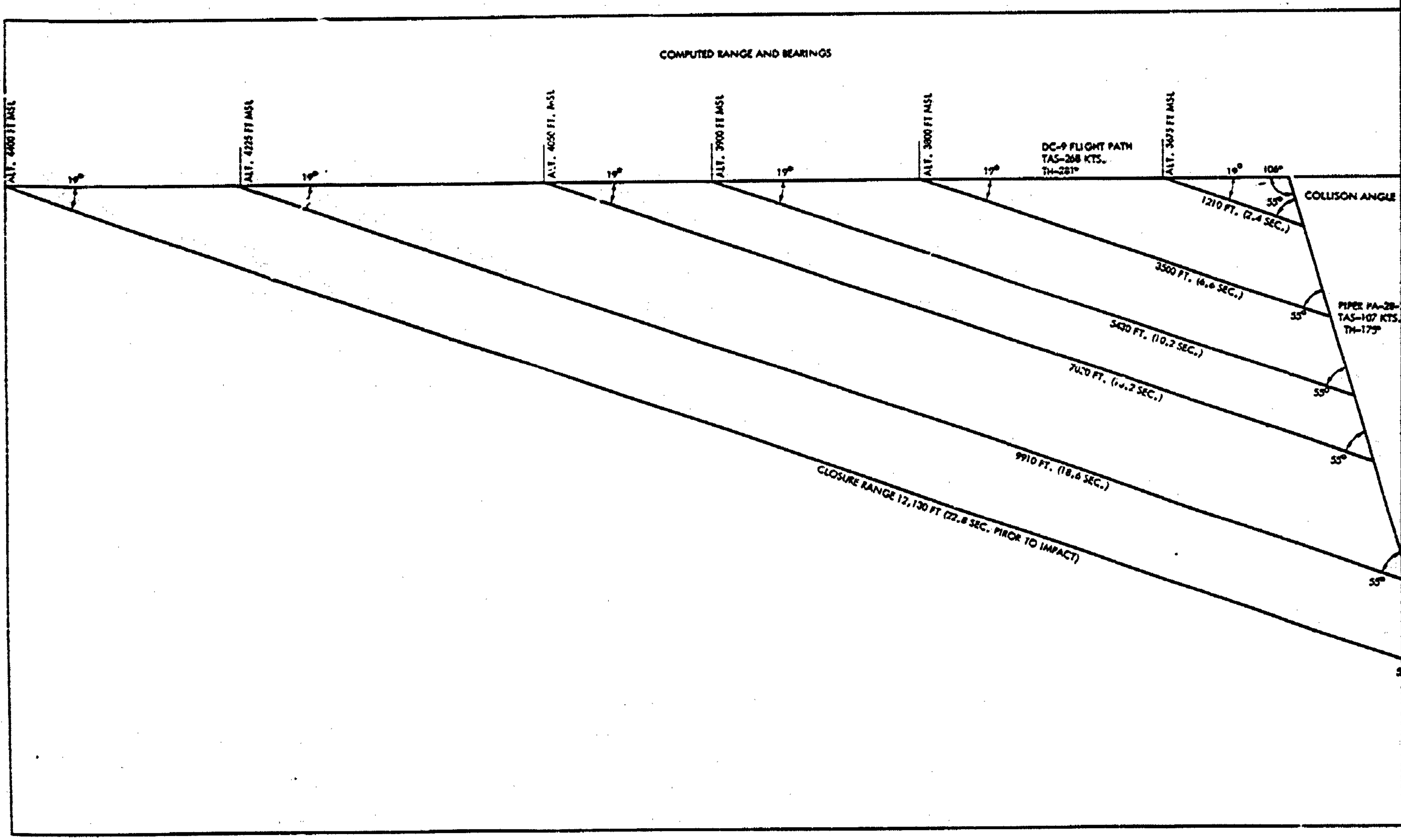
OVERSIZED

DOCUMENT

REQUIRES 2 FRAMES

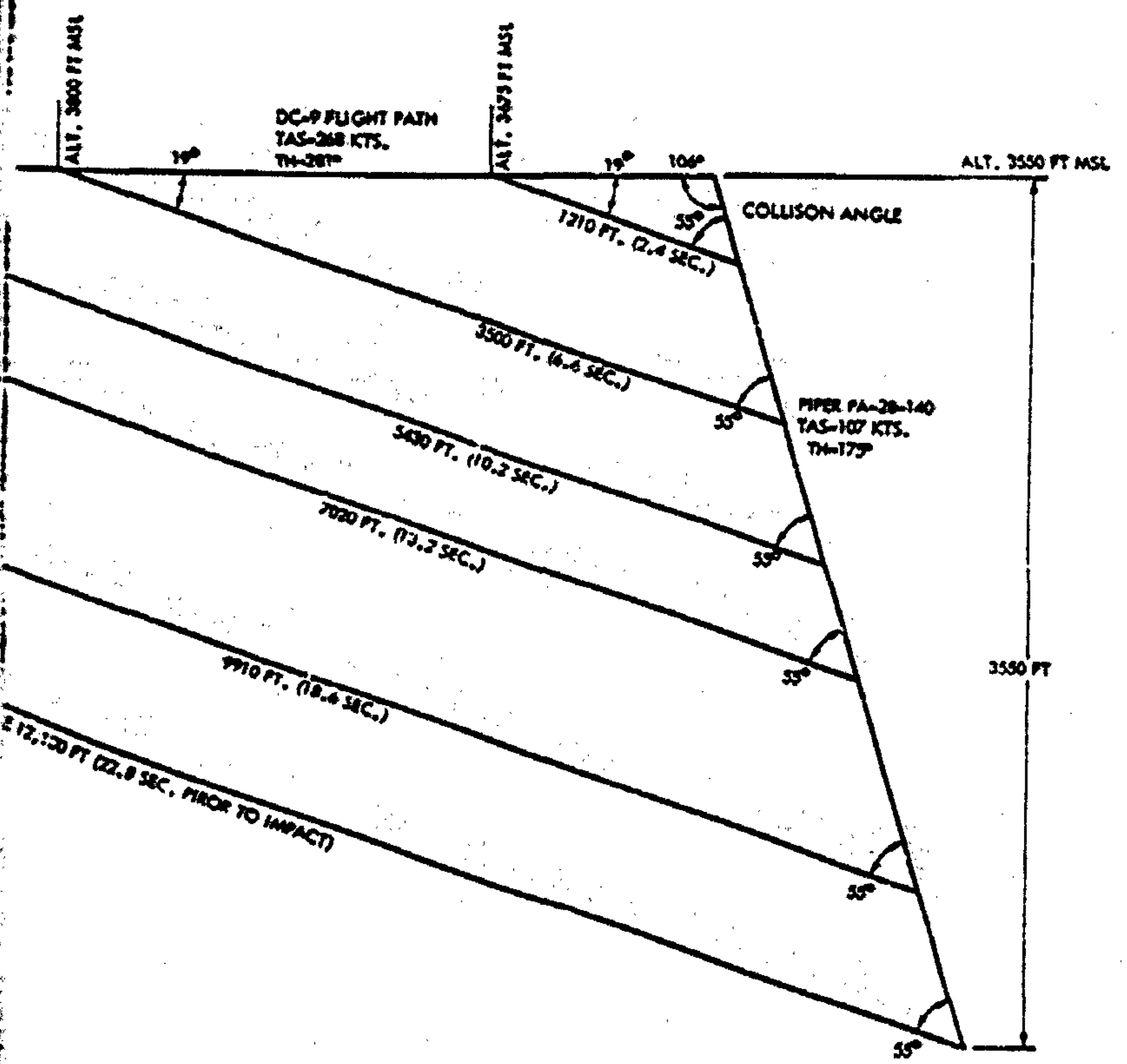
PAGE # 31

A Thru B



COMPUTED RANGE AND BEARINGS
ALT. 4225 FT MSL
ALT. 4050 FT. MSL
ALT. 3900 FT MSL
ALT. 3800 FT MSL
ALT. 3675 FT MSL
DC-9 FLIGHT PATH
TAS–268 KTS.
TH–281°
19°
106°
55°
COLLISON ANGLE
1210 FT. (2.4 SEC.)
3500 FT. (6.6 SEC.)
5430 FT. (10.2 SEC.)
7U̇0 FT. (‥.2 SEC.)
9910 FT. (18.6 SEC.)
CLOSURE RANGE 12,130 FT (22.8 SEC. PIROR TO IMPACT)
PIPER PA-28-
TAS–107 KTS.
TH–175°

Attachment A



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

ALLEGHENY AIRLINES DOUGLAS
DC-9, N988VJ, AND FORTH
CORPORATION, PIPER CHEROKEE
PA-28-140, N7374J, NEAR
FAIRLAND, INDIANA
SEPTEMBER 9, 1969

SEQUENTIAL

FRAMES

OF

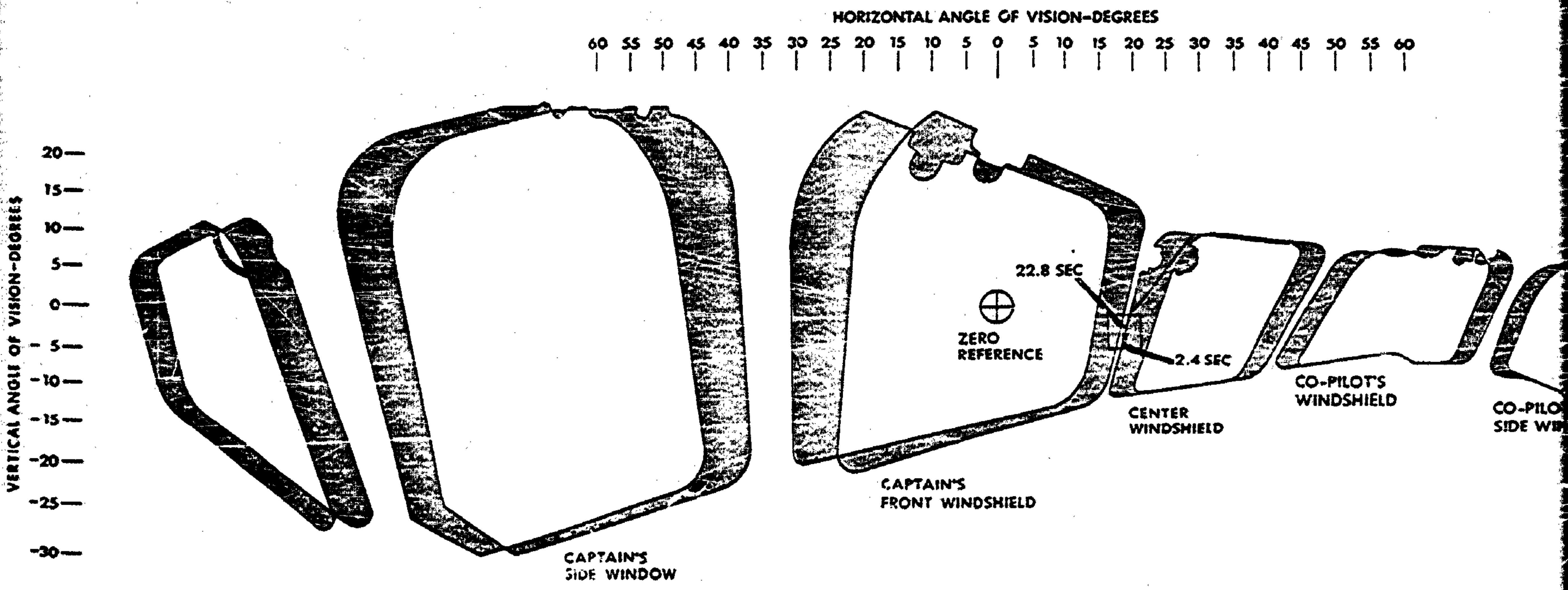
OVERSIZED

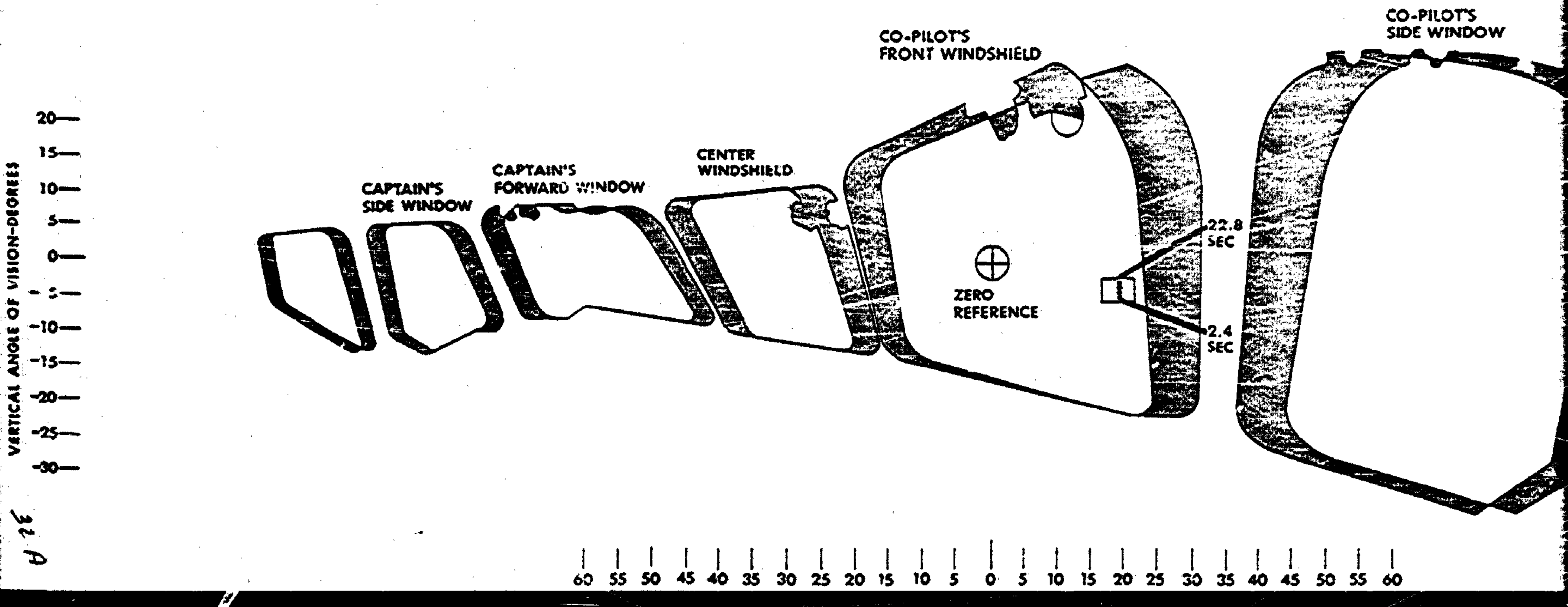
DOCUMENT

REQUIRES 2 FRAMES

PAGE # 32

A Thru B


HORIZONTAL ANGLE OF VISION-DEGREES
60 55 50 45 40 35 30 25 20 15 10 5 0 5 10 15 20 25 30 35 40 45 50 55 60
VERTICAL ANGLE OF VISION-DEGREES
20 15 10 5 0 -5 -10 -15 -20 -25 -30
22.8 SEC
ZERO REFERENCE
2.4 SEC
CAPTAIN'S SIDE WINDOW
CAPTAIN'S FRONT WINDSHIELD
CENTER WINDSHIELD
CO-PILOT'S WINDSHIELD


CO-PILOT'S FRONT WINDSHIELD
CO-PILOT'S SIDE WINDOW
VERTICAL ANGLE OF VISION-DEGREES
20 15 10 5 0 -5 -10 -15 -20 -25 -30
CAPTAIN'S SIDE WINDOW
CAPTAIN'S FORWARD WINDOW
CENTER WINDSHIELD
22.8 SEC
ZERO REFERENCE
2.4 SEC
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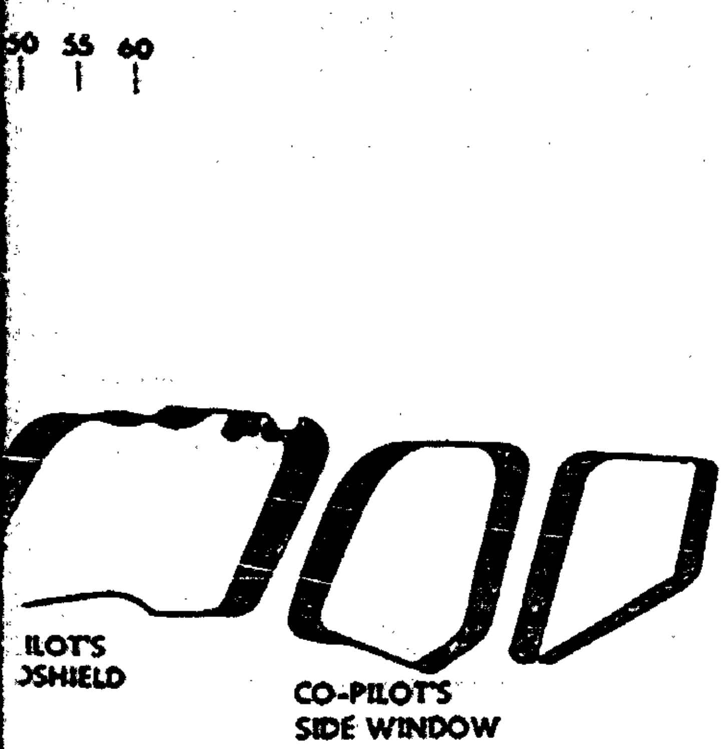
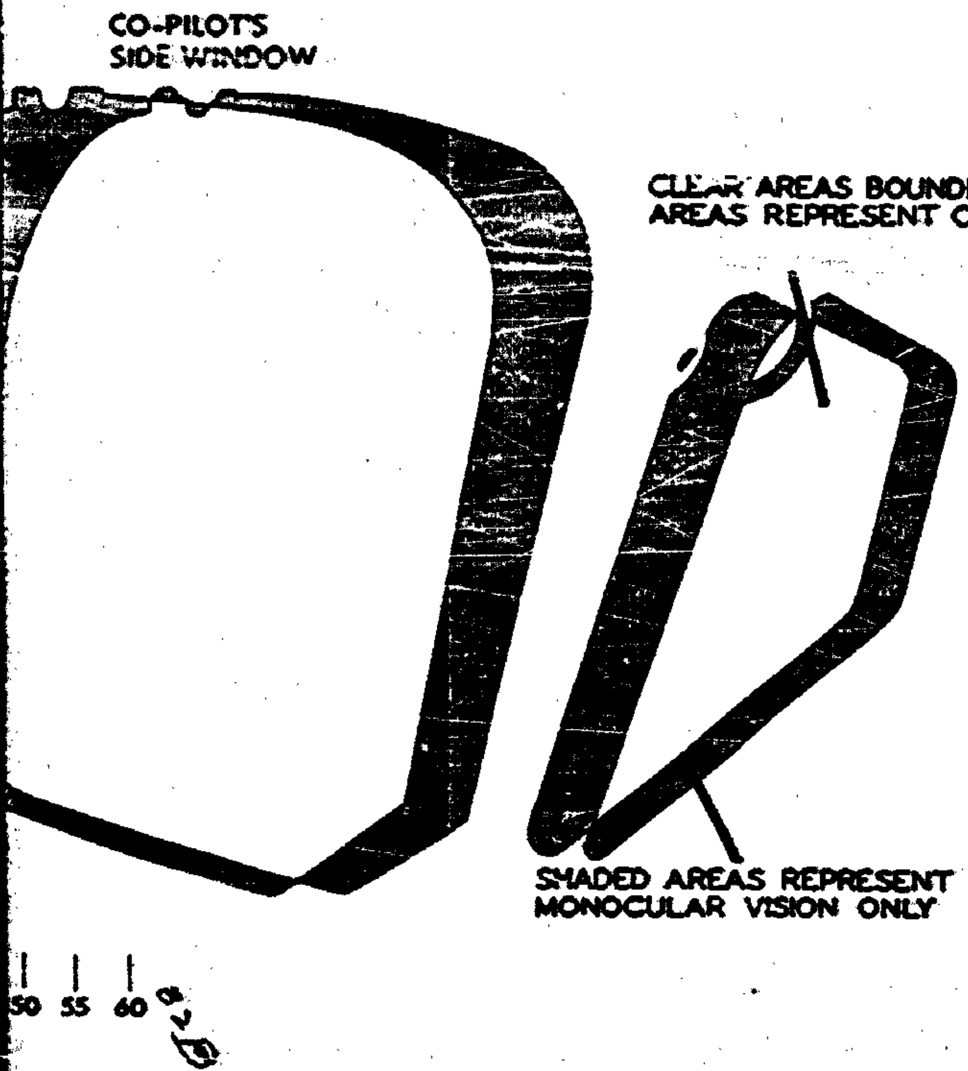


CALCULATED
DC-9 PILOT'S VIEW-NORMAL POSITION
DOUGLAS DESIGN EYE POSITION

INDICATES AREAS OF POSSIBLE SIGHTING FROM 22.8 SECONDS UNTIL 2.4 SECONDS PRIOR TO COLLISION.

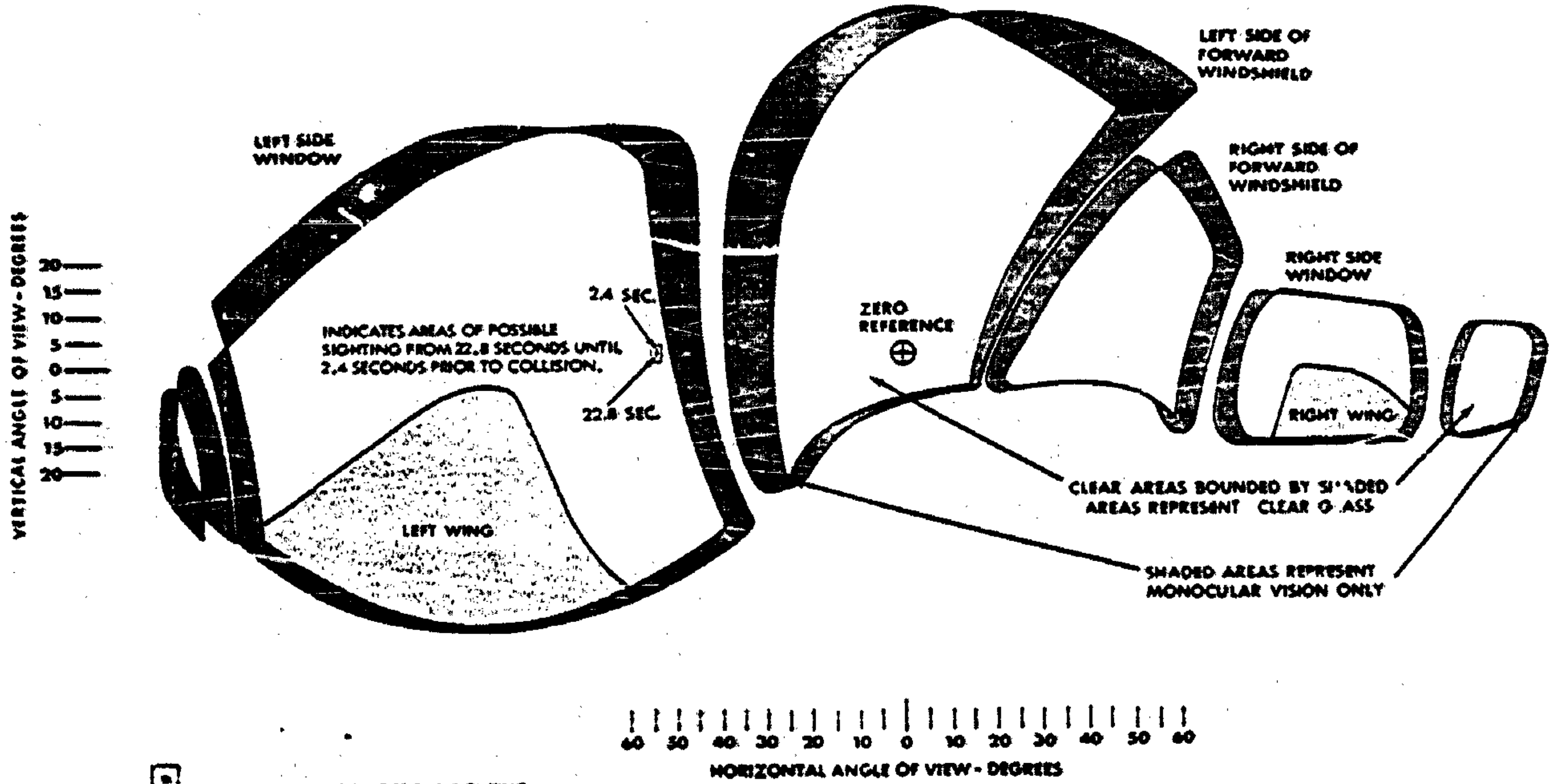


CALCULATED
DC-9 CO-PILOT'S VIEW-NORMAL POSITION
DOUGLAS DESIGN EYE POSITION

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

ALLEGHENY AIRLINES, DOUGLAS
DC-9, N988VJ, AND FORTH
CORPORATION, PIPER CHEROKEE
PA-28-140, N7374J, NEAR
FAIRLAND, INDIANA
SEPTEMBER 9, 1969

Attachment C

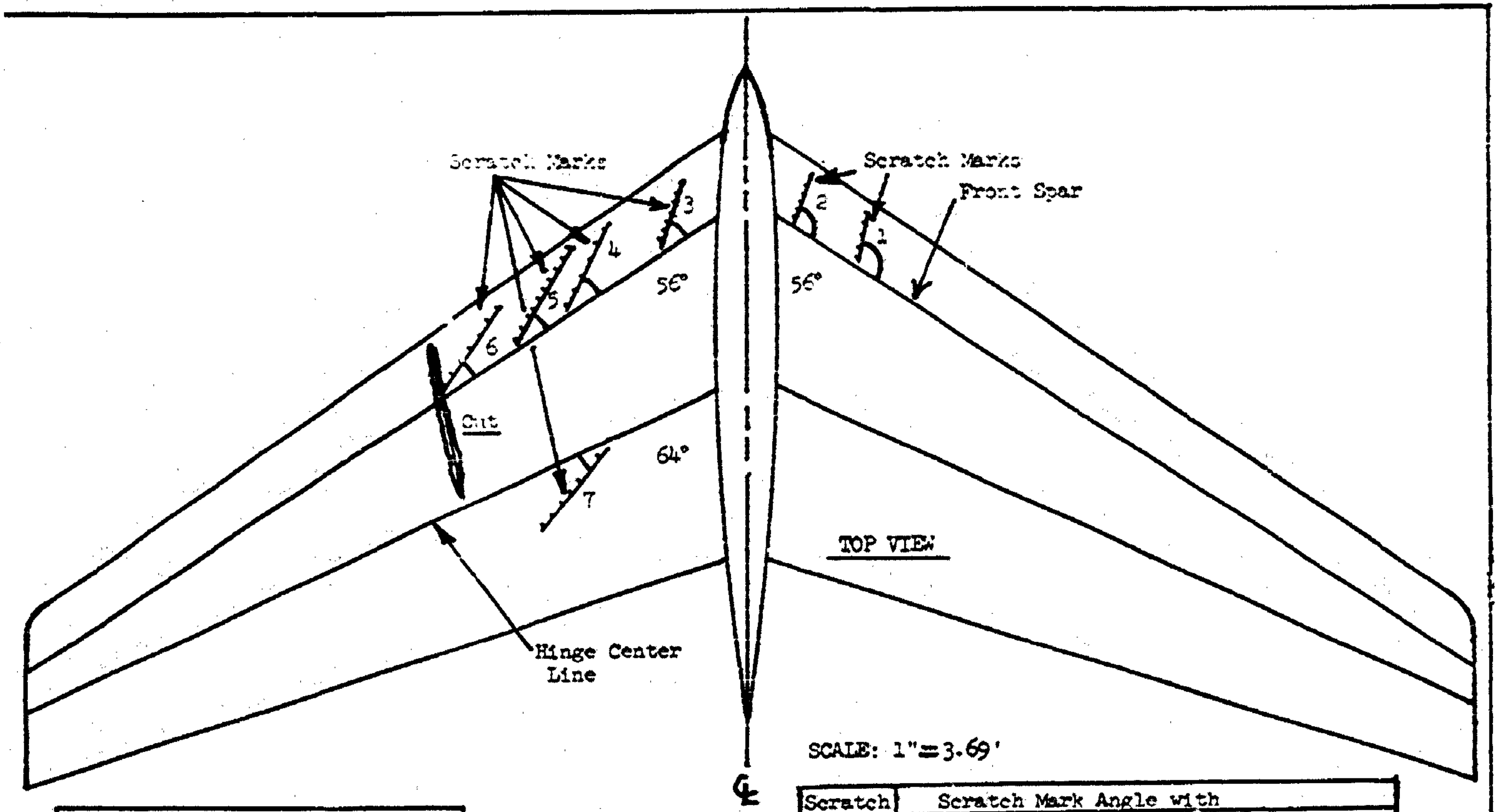


CALCULATED
PIPER CHEROKEE (PA-28-140B)
PILOTS VIEW
NORMAL POSITION

INCLUDES AREAS OF POSSIBLE SIGHTING FROM 22.8 SECONDS UNTIL 2.4 SECONDS PRIOR TO COLLISION

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

ALLEGHENY AIRLINES DOUGLAS DC-9, N988VJ, AND FORTH CORPORATION, PIPER CHEROKEE PA-28-140, N7374J, NEAR FAIRLAND, INDIANA
SEPTEMBER 9, 1969



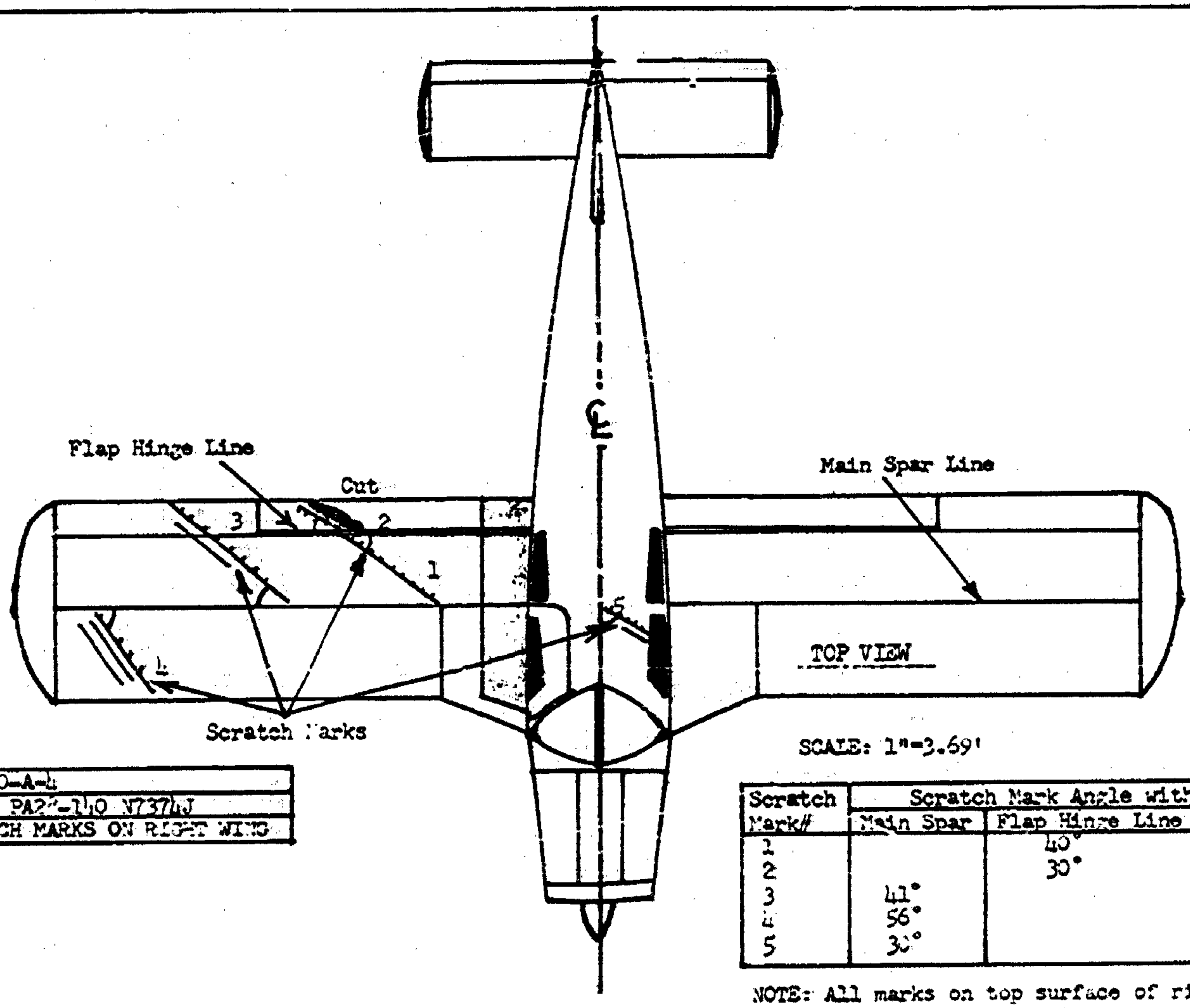
SCALE: 1" = 3.69'

DCA 70-A-4
Allegheny Airlines, Inc.
DC-9 N988VJ
SCRATCH MARKS ON HOR. STABILIZER

Scratch Mark #	Scratch Mark Angle with		
	Front Spar	Flap Hinge Line	Center Line
1	113°		10°
2	102°		22°
3	40°		16°
4	30°		26°
5	26°		30°
6	20°		36°
7		32°	32°

NOTE: All marks on bottom surface of horizontal stabilizer.

Attachment D



SCALE: 1"=3.69'

DCA 70-A-4
Piper PA28-140 N7374J
SCRATCH MARKS ON RIGHT WING

Scratch Mark#	Scratch Mark Angle with Main Spar	Flap Hinge Line	Center Line
1		40°	50°
2		30°	60°
3	41°		49°
4	56°		34°
5	30°		60°

NOTE: All marks on top surface of right wing and on top of cockpit.

Attachment E