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AIRCRAFT ACCIDENT REPORT

HUGHES AIR WEST DC-9, N9345
AND U.S. MARINE CORPS F-4B, 151458
NEAR DUARTE, CALIFORNIA
JUNE 6, 1971

ADOPTED: AUGUST 30, 1972

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D. C. 20591
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16. Abstract
A Hughes Air West E-9, N9345, and a U. S. Marine Corps F-4B, 151458, collided in flight near Duarte, California, at approximately 1811 P.d.t., June 6, 1971. All 49 occupants aboard the E-9 and the pilot of the F-4B were fatally injured. The radar intercept officer, the only other occupant of the F-4B, ejected safely after the collision. The E-9 was climbing to Flight Level 330 under radar control of the Los Angeles Air Route Traffic Control Center, and the F-4B was en route to MCAS El Toro at approximately 15,500 feet, in accordance with Visual Flight Rules. The collision occurred at approximately 15,150 feet. The visibility in the area, at the time of the accident, was good, and there were no clouds between the two aircraft.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of both crews to see and avoid each other but recognizes that they had only marginal capability to detect, assess, and avoid the collision. Other factors involved included, a very high closure rate, comingling of IFR and VFR traffic in an area where the limitation of ATC system precludes effective separation of such traffic, and failure of the crew of BuNo458 to request radar advisory service and particularly considering the fact that they had an inoperable transponder.

There are four new recommendations.

17. Key Words

Midair collision, Scheduled air carrier (IFR)
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HUGHES AIR WEST DC-9, N9345, AND
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NEAR DUARTE, CALIFORNIA
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SYNOPSIS

A Hughes Air west DC-9, N9345, and a U. S. Marine Corps F-4B, Bureau No. 151458. collided in flight near Duarte, California, at approximately 1811 P.d.t., June 6. 1971. All 49 occupants, 44 passengers and five crewmembers, aboard the DC-9, and the pilot of the F-4E were fatally injured. The radar intercept officer, the only other occupant in the F-4B, ejected from the aircraft after the collision and parachuted to the ground. He was not injured. Both aircraft were destroyed by the collision. ground impact, and fire.

The Hughes Air west DC-9 was under radar control of the Los Angeles Air Route Traffic Control Center. climbing to Fliqht Level 330. The F-4B was being flown at approximately 15.500 feet. in accordance with Visual Flight Rules, en route to the Marine Corps Air Station, El Toro, California. The collision occurred at an altitude of approximately 15,150 feet.

The visibility in the area. at the time of the accident, was good and there were no clouds between the two aircraft during the final minutes of flight.

The National Transportation safety Board determines that the probable cause of this accident was the failure of both crews to see and avoid each other but recognizes that they had only marginal capability to detect. assess, and avoid the collision, Other causal factors include a very hiqh closure rate, comingling of IFR and VFR traffic in an area where the, limitation of the ATC system precludes effective separation of such traffic, and failure of the crew of BuNo458 to request radar advisory service. particularly considering the fact that they had an inoperable transponder.

As a result of this accident the Safety Board recommends that the Federal Aviation Administration: (1) install video tape on all radar displays and "area" microphones in air traffic control facilities; (2) provide positive control airspace from takeoff to landing for all IFR traffic; and (3) insure that all radar facilities are capable of receiving Code 7700, and establish definitive procedures for the handling of such traffic.

The Safety Board also recommended that the Federal Aviation Administration and the Department of Defense cooperatively develop a program to inform all airspace users of the heaviest traffic areas. In addition, it was recommended that the Department of Defense: (1) restrict hiqh-speed, low-level operations to designated areas and routes; (2) delineate explicit circumstances where the 10,000 feet/250 knots limitation may be exceeded; (3) consider usinq air intercept radar for collision avoidance purposes; and (4) publicize the availability of the FAA Radar Advisory Service and consider making the use of this service mandatory.

1. INVESTIGATION

1.1 History of the Flight

Hughes Air west Flight 706 (RW706) was a regularly scheduled flight from Los Angeles, California, to Seattle, Washington, with intermediate stops at Salt Lake City, Utah, Boise and Lewiston, Idaho, and Pasco and Yakima, Washington. The flight departed Los Angeles International Airport at 1802 1/ and. following radar vectors from Los Angeles Departure Control, contacted the Los Angeles Air Route Traffic Control Center (ARTCC) at 1806. In accordance with a request, the flight reported leaving 12,000 feet at 1809, and the controller advised, "Air West seven zero six red, turn left heading zero four zero until receiving Daggett proceed direct." RW706 acknowledged. "OK, zero four zero direct to Daggett." This was the last recorded transmission from the flight.

The U. S. Marine Corps F-4B, Bureau NO. 151458 (BuNo458) departed the Marine Corps Air Station (MCAS) El Toro, California, on June 4 1971, as part of a flight of two aircraft. The flight was scheduled for an overnight cross-country to McChord Air Force Base (AFB), Washington, and return, McClellan AFB, California, was to be used for refueling northbound, and Mountain Home AFB. Idaho, was to be used southbound. Although the transponders on both aircraft apparently failed shortly after departure from MCAS El Toro, the fliqht of two was permitted to proceed to McChord AFB under control of the ATC System by radar. On June 5. the flight continued to Mountain Home AFB, but the radio in BuNo458 failed during the landing approach. After landing, the crews discussed the operational status of the two aircraft, and the flight leader decided that he would proceed to MCAS El Toro. The wingman and his Radar Intercept Officer (RIO) were instructed to await repairs to BuNo458 and then return to MCAS El Toro. The mechanical difficulties with the aircraft at this time included:

1. Inoperative transponder
2. Inoperative radio
3. Oxygen system leak
4. Degraded radar system

Maintenance personnel at Mountain Home APB replaced a fuse to fix the radio, but they did not have the personnel to check the transponder. They confirmed the oxygen leak, but could not repair it. No attempt was made to restore the radar to peak performance at that time.

The crew of BuNo458 filed a Visual Flight Hules (VFR) flight plan to Naval Auxiliary Air Station (NAAS) Fallon. Nevada, below the Area Positive Control (APC), 2/ because of the inoperative transponder and fuel requirements. On this leg of the flight the oxygen leak increased, and the oxygen was turned off shortly after takeoff from Mountain Home AFB. The maintenance personnel on duty at NAAS Fallon were unable to provide the appropriate repairs, so the pilot contacted his squadron duty officer for instructions. He was advised to proceed to MCAS El Toro at low altitude.

After refueling, the crew again filed a VFR flight plan below APC. The takeoff was delayed from 1400 to 1716 because MCAS El Toro was closed for an airshow between 1400 and 1630. The intended route of flight was direct Fresno, 5-65 Bakersfield, J-5 Los Angeles, direct MCAS El Toro. The fliqht departed at 1716. climbed initially to 1,500 feet, and then climbed to 15.500 feet to clear mountains and some clouds approximately 50 miles from NAAS Fallon. After crossing the mountains, they descended to 5,500 feet and remained at that altitude until they reached Bakersfield. Approximately 15 miles north of the Bakersfield Flight Service Station a position report was made, and the MCAS El Toro weather was checked. The crew also decided to deviate from the original plan at this point. They flew east of the planned course, over Palmdale, to avoid the anticipated heavy traffic over Los Angeles.

The fliqht continued in a low profile, minimum altitude 1,000 feet above the ground, until approximately 15 miles northwest of Palmdale. Due to deteriorating visibility, they again climbed to 15,500 feet. The RIO stated that the climb was made, using maximum engine power, without afterburner, and took less than 2 minutes. Shortly after level-off, the Distance Measuring Equipment (DME) feature of the VORTAC 3/ indicated 50 miles to MCAS El Toro. The pilot executed a 360° aileron roll at this time, which took approximately 3 seconds to complete. The RIO estimated that the true airspeed in the climb and after level-off was 420 knots, and that the collision occurred appzoximately 1 minute and 20 seconds after the roll. During most of this period, he was operating the radar in the mapping mode, but, due to the extremely degraded air-to-air detection capability, no airborne targets were seen. Since the radarscope was in the stowed position, the RIO was leaning forward, and his line of sight was directed downward at approximately a 45° angle while using the radarscope. Approximately 3 to 10 seconds prior to collision. the RIO raised his head, observed the DC-9 in his peripheral vision approximately 50° to the right and slightly beneath his aircraft. He shouted to the pilot, but the pilot had initiated an evasive roll before the RIO finished the warninq. He did not see RW706 take any evasive action.

After takeoff from Los Angeles, RW706 was qiven two radar traffic advisories hy departure control, and control was subsequently transferred to the R-18 sector of Los Angeles ARTCC. The data and radar positions of this sector were manned by developmental controllers 4/, each of whom was heinq supervised by a journeyman controller. Consequently, four individuals were observing the radarscope at the R-18 position prior to the collision. They all agreed that no primary tarqets were observed in proximity to RW706 at any time. Five traffic advisories were given to other aircraft in the R-18 sector in the 6-minute timespan prior to the collision.

After the collision, BuNo458 began to tumble violently about the lateral axis. The RIO waited about 5 seconds, and, after seeing numerous warning liqhts in the cockpit, he ejected from the aircraft. The ejection was successful, and he parachuted to the ground without injury.

Witnesses in the area of the accident gave widely varyinq accounts of the collision. Thirty-four witnesses saw or heard jet aircraft prior to the collision, and 24 persons observed the two aircraft on converging courses. Fifteen persons saw a fighter aircraft in a rolling or evasive maneuver prior to collision. Three persons on the ground and two pilots, at varying distances from the immediate collision area, observed a fighter aircraft proceeding along the route of flight described by the RIO. (See Attachment 1.) Several witnesses in the area of the collision reported seeing a fighter aircraft doing rolls and circling in the area.

1.2 Injuries to Persons

Injuries		Crew	Passengers	Others
Fatal	CC-9	5	44	0
	F-4B	1	0	0
Nonfatal	DC-9	0	0	0
	F-4B	0	0	0
None	DC-9	0	0	
	F-4B	1	0	

1.3 Damage to aircraft

Both aircraft were destroyed by the collision, ground impact, and subsequent fire.

1.4 Other Damage

Both aircraft crashed in a remote mountaincus area, and all ground damage was restricted to underbrush which was burned in the ground fire.

1.5 Crew Information

The crews of both aircraft were qualified for the respective flights. (See Appendix E for details.)

1.6 Aircraft Information

The DC-9 was properly certificated and both aircraft had been maintained in accordance with existing regulations. The weight and center of gravity of each were within prescribed limits. The DC-9 was serviced with Jet A fuel and the F-4B with JP-5 fuel. (See Appendix C for details.)

1.7 Meteorological Information

The weather in the vicinity of the accident site was characterized by low-level haze and smoke, scattered low clouds and high, thin, broken or scattered clouds. There was no frontal weather in the area.

The pertinent portion of the aviation area forecast issued by the National Weather Service at Los Angeles was in part, as follows:

> Scattered, variable to broken clouds at 23,000 feet, visibility 3 to 6 miles, haze and smoke. coastal

stratus increasing and moving onto immediate coast 1900 to 2100 then spreading inland about 20 miles by midnight with higher coastal terrain occasionally obscured.

The Vandenberg AFB 1700 radiosonde ascent showed a shallow layer of relatively moist unstable air near the surface to the base of an 8° C., inversion near 1,000 feet with the top near 4,000 feet. The associated winds aloft observation was, in part, as follows:

Height (feet m.s.l.)	Direction (°true)	Velocitv (knots)
Surface	265	5
1,000	260	5
3,000	340	5
6,000	020	7
9.000	110	9
12,000	060	16
15.000	020	19

Official sunset at Los Angeles was at 2002.

1.8 Aids to Navigation

The Los Angeles ARTCC uses three ARSR-1E radar systems for the control of traffic. Each of these systems has a range of approximately 150 miles. and is displayed at the control positions on an RBDE-5 horizontal scan converter with a 21-inch cathode ray tube. The antennae for the ARSR-1E systems rotate at 5 r.p.m. Additionally, each sector has a vertical display which is used as a backup system, and an aid in receiving radar handoffs. The vertical display is also an RBDE-5 scan converter.

The R-18 sector controller at the time of the accident was monitoring the San Pedro ARSR-1E system on the horizontal display. This is a joint-use system with the military. The antenna is located near Long Beach. California. The controls were adjusted to the 55-mile range. with 5-mile range marks. The display was off-centered approximately 40 miles to the southwest. The moving target indicator (MTI) 5/ was set at level 4, and the staggered pulse repetition frequency (PRF) circuit was operating.6/

The R-18 controller had the ASR-4 system selected on the RBDE-5 sector vertical display. The ASR-4 antenna is located at Los Angeles International Airport, and has a range of approximately 50 miles. The rate of antenna rotation is 12.75 r.p.m.

The R-36 sector controller was monitoring the Boron ARSR-1E radar system on the horizontal scan converter at the time of the accident. The Boron antenna is located in the vicinity of Edwards AFB. California. The contrcller had the San Pedro radar system on the sector vertical display. ne had radar-identified RW706 and was waiting for them to call prior to assuming control responsibility. Ee observed a transponder Code 7700 7/ appear on his horizontal display approximately 5 miles northwest of the marker for RW706. ne also heard an emergency beacon signal on the VBF Guard Channel 8/ which he was monitoring. He did not see the Code 7700 on the vertical display. The Code 1700 target appeared about two sweeps before the target of RW706 disappeared. The code 7700 then moved in a wide. counterclockwise. circular path, first toward the south-southeast and then toward the northeast. It disappeared in the vicinity of Norton AFB, approximately 10 minutes after it was first observed. Statements from other controllers in the center confirmed that the Code 7700 was received on the Boron and Mt. Laguna radar systems, but not on the San Pedro system. The Safety Board attempted to identify the source of the Code 1700 but was unsuccessful. No explanation has been found for the failure of the San Pedro system to receive the Code 7700.

1.9 communications

There were no reported difficulties with communications between either RW706 or BuNo458 and the respective ground facilities contacted by each.

1.10 Aerodrome and Ground Facilities

Not applicable.

1.11 Flisht Recorders

RW706 was equipped with a Sundstrand Data Control flight data recorder. Model EA-542, Serial No. 1810. The outer case sustained extreme external heat and fire damage. but only minor mechanical damaqe. The metal foil was intact, but deposits of soot. molten metal. and other residue required extensive cleaning to expose the recorded parameters. All parameters were functioning; however, the traces were faint and difficult to identify in certain areas after the cleaning process. The total elapsed time of recording was 8 minutes 55 seconds. Based on altitude information prior to departure from Los Angeles, the recorder was recording altitude 51 feet low. The recorded values at time 8 minutes 54.6 seconds were + 0.74g, 041°, 327 knots. and 15.125 feet. During the following 0.6-second time period. the vertical acceleration trace moved to + 5.0g at 8 minutes 55.2 seconds and instantaneously to -1.8g. The last recorded parameter values prior to electrical power loss at 8 minutes 55.2 seconds were -1.8g, 0410. 327 knots, and 15.150 feet.

RW706 also was equipped with a United Control cockpit voice recorder. Model V-557. serial number unknown. The fire damage consumed the dust cover. and all thermal-protective water and glycol had been expended. There was no deformation of the stainless steel magazine, hut only iron oxide dust was found in the tape storage compartment. As a result. no data were available.

BuNo458 was not equipped with any flight recorders and none were required.

1.12 Wreckaae

The main wreckage of the two aircraft was scattered over approximately 2 square miles. The DC-9 crashed in a canyon with approximately 60° slopes. Structure from Fuselage Station *(FS)* 427 aft, including wings and empennage was located in this area. One piece of P-4E aft fuselage structure was also found at the DC-9 crash site. This piece of the F-4E had become entangled in electrical wiring which was installed between FS318 and FS1099 of the DC-9.

The F-4B main wreckage site was located in another canyon approximately three quarters of a mile southeast of the DC-9. The only major structure not identified at this site included most of the right outer wing, the centerline. top. aft, fuselage structure and the empennage.

Wreckage portions of the DC-9 forward fuselage were removed, and a full-scale three-dimensional mockup of this section was made. A silhouette of the F-4B was then constructed with lumber. This silhouette was placed in various positions and attitudes to attempt to match the two distinct damage paths through the DC-9. One path was long and narrow, oriented at an angle of 30° to the DC-9 fuselage reference plane, and passed through the fuselage in the area below the main passenger loading door and first 10 windows. The other path was rectangular and passed through the forward, lower, cockpit area. When the F-4B vertical stabilizer was positioned at approximately FS110 (the fuselage area beneath the windscreen) on the left side of the DC-9 the right wing was in the damage area under the cabin door and windows. Both damage paths were on a descending angle of approximately 20° through the DC-9. However, both damage swaths were larqer than the F-4B structure, and' this angle could vary as much as 10° in either direction. It is not known whether the downward trajectory of the two swaths resulted primarily from the relative flightpaths of the two aircraft or the progressive disintegration of the F-4B structure as it passed through the OC-9.

1.13 Fire

No evidence of in-flight fire was found on the DC-9: however, the F-4B caught fire following the collision. There was a severe ground fire at each of the main crash sites. A total of seven fire trucks, two helicopters, one air traffic control unit, and approximately 72 officers and men responded to the fire alarm.

1.14 Survival Aspects

This was a nonsurvivable accident for the occupants of the DC-9.

The midair collision was survivable for the occupants of the F-4B. The RIO successfully ejected and he was subsequently rescued uninjured. The pilot was not able to eject and the F-4B collision with the ground was non-survivable.

BuNo458 was equipped with a Martin-Baker H7 rocket ejection seat in each cockpit. This seat was not designed to be fired through the canopy, and incorporated a canopy interrupter block in the actuation linkage to prevent such an occurrence.

The front seat face curtain. the primary means of firing the seat. was not recovered. The alternate firing handle had been actuated. Distortion of the actuation linkage indicated that the canopy interrupter block prevented further movement of the mechanism and subsequent ejection of the pilot.

In addition to the canopy unlock system provided in the ejection sequence, two manually operated systems are provided. However, regardless of which method is used to unlock the canopy. cases have been reported wherein the front canopy failed to jettison when the aft canopy was jettisoned first.

As a result of these Occurrences a change in the canopy jettison mechanism was instituted to incorporate ballistic canopy thrusters to assure that the canopy would separate from the aircraft. This modification had not been installed in BuNo458. This change was being incorporated in all F-4B aircraft on a fleetwide basis. and modification of aircraft at MCAS El Toro was scheduled to begin in July 1971.

1.15 Tests and Research

A radar flight check of the San Pedro radar was conducted on June 8, 1971. using an F-4B. Routine scheduled maintenance had been performed on the system between the time of the accident and the flight check. The RIO had not been formally interviewed by Safety Board investigators at that time. Consequently. the flight track was only an approximation of the presumed track. The San Eedro system was capable of tracking the primary target of the F-4B above 7,500 feet. Several controllers commented that they had never seen the radar perform so well.

The Safety Board coordinated with the Federal Aviation Administration (FAA) and the U S Marine Corps to conduct another flight check of the San Pedro radar on June 16, 1971. The track of BuNo458 described by the RIO was duplicated as closely as possible on three runs. with some variations in the altitude on one run. Three additional runs were conducted in the general area the flight traversed. but with flight track and altitude variations as suggested by the witness group. The radarscope, channel, and control settings were the same as at the time of the accident, except that the secondary target was offset so that it would not interfere with tracking the F-4B primary target. Tracking continuity was poor and the primary target was visible less than 50 percent of the time. The secondary target did provide assistance in following the aircraft movement during voids in the primary target coverage. Photographs of the test runs. as displayed on a maintenance monitor, were taken on virtually every sweep of the antenna. These photographs were studied by the air traffic control group. The examination corroborated the initial reaction to the tracking quality of the F-4B target. but it also demonstrated that the primary target alone was not of sufficient strength to assure notice by a controller who was unaware of the aircraft presence.

The F-4B in each test was not configured the same as BuNo458 at the time of the accident. The first test F-4B was in a clean configuration, and the second F-4B test aircraft was equipped with two large wing tanks. A baggage tank was installed on the fuselage centerline of BuNo458. Consequently. BuNo458 represented a larger reflective cross-section for radar detection than the first test aircraft. and less reflective surface than the second aircraft. The validity of the flight checks also was compromised by such variables as meteorological phenomena and deterioration in operating parts of the radar or improved performance due to replacement of failed parts.

A visibility study was conducted to determine the physical limitations to vision from the cockpit of each aircraft. A flightpath for each aircraft was reconstructed. (See Attachment 1.) The collision geometry and closure rates for the last 40 seconds also was reconstructed. (See Attachment 2.) The flightpath of RW706 was based on the flight recorder data. and the F-4B flightpath was predicated on the statement of the RIO. A dual lens camera was used to record a panoramic view from the design eye-reference point at each crewmember's station. (See Attachments 3 and 4.) These binocular photographs show the position of each aircraft in the field of vision of each crewmembex. based on his fixed-eye-reference point. Naturally. any movement from this position would affect the location of the other aircraft in his field of vision.

In the course of this investigation, the McDonnell-Douglas Corporation provided information concerning roll and pitch rates for the F-4B aircraft. The following has been extracted from the supplied data:

Subject	Full Stick Throw	1/2 Stick Throw	1/4 Stick Throw
What would be the maximum rate of steady nose-down pitch?	-10 deg./sec.	-4 deg./sec.	-2.5 deg./sec.
Concerning the nose-down pitch rate, what would be the time interval required from the first control input to;			
(a) Achieve initial aircraft movement?	0.10 sec.	0.10 sec.	0.10 sec.
(b) Achieve the maximum steady nosedown pitch rate	7.0 sec.	6.5 sec.	6.0 sec.
How many degrees nose-down would have been achieved at the point that the maximum pitch rate had been attained	15.0 deg.	9.0 deg.	5.0 deg.
Altitude lost and airspeed at 20° nosedown pitch: a) alt. loss	16 ft.	210 ft.	590 ft.
b) KTAS	420	426	436
Altitude loss and airspeed @ 20° nosedown flightpath angle: a) alt. loss	180 ft.	385 ft.	620 ft.
b) XTAS	424	430	437

In addition to the above, the data indicated that a bank of 30° could be achieved in as little time as 0.75 second. If roll-and-pitch control inputs are coupled during the maneuver, the time to achieve a given bank/pitch attitude is less than the time required if the attitude is achieved as the result of two separate maneuvers. In this instance. the data indicate that a 20° nosedown, 30° left bank attitude could be achieved in less than 3 seconds.

1.16 Other

The Staff Vice President. Flight Operations for Air west. stated that attempts were made to foster crew vigilance and scanning by minimizing crew duties in the cockpit. use of checklist procedures. encouraging use of the autopilot as much as possible. and through emphasis in their training program. However. the various manuals and training programs did not specifically contain any statement relating to lookout doctrine or scanning techniques, nor did the company have any plan to implement such a program.

The pilot of BuNo458 received training in lookout doctrine and scanning techniques in flight school. After assignment to the squadron, the pilot and RIO received additional training on scan techniques with emphasis on tactical intercept and pursuit. Each pilot and RIO receives formal upgradinq and refresher vision training at least once every 3 years. Additionally, the crews routinely include reminders in lookout doctrine during briefing for each multiple aircraft flight.

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

(a) ATC and Radar Factors

The primary function of radar is to provide the controller with a visual presentation which will assist him in the control and separation of known traffic. It also provides the controller with another limited capability - that of providing separation of identified from unidentified traffic through the medium of the traffic advisory when workload permits. In some cases. due to the technical limitations of the radar equipment, adequate separation has not been achieved. Because of the nix of known and unknown traffic it is not only incumbent upon aircrews to maintain a high degree of vigilance to "see and avoid". but also upon the controllers in monitoring the radar display. In this accident three independent radar systems failed to detect the primary target of BuNo458 and as a result no warning was given to the crew of RW706 regarding the direction and distance of the hazard. If the crew of RW706 had been provided with this information their chances of seeing and avoiding the other aircraft would have been enhanced. One solution to the limitations of radar would be the establishment of some minimum standard of reflective capability for all aircraft and the incorporation of some form of signal enhancement equipment aboard all aircraft, as necessary to meet the standard, as previously recommended by the Board. (See Report Number: NTSB-AAS-70-2, pages 119-128.)

The radar coverage chart (classified for military security) for the San Pedro system indicates that the collision occurred at an altitude which is within the basic radar line of sight coverage. The limitations to radar advisory service within that coverage area include more than the controller workload. Other factors affecting detection of primary targets include:

(1) Radar cross-section presented by the design and configuration of the aircraft
(2) weather conditions such as precipitation and temperature inversions
(3) Ground clutter
(4) Blind spots

In this instance, detection of BuNo458 was hampered by the aircraft radar cross-section and a temperature inversion. Although simulations of the flightpath indicate that the primary target was intermittently detectable, the low probability of such detection is dramatized in the following computation:

> The total elapsed time a target would have been detectable was 120 seconds, equal to 10 sweeps of the antenna. At approximately 420 knots (7 miles per minute), the aircraft would travel 1.4 miles during each sweep. The target would actually move a total of 2.5 inches, or 0.25-inch/sweep, across the 21-inch display. The small time element involved and short distance moved, in combination with the probability of less than 50 percent primary target tracking continuity, indicate that it would have been extremely difficult for the controllers to differentiate between normal clutter and an aircraft return, if any target was displayed at all.

The volume of traffic and controller workload associated with the R-18 sector were sufficiently light to permit radar traffic advisories if requested. Advisories on possible conflicting traffic were being given to other controlled aircraft during the time period surrounding the collision. All four controllers associated with the activity at the position stated that no primary targets were observed in the vicinity of RW706. Consequently, the Board concludes that no readily discernible target from BuNo458 was displayed. If a request for radar advisories had alerted the controllers to the presence of an aircraft in that area, any intermittent or questionable target sighted could have been tentatively identified as BuNo458. The R-18 controller could have advised RW706 of the conflicting traffic under these circumstances.

(b) Reports of Aircraft Acrobatics

During the investigation considerable public attention was focused on witness reports of an aircraft performing acrobatics in the vicinity of the collision. The RIO testified that only one aileron roll was performed by the pilot of BuNo458, as he leveled off at 15,500 feet. An analysis of the flight from NAAS Fallon indicates that there was insufficient time available for any repeated maneuvers to have been performed. The witnesses might have been observing another aircraft, or they were actually viewing the qyrations of BuNo458 following the collisicn. Whereas no specific Federal Aviation Regulation prohibited the aileron roll, the ability of the crew to see other aircraft during the maneuver was unquestionably minimal due to the rapidly changing attitude and the acceleration forces imposed. The Board concludes that the aileron roll had no other significance to the accident, since the two aircraft were separated by approximately 13 miles at the time. However, it was imprudent of the pilot to perform such a maneuver in other than an acrobatic area.

(c) Operational Factors

This accident is another example of a heterogeneous mix of VFR and IFR traffic, with each aircraft ccmplying with applicable regulations, resulting in a midair collision. Several factors in the operation of the two aircraft combined to provide the conditions suitable for a midair collision.

1. Operation of BuNo458

Mechanical difficulties with BuNo458, and the resulting operational decisions. placed the aircraft at low altitude and high airspeed, instead of in the APC, as would normally be expected on cross-country flights. The transponder had failed on the previous day. making entry into the positive control airspace dependent on the discretion of the air traffic control facility. When the oxygen system also became defective, with no opportunity to repair either system, the decision to proceed to MCAS El Toro at relatively low altitude was the obvious solution to both problems. The transponder was not required, and cockpit pressurization negated the physical need for supplemental oxygen, even if the leak depleted the entire supply. The oxyqen leak did increase. and most of the flight to NAAS Fallon was flown. without supplemental oxygen. At this point. the pilot was instructed by higher authority to complete the flight with the defective systems. An additional significant factor in the operation of BuNo458 was the high-cruising airspeed, which is typical of modern jet aircraft. The high airspeed was used to avoid high specific fuel consumption and the less stable flight regime encountered at slower airspeeds. Consequently. the probability of visual detection was minimized by the speed. size. and unexpected presence of BuNo458.

In addition to these operational constraints imposed on the pilot of BuNo458, consideration of traffic and weather conditions was also evidenced in the planning and conduct of the flight.

The pilot of BuNo458 was sufficiently aware of the heavy volume of traffic in the Los Angeles area to alter his flight to the east in order to avoid any conflict. He further demonatrated concern for adequate vigilance by climbing to 15.500 feet because of the deteriorating visibility. However. the advantage which would have accrued from the deviation around Los Angeles was largely offset by the subsequent climb to higher altitude. This placed BuNo458 in the airspace segment normally used by eastbound traffic climbing to the high-altitude route structure.

Two other decisions by the pilot of BuNo458 also had a significant effect on the collision. First he did not attempt to request radar traffic advisories. This would have alerted the appropriate controller that a nontransponder target was in the area and undoubtedly would have resulted in an attempt to establish radar identification. Even if radar contact had not been accomplished at that time, the general location would have been established, and traffic advisories could have been issued accordingly. In spite of the fact that crews sometimes do not sight the traffic even though the advisories are issued in specific terms (clock code and distance) the issuance of a general warning (geographic location and direction of flight) would have served to narrow the field of search. thereby increasing the probability of detection.

Secondly. he requested the RIO to conduct a radar mapping exercise at a time when he was traversing an area of dense traffic. Although it may be argued that outside visibility from the rear cockpit is relatively poor, all possible assistance in maintaining a lookout should have been used. If any radar exercise were to have been conducted, it should have been in the search mode. Even in the degraded condition of the radar. this would have been preferable.

2. Overation of RW706

An analysis of the final 0.6 second of flight recorder operation shows that at 8 minutes 54.6 seconds. the vertical acceleration transducer sensed a positive g force. moving from +0.74g and culminating in a +5.08g reading at 8 minutes 55.2 seconds. At the instant the stylus recorded this, it moved instantaneously to a -1.8g reading. The return to. and overtravel beyond. a +1g (normal) position (-1.8g) . with no measurable elapsed time. strongly suggested rapid response or normalizing of the spring-restrained seismic mass in the electromechanical transducer after high excitation in the positive direction. These g recordings were made possible by the recording rate of 10 per second for this parameter, whereas the other three parameter rates are one per second.

The Safety Eoard believes that these excursions on the acceleration trace resulted from shock loading at impact and not from any attempted evasive maneuver by RW706.

Since the crew of RW706 took no evasive action prior to the collision, this indicates that either they did not see BuNo458 or saw it too late to take appropriate action. There are several factors which individually or collectively could have reduced the ability of the DC-9 crew to see and avoid the F-4B. The crew probably engaged the autopilot to maintain climb schedule and. under radar control, probably expected traffic advisories of converqing targets from the controller. Further reduction in outside vigilance might have resulted from such normal cockpit functions as determining 'or changing various radio frequencies, adjusting settings or controls of the flight director or thrust levers. However. the probable reasons why the RW706 crew did not see BuNo458 were: (1) both aircraft had a nearly constant relative hearing to each other; (2) the high closure speeds; (3) the lack of conspicuity of BuNo458; and (4) the lack of recurrent training in efficient lookout doctrine and scanning techniques.

(d) Human Factors in Target Detection and Assessment

The Board's cockpit visibility study (Attachments 3 and 4) indicates that at least 40 seconds prior to impact, BuNo458 was less than 45° to the left of the DC-9 captain's and first officer's normal sight line. Approximately 35 seconds prior to collision, RW706 completed a left turn and was then climbing on a constant heading. Although the target size of BuNo458 was small at this time (0.017-inch) ▪ the smoke trail from engine exhaust would have at least tripled the effective target size. The visual angle subtended by such a target would be approximately 10.8 minutes of arc. The empirically derived threshold for detection is nominally 4 minutes of arc. At approximately 15 seconds before the collision, just prior to the onset of the "blossoming effect" which occurred as the intruder target size increased dramatically, the size of BuNo458 and a smoke trail twice its length would have grown to approximately 0.117-inch. In the next 10 seconds, the target size would triple, in the last 5 seconds it would expand to fill the entire visual field. These figures are predicated on the constant foreshortened length of BuNo458 which would result from the relative positions of the two aircraft, and no attempt was made to adjust for the target size during the evasive action taken by BuNo458.

The cockpit visibility study (Attachments 3 and 4) also indicates that RW706 would have been approximately 39° to the right of the normal sight line of the pilot of BuNo458 and approximately 37° for the RIO, for the last 40 seconds prior to collision. The target size of RW706, allowing for the foreshortening due to angular displacement, 35 seconds prior to impact was approximately 0.037-inch. At this point the target would subtend approximately 7 minutes of arc, which is well within the detectable threshold mentioned earlier. No addition to target size was made for engine exhaust because one engine was modified, which reduced the visible smoke emission. This would have presented less than optimum density for detection. During the final 15-second period prior to collision, the target size of RW706 blossomed rapidly, tripling in size between 15 seconds and 5 seconds and then expanding to fill the entire visual field in the final 5 seconds,

Although the F-4B and DC-9 target images were theoretically of sufficient size to permit detection at 35 seconds prior to collision, a number of factors could have contributed in this case to reduce the likelihood of detection at that time. In the analysis of any midair collision, laboratory data on human response and capabilities 9/ must be adjusted to real-world conditions. The extent to which these data vary depends on the effect of many factors; i.e., 'windshield refractance, surface irregularities and cleanliness, size and location of windshield frames., the background against which a target is viewed, atmospheric light scatter: and viewer training, ability, and preoccupation: All may be involved to varying degrees at the time a target is within a perceptible threshold. The extent to which these factors affected detection of RW706 or BuNo458 cannot be determined precisely. However, the various studies comparing laboratory data to real-world situations show dramatic reduction in the probability of visual detection due to the factors listed above.

A nonstructured or ill-defined .homogeneous background presents a less-than-desirable field when the search for a target is conducted, The lack of defined background texture, coupled with a constant background hue, can severely limit not only the detectability of a target but also the ability to perceive target motion. once the tarqet is detected.' While the effects of atmospheric light scatter, and the reported haze layer at 9.000 feet cannot be quantitatively determined in this accident. it is reasonable to surmise that RW706 presented less than optimum conspicuity when viewed against the haze layer. Moreover, its motion relative to the background haze would be difficult to detect. Had either aircraft displayed high intensity strobe lights. the increased conspicuity probably would have enhanced early detection of each aircraft.

'Another factor which can affect the detectability of airhorne targets is the myopic nature of the human eye when an air-to-air search is being conducted. The condition results from the tendency of the eye to focus at approximately 20 feet during a visual search into an essentially empty visual field. Although this condition is more prevalent at extremely high altitudes where the horizon becomes ill-defined and high ambient lighting becomes a factor, it is also possible that a myopic condition could exist at markedly lower altitudes when a pilot is searching aqainst an ill-defined homogeneous field. The possibility therefore exists that the crews of RW706 and BuNo458 could have been subject to some degree of myopic vision with a resultant reduction in their ability to detect a small target.

Finally, the effectiveness of crew scanning is dependent on training and the time sharing of activities inside and outside of the cockpit. Based on a fixed-eye reference point. neither target uas masked by intervening cockpit structure for any significant period of time; however. each target was in the peripheral visual field 10/ of all crewmembers. The lack of relative motion of either target in the peripheral vision of any crewmember could have made early detection of the other aircraft highly unlikely. Similarly, the small size and lack of relative movement of either target, even though detected at 35 seconds prior to collision, would undoubtedly have precluded accurate assessment of the vertical and horizontal separation or rate of change of target size. Thus even if the DC-9 and F-4 crews detected the other aircraft. the cues for accurate assessment of the collision geometry could have been marginally adequate.

It may be postulated that as the closure distance decreased from 20 to 10 seconds prior to the collision the target would become better defined and RW706's climb attitude could be more accurately discerned by the pilot of BuNo458. Thus a sighting during the period between 20 and 10 seconds prior to collision might not have been interpreted as an imminent collision threat because of the smallness of the target size. However, target size notwithstanding, the fixed bearing of RW706 and its location near the horizon would have suggested that a collision threat existed and that he should maneuver to assure a comfortable separation. Moreover, the F-4B pilot's military flying experience, including tactical intercept training should have increased the likelihood of the initiation of a right turn or other maneuver which would have increased the miss-distance. The lack of any such maneuver indicates that he did not sight the DC-9 in sufficient time to have executed an appropriate maneuver to avoid the collision.

In light of the above discussion of the likelihood of early detection, the Safety Eoard concludes that although detection of RW706 by the pilot of BuNo458 might have occurred as much as 35 seconds prior to collision, it is more likely that it occurred at some time markedly less than 20 seconds prior to the collision.

The possibility of an early detection of BuNo458 by the crew of RW706 was considered. However, with BuNo458 located near the horizon and on a constant or nearly constant bearing, early detection probably would have prompted the crew of RW706 to monitor the progress of BuNo458 thereafter and seriously to consider altering their climb schedule or headinq to ensure safe passing separation. Assuming continued assessment by the RW706 crew, as the range decreased, the likelihood of their making a precautionary alteration in flightpath would seem to increase. Therefore, in the absence of any such deviation in flightpath, the Safety Board concludes that it is most likely that the crew of RW706 never saw BuNo458, or saw it moments prior to the collision and had no time to initiate an evasive maneuver.

In order to determine a likely time for detection of RW706 by the pilot of BuNo458, it was necessary to consider the RIO's warning coincident with the rolling maneuver as a starting point, together with aircraft response times and laboratory data suggestive of pilot response times in collision situations. The data suggest that it would take 0.24 second to accommodate to foveal vision, cnce a target was detected. Neural processes would take an additional 0.3

second. The data further suggest as much as 3 seconds could have elapsed during recognition and assessment of the various cues and determination that a potential threat existed. Approximately 2 seconds could have then elapsed while deciding whether an evasive maneuver was necessary and if so, the type of maneuver to initiate. Another 0.5 second could have elapsed for human motor response. Aircraft performance data indicate approximately 3 seconds could have been required for aircraft response, depending cn the rate and type of control input. Based on the RIO's testimony and analysis of other events, the pilot's participation in the radar mapping exercise was completed approximately 20 seconds prior to the collision. However, this remaining 20 seconds was most likely not entirely spent in constant visual search of surrounding airspace. Such intracockpit duties as monitoring the attitude indicator to maintain fliqhtpath attitude. airspeed, and status of aircraft subsystems would have occupied some finite amount of this time. Thus. the time available for detecting any outside target could have been significantly less than 20 seconds. It is postulated that 10 seconds could have been spent performing a noncontinuous visual search of the surrounding airspace, while the remaining 10 seconds were shared with scanning cockpit displays. Because the DC-9 target was very small, stationary, and located in his peripheral vision, it is most likely that the pilot did not see the DC-9 until just moments before the collision. The completely unexpected appearance of the DC-9, together with its dramatic growth in size during the 10 seconds prior to collision rendered proper assessment of the situation extremely difficult if not impossible. The Safety Foard concludes therefore, that it is likely that the pilot of BuNo458 detected RW706 less than 10 seconds before the collision and that the evasive maneuver was initiated approximately 2 to 4 seconds before collision. Within the final remaining 2 to 4 seconds a left roll was made as an attempt to avoid a collision. A more appropriate maneuver consistent with previous training would have been a roll to the right to increase miss-distance. However, the Board cannot determine with certainty that even this type of maneuver would have assured safe passage of the F-4.

/The Board further concludes that the visual cues for accurate assessment of the collision geometry by the pilot of BuNo458 probably were inadequate. Then, when target range had been reduced sufficiently to afford improved visual cues, the time remaining was so brief as to make unduly difficult the accurate assessment of the geometry and proper response.

(e) Consideration of See and Avoid Concept

Section 91.67 of the Federal Aviation Regulations (FAR) 11/ places the burden on both crews to see and avoid other aircraft. Assuming detection of the other aircraft, FAR 91.67(c) placed an additional responsibility on BuNo458 to respect the right of way of RW706

Nonetheless, as can be appreciated from the foregoing analysis of this collision, the likelihood of a pilot's either not seeing an intruder at all or seeing the intruder and misinterpreting visual cues and then attempting an evasive maneuver based on incomplete visual cues, is highly probable. The problem-solving process required of pilots in these situations is often highly complex, and in many cases the problem is impossible to solve in time to avoid a collision. This is demonstrated by the fact that the crew of BuNo458 had received recent training in lookout doctrine and scanning techniques but were unable to avoid the collision.

Conversely, the crew of RW706 received no formal company training on lookout doctrine or scanning techniques, and no such training is required by either the company or the FAA- Although Air West pilots are evaluated for "alertness", this evaluation appears to encompass conditions inside the cockpit as well as outside. There are no definitive criteria to determine how effectively a pilot maintains a proper lookout. It may be argued that previous military training in lookout doctrine and scanning techniques, coupled with years of flying experience, would result in excellent time-sharing for responsibilities inside and outside. However, it is equally true that years of experience without constant review and improvement would result in establishment and reinforcement of improper habit patterns. Overcoming such a behavioral pattern, which involves no conscious process, would require a concerted retraininq program with periodic recurrent training. The Board believes it significant that there is no indication that the crew of RW706 ever saw BuNo458 under these circumstances. The Board, therefore. reiterates the position taken many times before that for certain operational conditions, the "see and avoid" concept is simply inadequate and the development of collision avoidance systems must be vigorously pursued.

Whereas this accident resulted from high closure rates and, consequently, small target size until shortly before the collision, the Board also recognizes the more common type of midair collision occurring between aircraft at relatively low closure rates. The Board believes that for this latter type of collision, the detectability and assessment of the collision threat from an intruding aircraft can be enhanced by proper pilot techniques and a more thorough understanding of visual phenomena. The Safety Board's publications 12/ related to midair collisions between aircraft in visual meteorological conditions have stressed the need for increased pilot vigilance. Recommendations have been sent to the FAA, the air carriers, commercial operators, pilot associations, and the many aviation-oriented interest groups to increase the awareness of pilots to the midair-collision threat. It is therefore gratifying to see that many of the professional publications and meetings of these organizations are focusing on the many facets of this problem.

Similarly, a terminal control area has been implemented in the Los Angeles area, since the accident. This action is a positive step toward reducing the threat of midair collisions, but the Board believes the concept would not prevent the recurrence of this accident. Estatlishment of climb and descent corridors, as previously recommended by the Eoard would tend to eliminate this type of accident.

2.2 Conclusions

(a) Findings

1. Both aircraft were airworthy.

2. All flightcrew members were qualified.

3. RW706 was operating in accordance with an IFR flight plan under radar control of the Los Angeles ARTCC.

4. BuNo458 was operating in accordance with a VFR flight plan and was not under control

of the ATC system.

5. The air traffic controllers were qualified for their assigned duties.

6. BuNo458 was not detected on radar because of an inoperative transponder, the aircraft radar cross-section, and a low level temperature inversion in the area.

7. There was no restriction to in flight visibility in the area of the accident.

8. The pilot of BuNo458 exercised poor judgment in performing an aileron roll, but the roll did not contribute to the accident.

9. The pilot of BuNo458 attempted to eject from the aircraft, but he was unable to do so because the forward canopy did not jettison.

10. If BuNo458 had requested radar traffic advisories, the controller could have advised RW706 of the presence of BuNo458 and the probability of avoiding the collision would have increased significantly.

11. USMC flightcrews receive training in lookout doctrine and scanning technique.

12. No formal training or evaluation of crew scanning technique and lookout doctrine is accomplished by Air West.

13. Both aircraft were theoretically cf sufficient size to permit detection by each other at 35 seconds prior to collision. However, detection and assessment were probably compromised by target size due to high closure rate, target contrast and location in the peripheral visual field, and other visual limitations.

14. At 35 seconds before impact, both aircraft were on an essentially constant relative bearing and would have'been difficult to detect because each target would be near the minimum detectable size and would remain relatively

stationary.

15. In view of the absence of evasive action on the part of RW706 (i.e., no alteration of heading, climb profile or airspeed) it is logical to conclude that the crew did not sight BuNo458 in time to initiate such evasive action.

16. The pilot of the F-4B probably first observed the target of the DC-9 at about 8 to 10 seconds prior to collision, devoted the first portion of this brief period to assessing such cues as relative bearing, speed, and climt angle, and initiated a reflex evasive maneuver approximately 2 to 4 seconds prior to the collision.

(b) Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident uas the failure of both crews to see and avoid each other but recognizes that they had only marginal capability to detect, assess. and avoid the collision. other causal factors include a very high closure rate, comingling of IFR and VFR traffic in an area where the limitation of the ATC system precludes effective separation of such traffic, and failure of the crew of BuNo458 to request radar advisory service, particularly considering the fact that they had an inoperable transponder.

3. RECOMMENDATIONS

As a result of this accident the National Transportation Safety Board recommends that the Administrator of the Federal Aviation Administration:

1. Install video tape at all FAA ATC radar displays, both term-nal and en route for use as an investigation tool. (A-72-200)

2. Install an open "area" microphone at each terminal and center sector position to record all conversation at the control positions. (A-72-201

3. Establish climb and descent corridors extending from the top of the TCA's to the base of APC, to remain in

effect until the base of APC bas been lowered to the top of the TCA's. (A-72-202)

4. Establish more definitive procedures for the guidance of controller personnel in handling Code 7700 aircraft. (A-72-203)

5. Review radar performance monitoring procedures to assure that all radar facilities are capable of receiving Code 7700 transponder returns. (A-72-204)

The National Transportation Safety Eoard also recommended (A-71-52) that the FAA take the following action:

Coordinate with the Department of Defense, and. in areas where a large intermix of civil and military traffic exists, develop a program to insure that appropriate graphical depictions of airspace utilization and typical flow patterns are prominently displayed at all airports and operational bases for the benefit of all airspace users.

The Federal Aviation Administration responded, in a letter dated November 10, 1971, as follows:

"This is in response to your safety recommendation, A-71-52. issued 9 November 1971.

"Recommendation number 4 of our Near Midair Collision Report of July 1969 is similar to your recommendation.

"As a result of that recommendation we:

1. Developed a new Part 4 of the Airman's Information Manual in January 1970 (Graphic Notices and Supplemental Information). As graphics are made available, they are included in the semiannual Part 4 or are carried in the every 28-day Part 3, until they can be transferred to Part 4.

2. Developed various types of graphic displays of normal IFR and VFR routes.

3. Developed graphics for the 22 large terminal hubs. Fifteen are published in the AIM, and the remaining seven are in various stages of processing.

4. Dweloped graphics for other than large hubs including Air Force Bases. Eight are published in the AIM and three are in the final stages of development. Nine of the eleven display Air Force Base activities.

"In addition to the above, we have developed a VFR Terminal Area Chart (copy enclosed) which we will be testing and evaluating. This chart of Chicago Area depicts the Terminal Control Area, VFR and IFR routes and military operations at NAS Glenview. The chart is designed for use by pilots and for display at all airports and operational bases.

"As you can see, we have expanded upon the original recommendation in our Near Midair Collision Report. As a continuation of this expansion, we will coordinate further with the Department of Defense to incorporate other military bases into the program.

"After review of the material we have outlined above, we would appreciate any further comments you may have concerning this matter."

On February 8, 1972, the Safety Board further recommended (A-72-12 6 13) that the FAA:

1. Develop VFR Terminal Area Charts, similar to that prototype portraying the Chicago TCA, for all other TCA's and, if feasible, for other large air traffic hubs.

2. Initiate a program to publicize the existence of, and the location of, these graphics for prospective users. The program should incorporate, in part. Examograms and. in airmen examinations. questions referring to these graphics.

The Federal Aviation Administration concurred with these recommendations in a letter, dated February 15, 1972.

Other recommendations (A-71-46 thru 51) were sent to the Department of Defense on November 2, 1971, suggqesting the following actions:

1. Review the feasibility of restricting all types of low-level training, which requires airspeeds in excess of the FAR limitations, to designated restricted areas and low-level navigation routes.

2. Rephrase the wording contained in your altitude/airspeed limitations, and delineate explicitly those instances wherein airspeeds in excess of the 10,000 feet/250 KIAS limitations are authorized. The Board believes that the exceptions should be limited to the following:

   "a. Climbs and descents to traffic patterns, authorized and/or designated training areas and low-level navigation routes.

   "b. Those instances where safety of either crew or aircraft require operations in excess of the limitation.

3. Explore the feasibility of using the air intercept radar on all military aircraft to provide collision avoidance assistance as an additional aid to the "see and be seen" concept; and should this prove feasible, institute and establish procedures to use the radar for this purpose on all flights where its use is not required for more urgent military mission requirements.

4. Institute a program to provide more publicity to the existence, function, and use of the FAA Radar Advisory Service in those instances where VFR flight is required through high-density traffic areas. Consideration should be given to making the request for such service a mandatory procedure."

The Department of Defense responded, in a letter dated December 2, 1971, as follows:

"This letter is in response to the National Transportation Safety Board safety recommendations A-71-48 thru 51, which you forwarded to Secretary Laird on 9 November 1971.

"These recommendations have been referred to the military services for their consideration. I am advised that during their initial review the recommendations were considered sound and would be implemented to the extent feasible. The details of such action are being staffed. The results of this staffing will be the promulgation of specific instructions and guidance to their operating commands.

"Thank you for your helpful recommendations which are so important to our mutual interest in achieving the greatest degree of air safety."

The safety Board previously made recommendations on the problem of midair collisions in the Board's special accident prevention study "Midair Collisions in U. S. Civil Aviation - 1968" which was released in July 1969. and the *Report of Proceedings of the National Transportation Safety Board into the Midair Collision Problem - November 4 through 10. 1969" which was released February 22, 1971.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOHN H. REED
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ ISABEL A. BURGESS
Member

/s/ WILLIAM R. HALEY
Member

LOUIS M. THAYER, Member, was absent, not voting.

September 22, 1972

FOOTNOTES

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

2/ Airspace within which all traffic is under positive control. and all aircraft must operate in accordance with Instrument Flight Rules (IFR). At the time of the accident, the positive control began at Flight Level 240.

3/ A collocated very high frequency omnirange and ultrahigh frequency tactical air navigational aid. The DME feature gives a slant range measurement to the facility.

4/ A controller qualified in *the* type of work being done, i.e., radar, data. tower. etc.. but who is not checked out in the specific position of a facility, i.e., R-18, D-18, etc.

5/ MTI is a feature of the display which tends to eliminate returns from stationary targets. It is infinitely adjustable within the range capability of the radarscope. and has six preselected levels of signal attenuation available.

6/ PRF was designed to virtually eliminate any blind speed effect which could occur when targets are traveling tangent to the antenna. within the range of the MTI selection. Such targets would otherwise not appear on the radarscope due to apparent lack of motion.

7/ code 7700 is a universally used emergency code for transponders.

8/ Guard channel is the international emergency frequency. It is 121.5 MHz for very high frequency (VHF) communications.

9/ A study of Requirements for a pilot Warning Instrument for Visual Airborne Collision Avoidance. sperry Gyroscope Company. Great Neck. Long Island. December 1963; and Vision In Military Aviation. J.W. Wulfeck. et al., WADC Technical Report 58-399, November 1958, Wright Air Development Command. Wright-Patterson AFB. Ohio.

10/ Foveal vision takes place within 20° of the center portion (fovea) of the eye. Peripheral vision occurs outside this 20° cone of foveal vision.

11/ FAR 91.67 states in part: "When weather conditions permit, regardless of whether an operation is conducted under Instrument Flight Rules or Visual Flight Rules, vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft in compliance with this section. when a rule of this section gives another aircraft the right of way, he shall give way to that aircraft and may not pass over, under. or ahead of it. unless well clear." FAR 91.67 (c) provides that: "When aircraft of the same category are converging at approximately the same altitude . . . the aircraft to the other's right has the right of way. . . ."

12/ Midair Collisions in US Civil Aviation–1966; Aircraft Accident Report NTSB–AAR–69–2; Aircraft Accident Report NTSE–AAR–69–4; Aircraft Accident Report NTSE–AAR–70–15; and Report of Proceedings into the Midair Collision Problem NTSB-AAS-70-2.

APPENDIX A

INVESTIGATION AND HEARING

1. Investigation

The Board received notification of the accident at approximately 1830 on June 6. 1971. from the Federal Aviation Administration. An investigating team was immediately dispatched to the scene of the accident. Working groups were established for Operations Air Traffic Control, Witnesses. Weather. Human Factors. Structures. Powerplants. Systems. and Flight Recorder. In addition the maintenance records for each aircraft were reviewed. The Federal Aviation Administration, Department of Navy. Hughes Air West. McDonnell-Douglas Corporation, and Air Line Pilots Association all participated in the investigation as interested parties. The on-scene investigation was completed on June 19, 1971.

2. Hearing

A public hearing was held at Pasadena. California. on July 27 to July 30, 1971. Parties to the Hearing included the Federal Aviation Administration. Department of Navy. Hughes Air West. McDonnell-Douglas Corporation, Air Line Filots Association and Aircraft Owners and Pilots Association.

3. Reports

A preliminary factual report of the investigation was released by the Board on July 26, 1971. A summary of the testimony was issued on Auqust 20. 1971.

APPENDIX B

Crew Information

Captain Theodore Nicolay. aged 50. held airline transport pilot certificate No. 474317. with ratings in airplane multiengine land. F-27. DC-3. and DC-9. He had accumulated 15,490 total flying hours. including 2.562 hours in the DC-9. He completed his last proficiency check on March 8 1971. and his FAA first-class medical certificate was issued on January 25. 1971. with no limitations.

First Officer Price Bruner, aged 49, held airline transport pilot certificate No. 611777. with ratings in airplane multiengine land. F-27/227, DC-3. DC-9 and commercial privileges in airplane single-engine land. He had accumulated 17,128 total flying hours, including 272 hours in the DC-9. He completed his last Proficiency check on December 7. 1970. and his FAA first-class medical certificate was issued on December 18. 1970, with no limitations.

The flightcrew members had been on duty approximately 6 hours. including about 1 hour 50 minutes flight time, when the accident occurred. Their rest period prior to reportinq for duty was 18 hours 13 minutes.

Hostess Joan R Puylaar, aged 34. was hired on August 22, 1959.

Hostess Particia Shelton. aged 28. was hired on October 18, 1963.

Hostess Helena Koskimies, aged 30. was hired on October 16, 1967.

All cabin crewmembers completed their prescribed emerqency recurrent training in September 1970.

First Lieutenant James R Phillips, aged 27. held commercial pilot certificate No. 1619834. with ratings in airplane single- and nultiengine land. He also held a valid flight instructor certificate. He had accumulated 440 total military flying hours, including 170 hours in the F-4B. He also had accumulated approximately 400 hours in civil aircraft. He completed his last Naval Air Training and Operating Procedures Standardizations Programs (NATOPS) flight check on December 8, 1970, possessed a Standard Instrument Card, and passed his annual medical examination on June 23, 1970, with no limitations.

First Lieutenant Christopher E Schiess, aged 24, joined the U. S. Marine corps on November 7, 1969, and completed his RIO training January 3, 1971. He had accumulated 195 total flying hours, including 89 hours in the F-4B. He was current on all prescribed training and passed his annual medical examination on July 13, 1970.

Both crewmembers had been on duty approximately 7 hours 4 minutes, including 1 hour 53 minutes flying time at the time of the accident. Their rest period prior to reporting for this flight was 19 hours 10 minutes.

APPENDIX C

Aircraft Information

N9345, a McDonnell-Douglas DC-9-31, serial No. 47441, was owned by the C.I.T. Corporation, 650 Madison Avenue, New York, New York, 10020, and operated by Hughes Air West, San Francisco International Airport, San Francisco, California, 94128. It had been flown a total of 5,542 hours at the time of the accident. A review of the records indicated that all applicable Airworthiness Directives either had keen complied with or were scheduled for completion. Pratt & Whitney JT8D-7 engines were installed as follows:

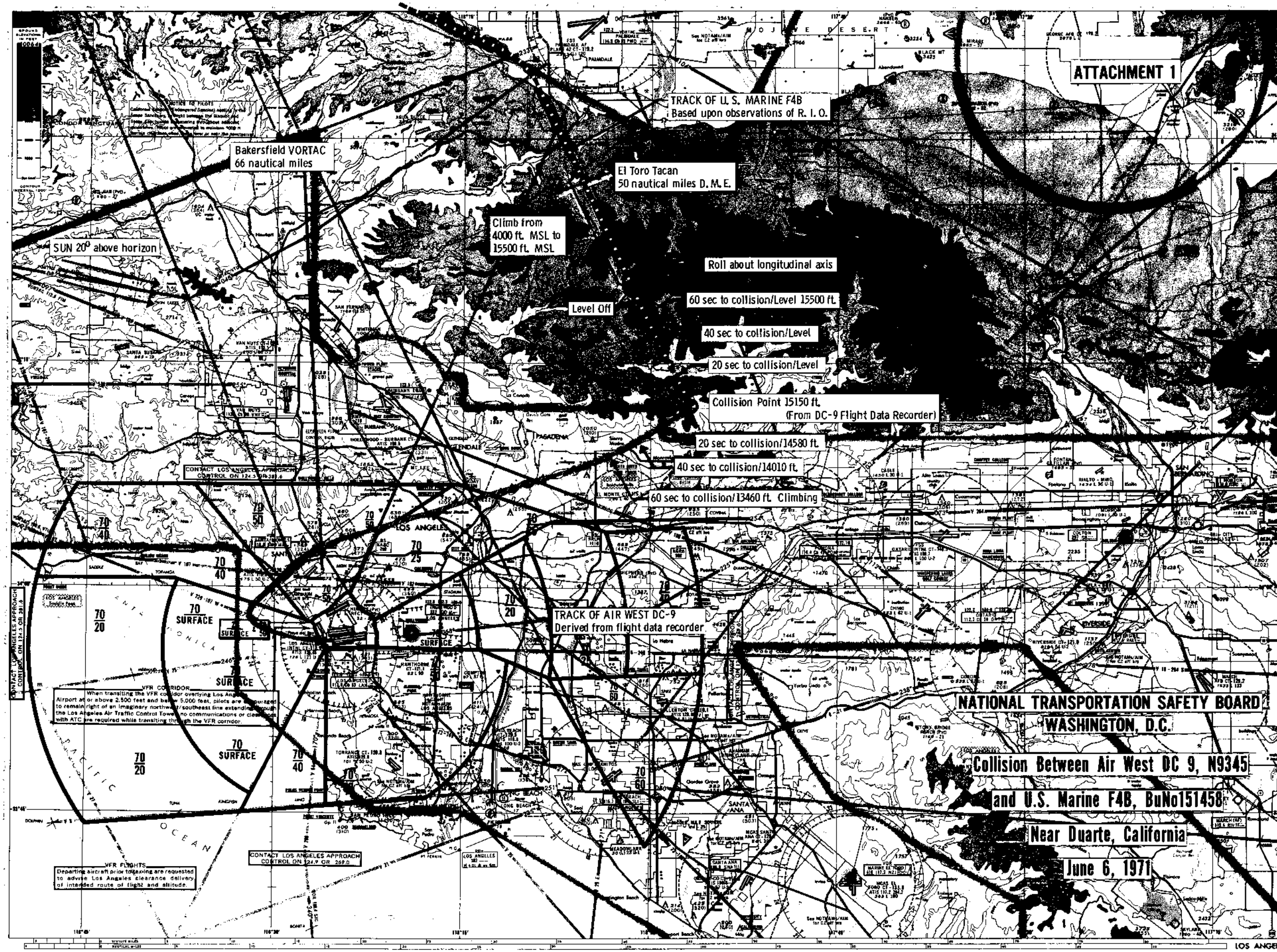
Position	Serial Number	Time Since Overhaul
1	P65704-D	5265.69
2	P654152-B/D	2263.06

The aircraft weighed 86,518 pounds at engine start and the center of gravity was 21 percent MAC. Both are within the allowable limits.

Bureau Number 151458, a McDonnell-Douglas F-4B, was received on April 15, 1964, and had been operated by various squadrons of the U. S. Marine Corps. At the time of the accident, it was assigned to VMFA-323, and had keen flown a total of approximately 2,030 hours. A review of the records indicated that the aircraft was maintained in accordance with the appropriate regulations. General Electric J79-8 engines were installed as follows:

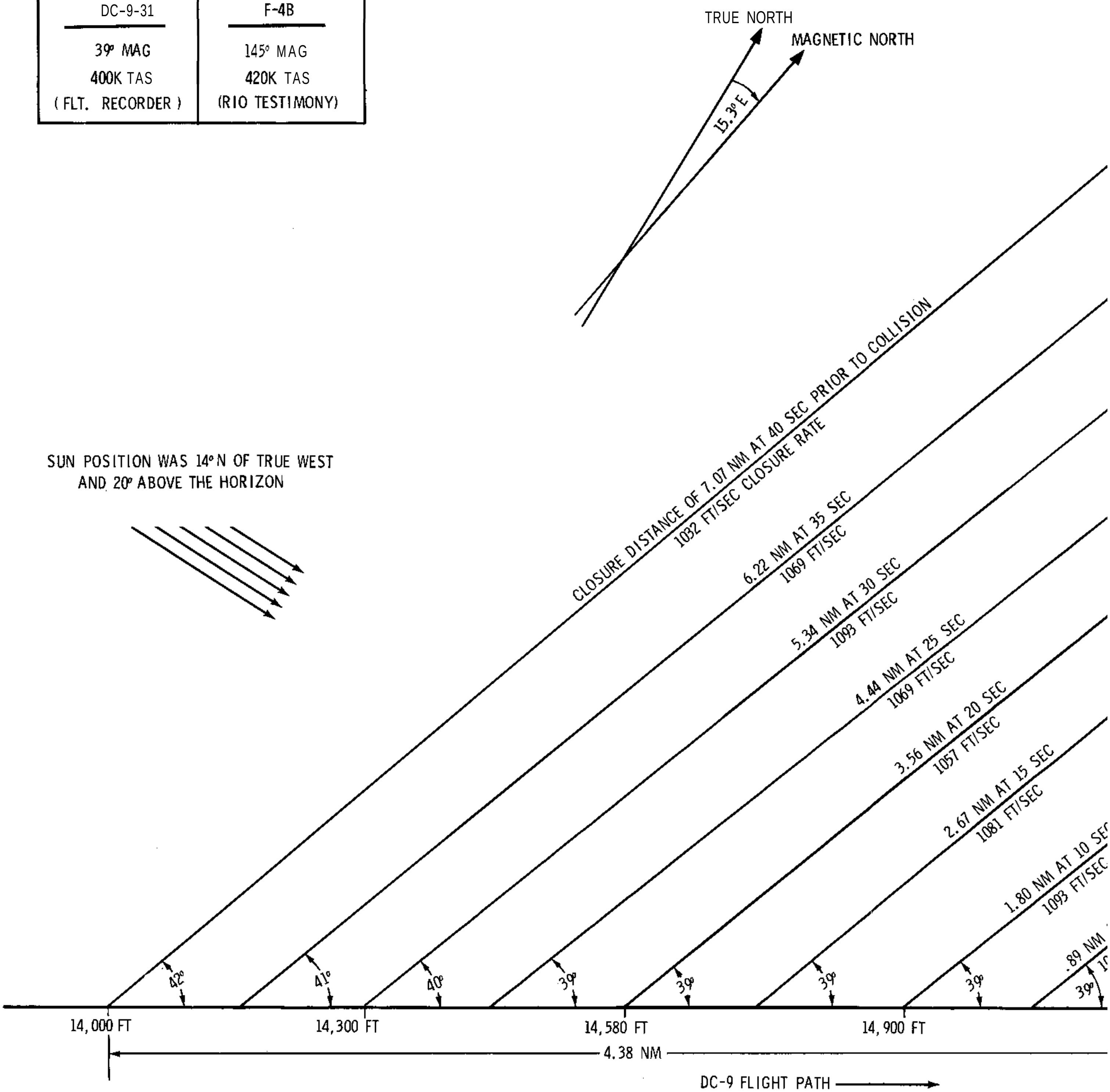
Positiog	Serial Number	Time Since Overhaul
1	401437	842.5
2	421669	258.8

The aircraft weighed approximately 43,310 pounds at engine start. Both the takeoff weight and center of gravity were within prescribed limits.

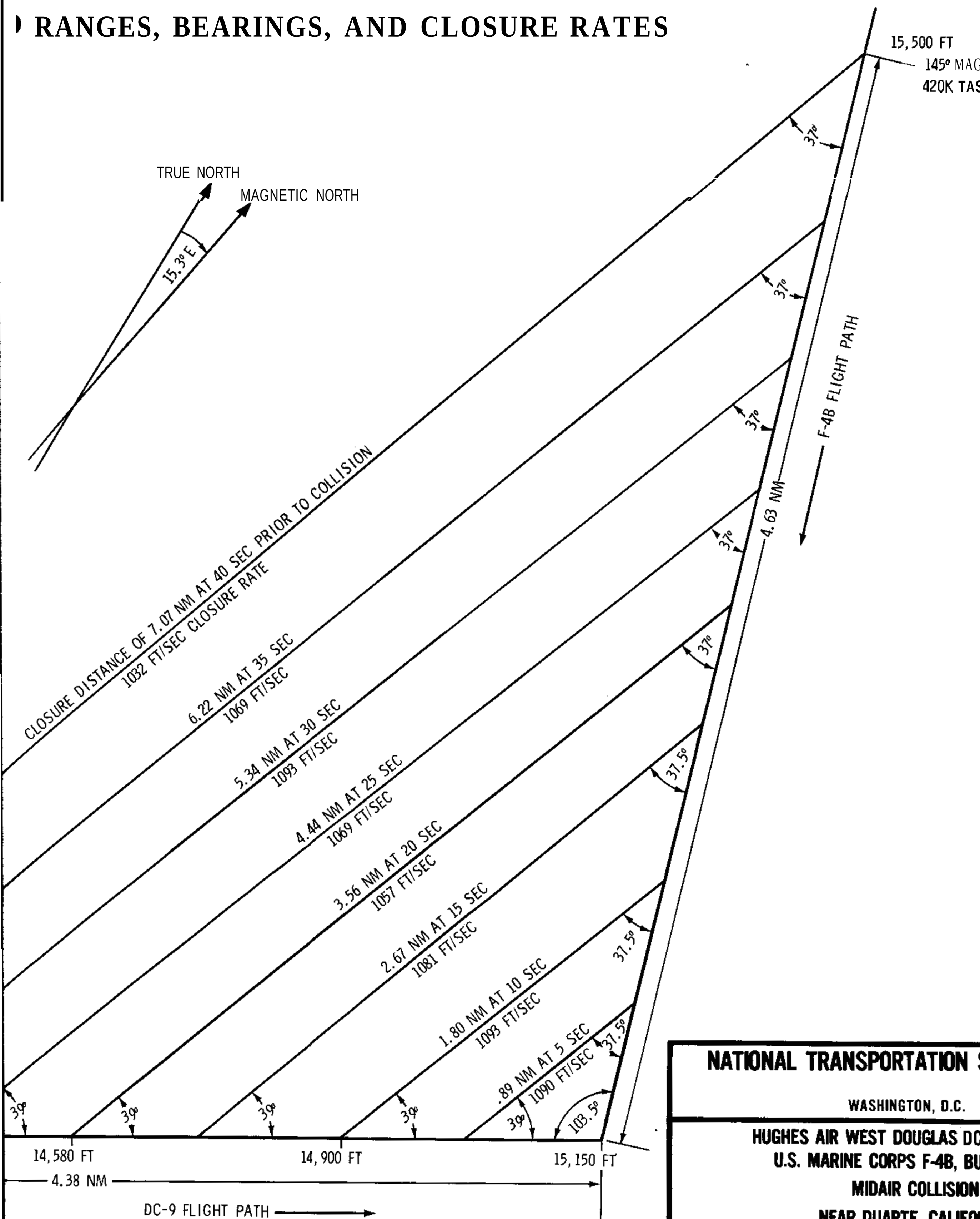

ATTACHMENT 1
TRACK OF U. S. MARINE F4B
Based upon observations of R. I. O.
Bakersfield VORTAC
66 nautical miles
El Toro Tacan
50 nautical miles D. M. E.
Climb from
4000 ft. MSL to
15500 ft. MSL
SUN 20° above horizon
Roll about longitudinal axis
Level Off
60 sec to collision/Level 15500 ft.
40 sec to collision/Level
20 sec to collision/Level
Collision Point 15150 ft.
(From DC-9 Flight Data Recorder)
20 sec to collision/14580 ft.
40 sec to collision/14010 ft.
60 sec to collision/13460 ft. Climbing
TRACK OF AIR WEST DC-9
Derived from flight data recorder
NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.
Collision Between Air West DC 9, N9345
and U.S. Marine F4B, BuNo151458
Near Duarte, California
June 6, 1971
LOS ANGELES

COMPUTED RANGES, BEARINGS, AND CLOSURI

PRIOR TO EVASIVE MANEUVER	
DC-9-31	F-4B
39° MAG	145° MAG
400K TAS	420K TAS
(FLT. RECORDER)	(RIO TESTIMONY)



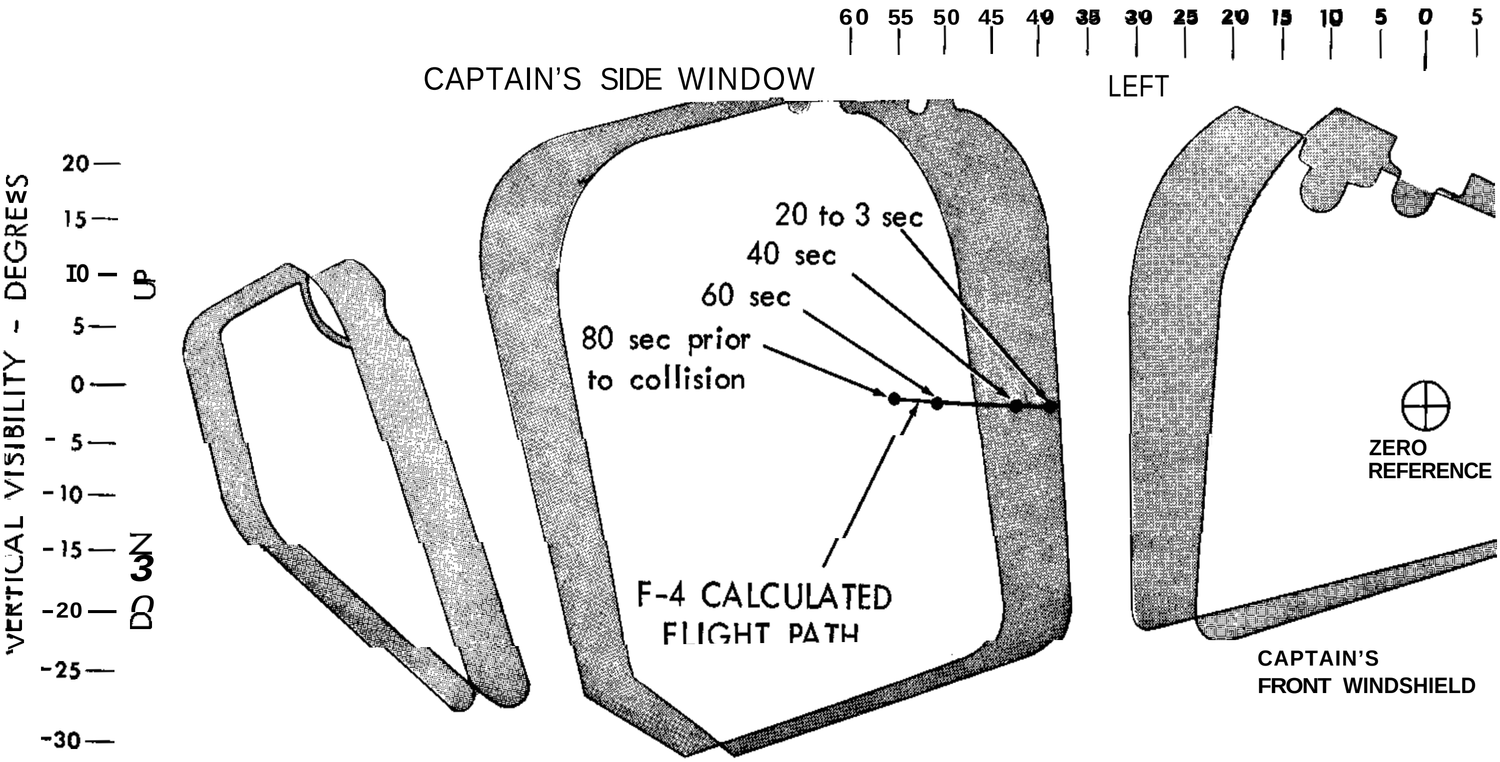
RANGES, BEARINGS, AND CLOSURE RATES



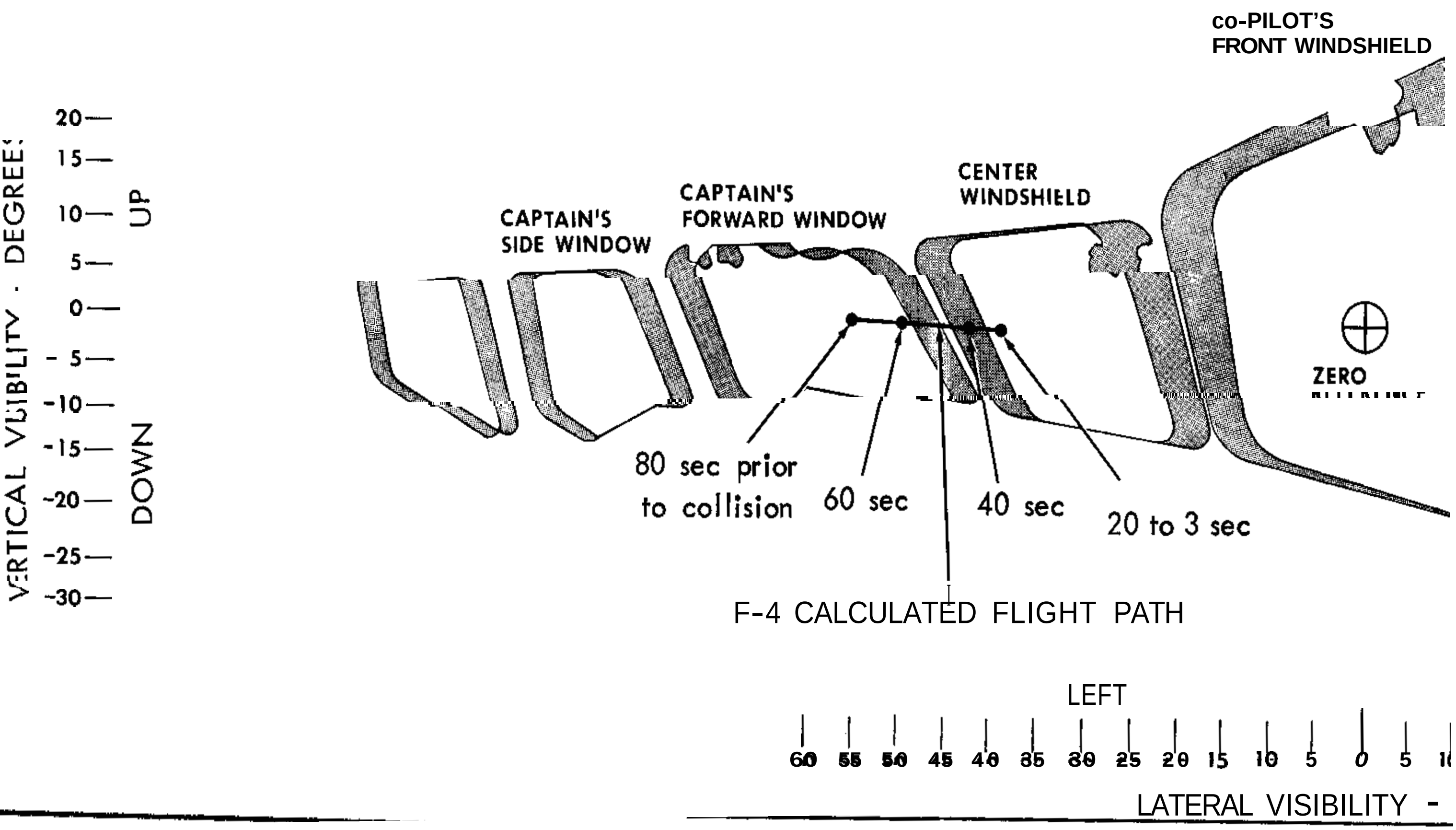
NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C.

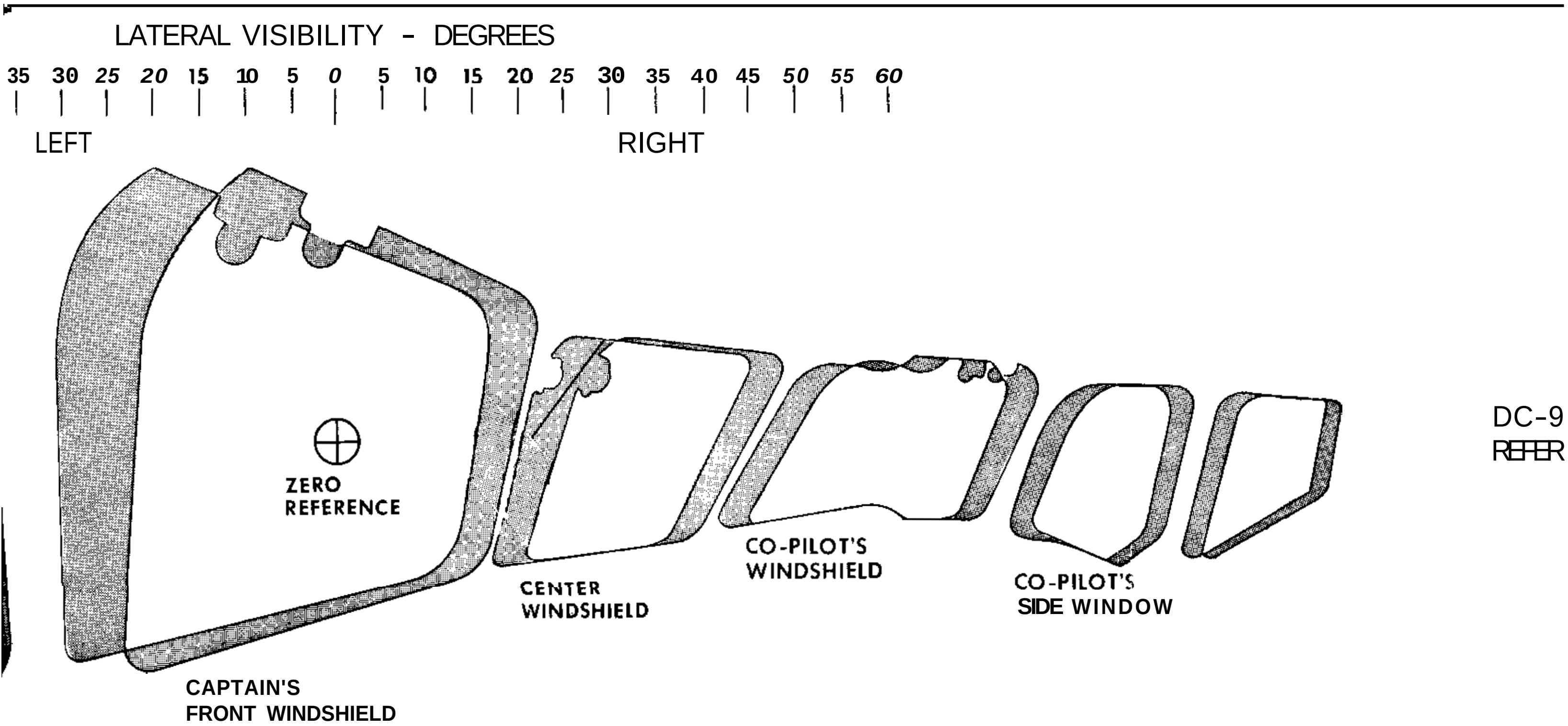
HUGHES AIR WEST DOUGLAS DC-9-31, N9345
U.S. MARINE CORPS F-4B, BUNO 151458
MIDAIR COLLISION
NEAR DUARTE, CALIFORNIA
JUNE 6, 1971

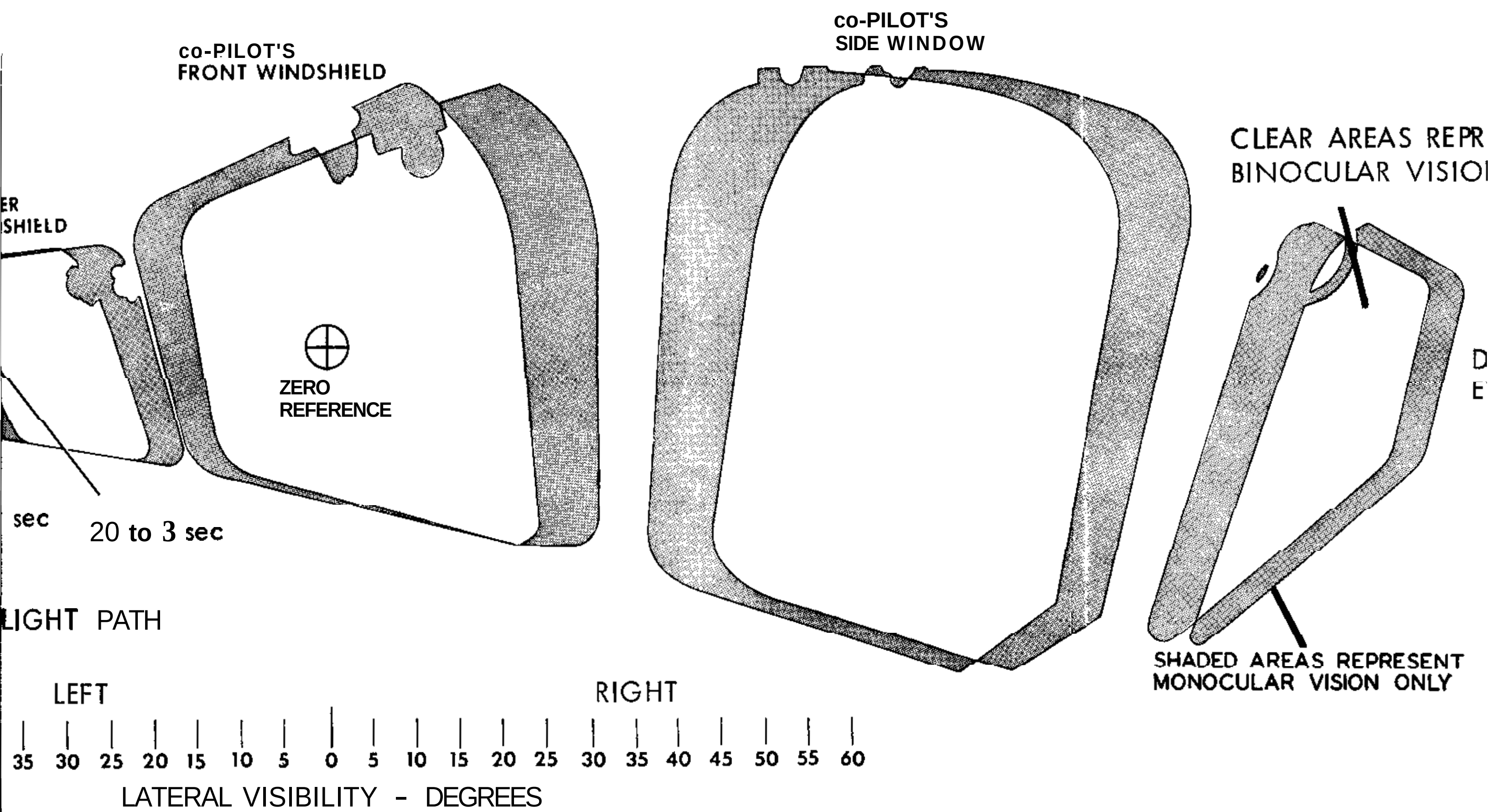


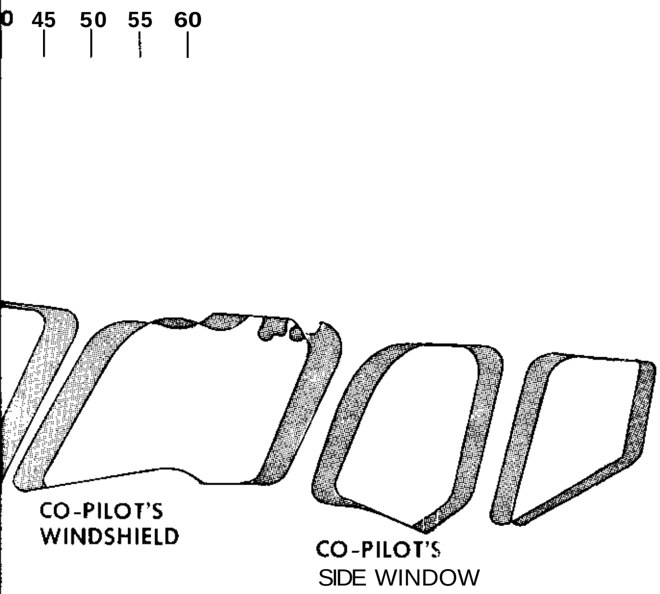
60 55 50 45 40 35 30 25 20 15 10 5 0 5
LEFT
CAPTAIN'S SIDE WINDOW
VERTICAL VISIBILITY - DEGREES
20
15
10
5
0
-5
-10
-15
-20
-25
-30
UP
DOWN
20 to 3 sec
40 sec
60 sec
80 sec prior to collision
F-4 CALCULATED FLIGHT PATH
ZERO REFERENCE
CAPTAIN'S FRONT WINDSHIELD



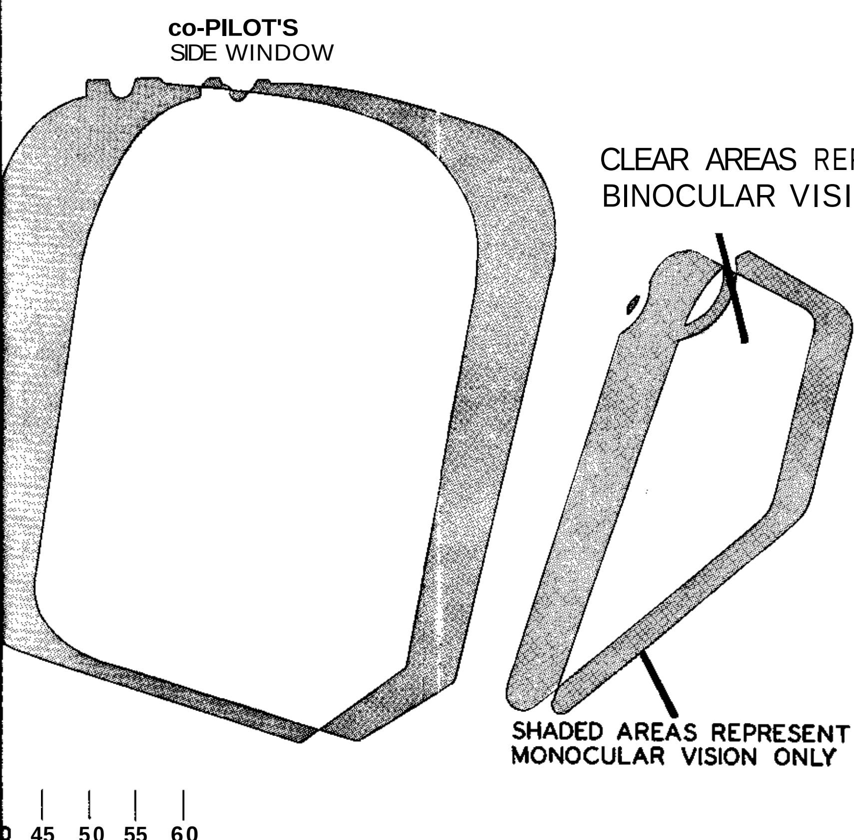
CO-PILOT'S FRONT WINDSHIELD
VERTICAL VISIBILITY - DEGREES
20
15
10
5
0
-5
-10
-15
-20
-25
-30
UP
DOWN
CAPTAIN'S SIDE WINDOW
CAPTAIN'S FORWARD WINDOW
CENTER WINDSHIELD
ZERO
80 sec prior to collision
60 sec
40 sec
20 to 3 sec
F-4 CALCULATED FLIGHT PATH
LEFT
60 55 50 45 40 35 30 25 20 15 10 5 0 5
LATERAL VISIBILITY -


LATERAL VISIBILITY - DEGREES
35 30 25 20 15 10 5 0 5 10 15 20 25 30 35 40 45 50 55 60
LEFT
RIGHT
ZERO
REFERENCE
CENTER
WINDSHIELD
CO-PILOT'S
WINDSHIELD
CO-PILOT'S
SIDE WINDOW
CAPTAIN'S
FRONT WINDSHIELD
DC-9
REFER


co-PILOT'S
SIDE WINDOW
co-PILOT'S
FRONT WINDSHIELD
CLEAR AREAS REPR
BINOCULAR VISIO
ER
SHIELD
ZERO
REFERENCE
D
E
sec
20 to 3 sec
LIGHT PATH
SHADED AREAS REPRESENT
MONOCULAR VISION ONLY
LEFT
RIGHT
35 30 25 20 15 10 5 0 5 10 15 20 25 30 35 40 45 50 55 60
LATERAL VISIBILITY - DEGREES



DC-9 VISIBILITY FROM CAPTAIN'S DESIGN EYE REFERENCE POINT



DC-9 VISIBILITY FROM FIRST OFFICER'S DESIGN EYE REFERENCE POINT

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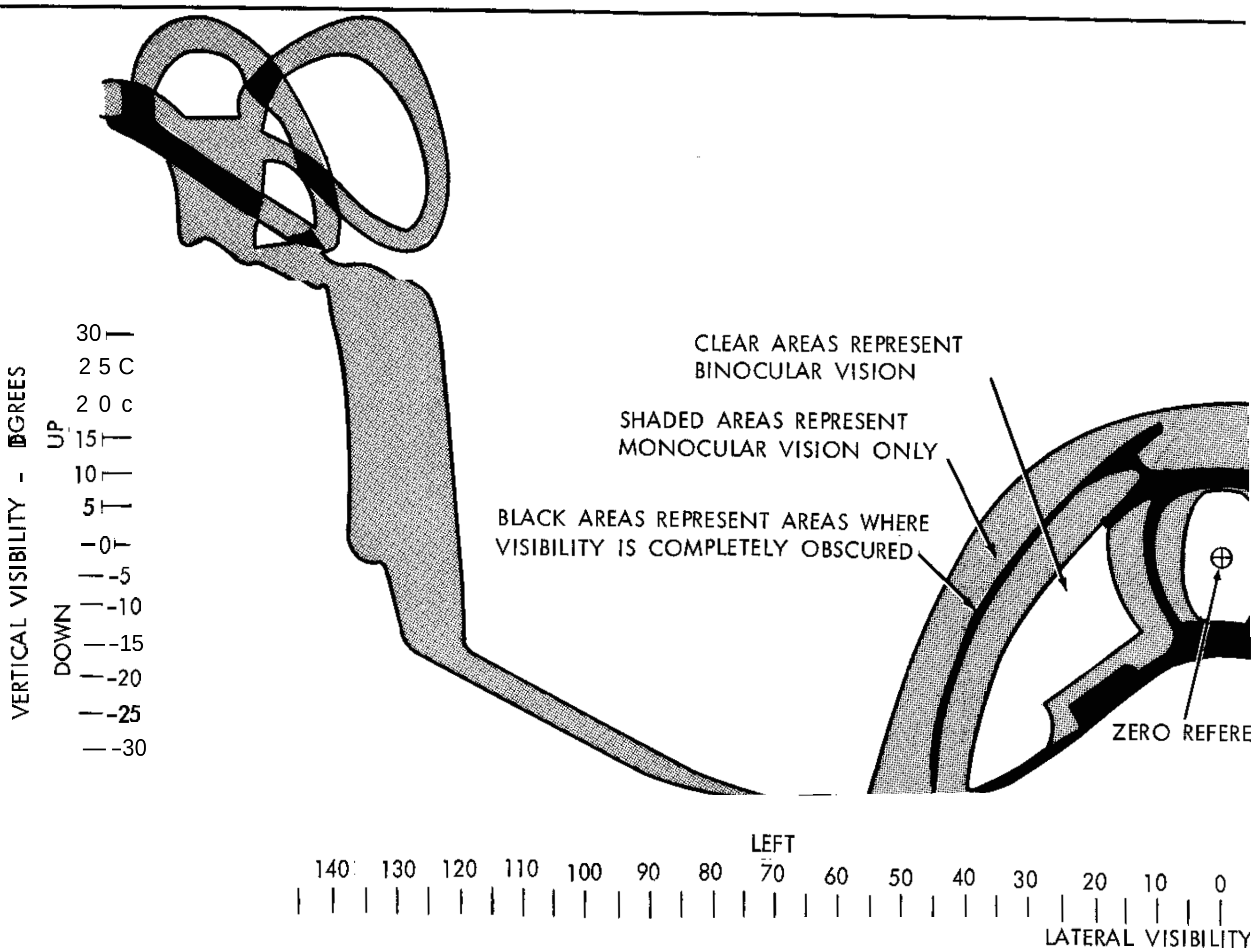
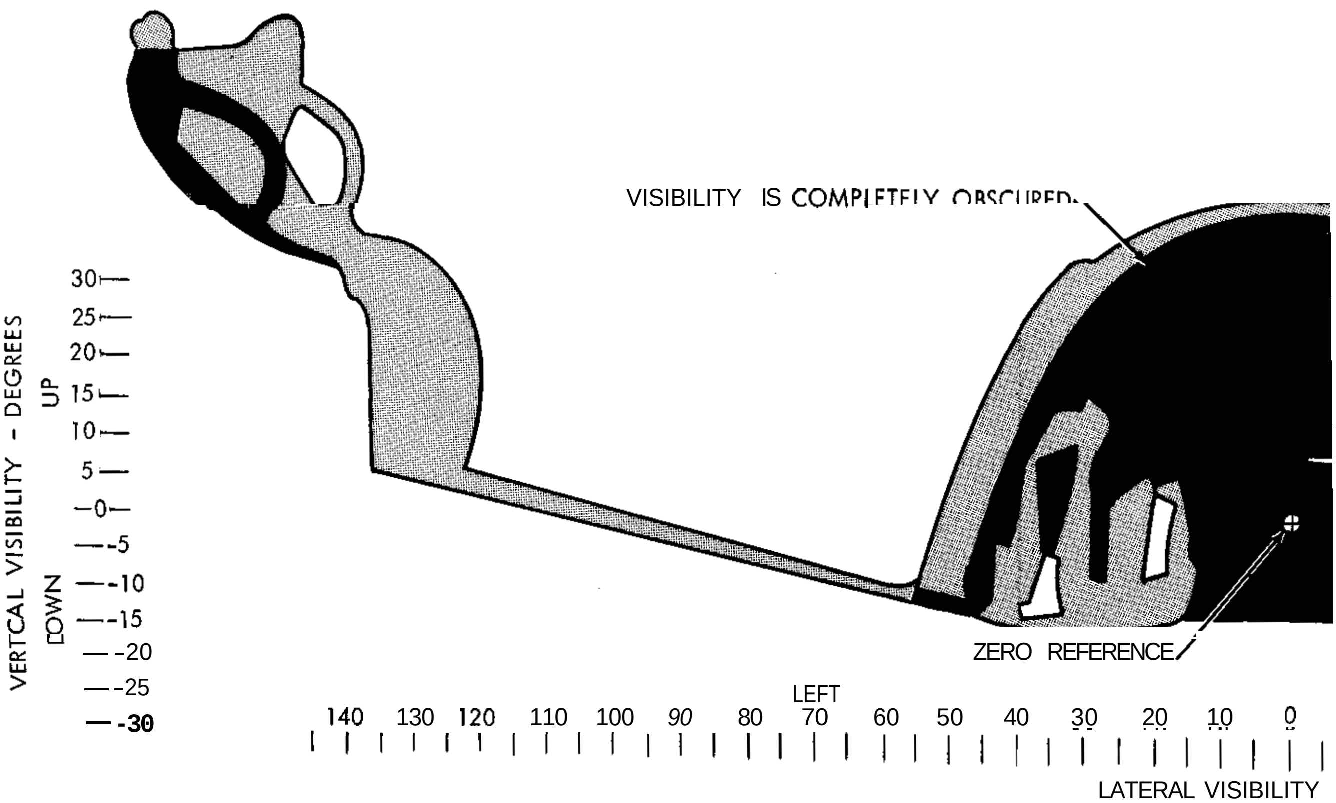
WASHINGTON D.C.

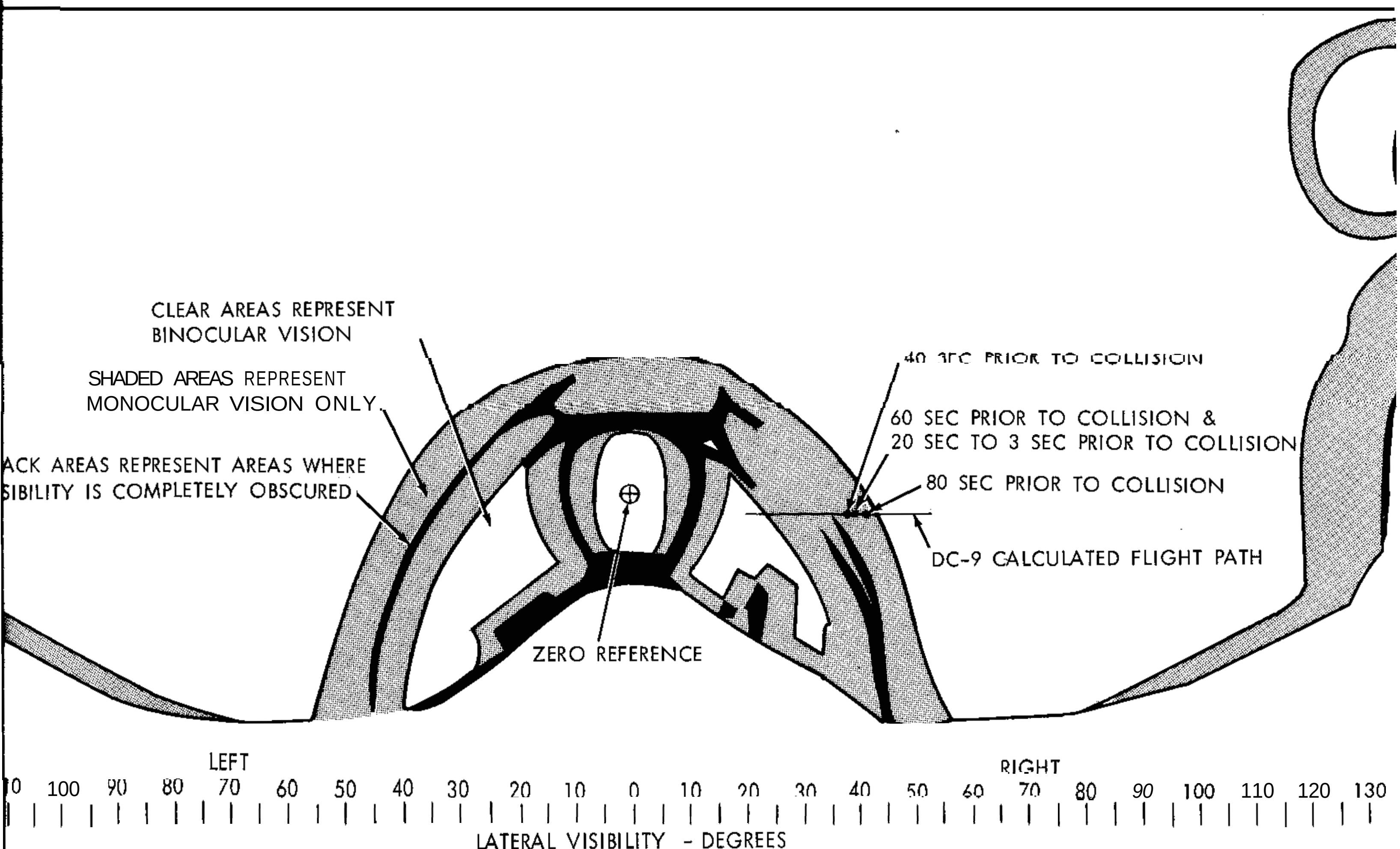
HUGHES AIR WEST DOUGLAS DC-9-31, N9345
U.S. MARINE CORPS F-4B, BUNO 151458
MIDAIR COLLISION
NEAR DUARTE. CALIFORNIA
JUNE 6, 1971

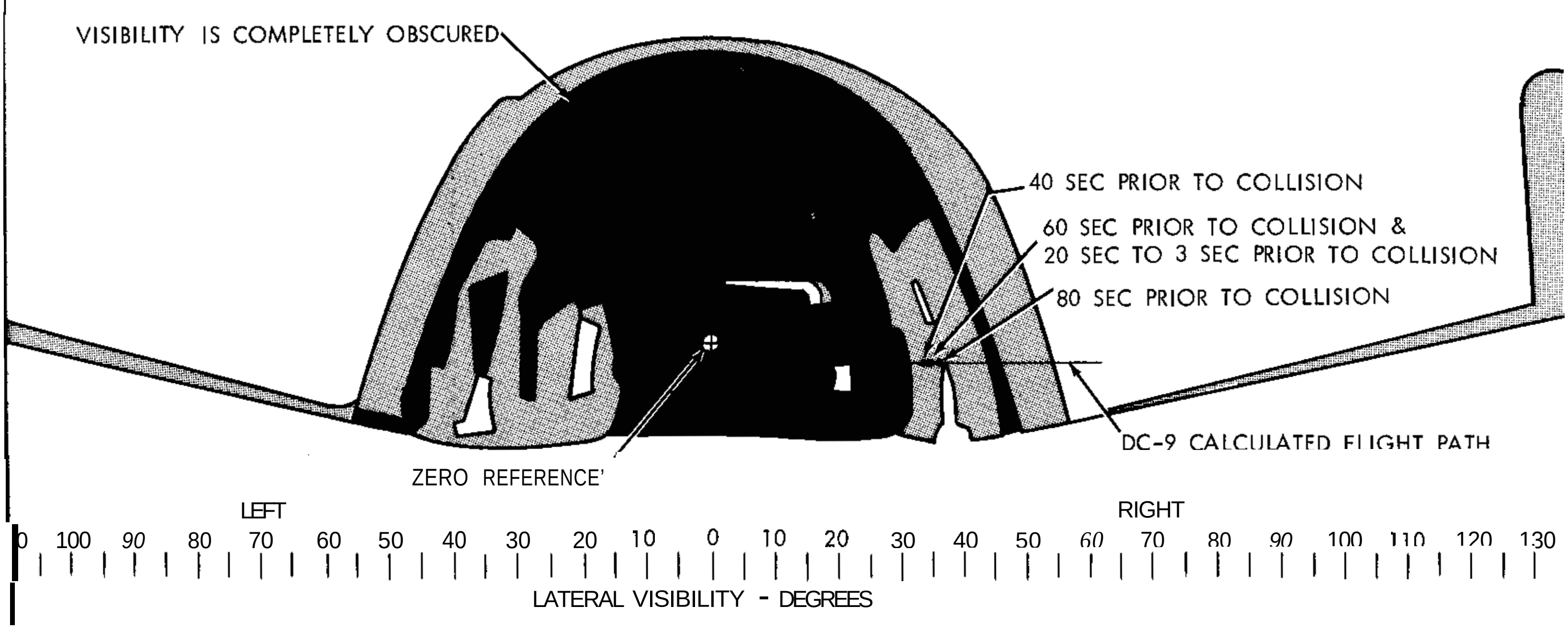


VERTICAL VISIBILITY - DEGREES
UP
DOWN
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
CLEAR AREAS REPRESENT BINOCULAR VISION
SHADED AREAS REPRESENT MONOCULAR VISION ONLY
BLACK AREAS REPRESENT AREAS WHERE VISIBILITY IS COMPLETELY OBSCURED
ZERO REFERE
LEFT
140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
LATERAL VISIBILITY

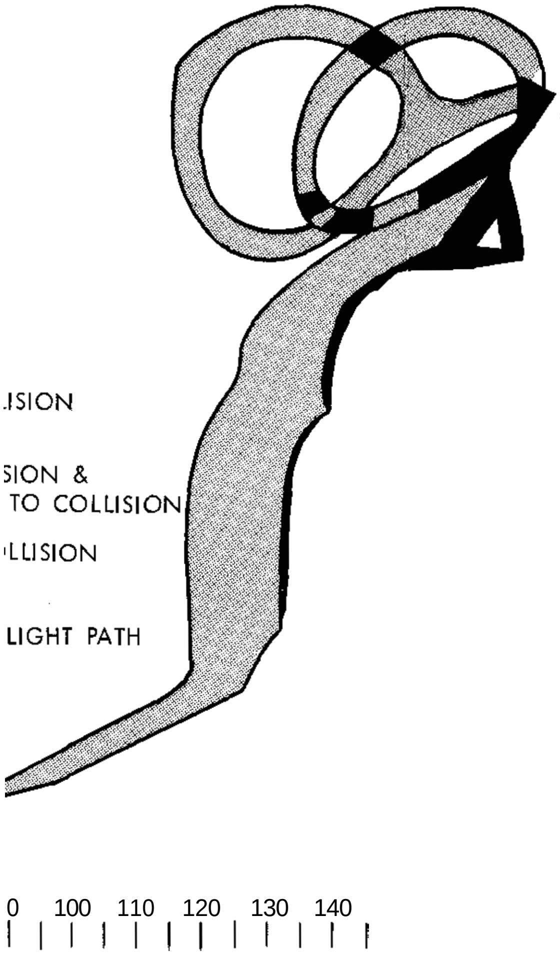


VERTICAL VISIBILITY - DEGREES
UP
DOWN
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
VISIBILITY IS COMPLETELY OBSCURED
ZERO REFERENCE
LEFT
140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
LATERAL VISIBILITY

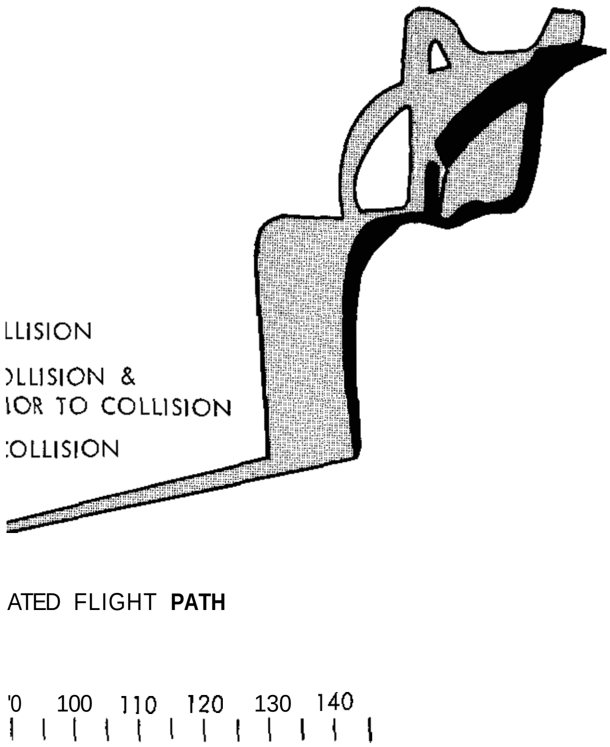

CLEAR AREAS REPRESENT BINOCULAR VISION
SHADED AREAS REPRESENT MONOCULAR VISION ONLY
ACK AREAS REPRESENT AREAS WHERE SIBILITY IS COMPLETELY OBSCURED
40 SEC PRIOR TO COLLISION
60 SEC PRIOR TO COLLISION & 20 SEC TO 3 SEC PRIOR TO COLLISION
80 SEC PRIOR TO COLLISION
DC-9 CALCULATED FLIGHT PATH
ZERO REFERENCE
LEFT
RIGHT
10 100 90 80 70 60 50 40 30 20 10 0 10 20 30 40 50 60 70 80 90 100 110 120 130
LATERAL VISIBILITY - DEGREES


VISIBILITY IS COMPLETELY OBSCURED
40 SEC PRIOR TO COLLISION
60 SEC PRIOR TO COLLISION & 20 SEC TO 3 SEC PRIOR TO COLLISION
80 SEC PRIOR TO COLLISION
DC-9 CALCULATED FLIGHT PATH
ZERO REFERENCE'
LEFT
RIGHT
0 100 90 80 70 60 50 40 30 20 10 0 10 20 30 40 50 60 70 80 90 100 110 120 130
LATERAL VISIBILITY - DEGREES

F-4B VISIBILITY FROM PILOT'S DESIGN EYE REFERENCE POINT



F-4B VISIBILITY FROM RIO'S DESIGN EYE REFERENCE, POINT



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HUGHES AR WEST DOUGLAS DC-9-31, N9345
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