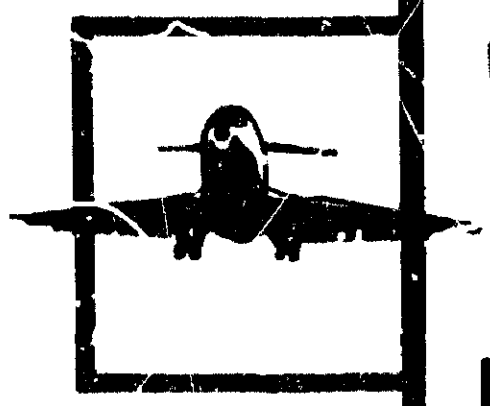
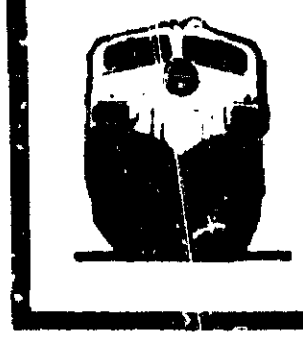
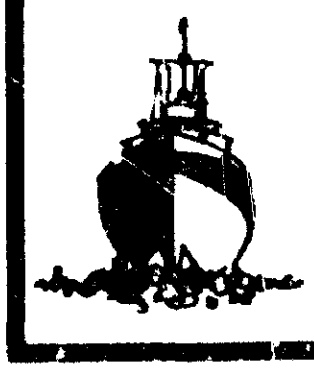
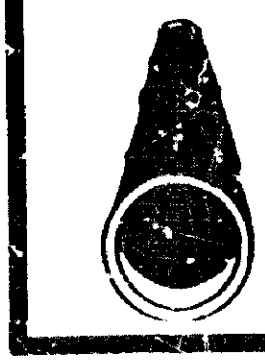
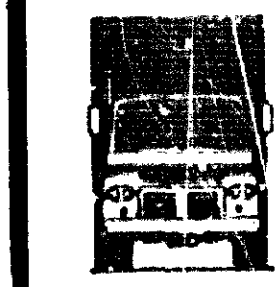
PB83-910403











NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

NORTH AMERICAN ROCKWELL AERO COMMANDER
MODEL 560E, N3827C
AND CESSNA 182Q, N96402
MIDAIR COLLISION
LIVINGSTON, NEW JERSEY
NOVEMBER 20, 1982

NTSB/AAR-83/03

UNITED STATES GOVERNMENT

TECHNICAL REPORT DOCUMENTATION PAGE

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15. Supplementary Notes

16. Abstract

About 1614 e.s.t., on November 20, 1982, a North American Rockwell Aero Commander Model 560E, N3827C, and a Cessna Model 182Q, N96402, collided in midair about 2,000 feet over Livingston, New Jersey, and crashed. The weather was clear at the collision altitude, and both airplanes were operating under visual flight rules. The accident occurred in the controlled airspace of the New York Terminal Control Area. Shortly before the collision, the pilot of N3827C had advised a New York Terminal Radar Approach Control controller of his location and altitude. There was no evidence that the pilot of N96402 had radio contact with an air traffic facility. The pilot and the passenger in N3827C were killed; the pilot of N96402, who was the airplane's only occupant, also was killed.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the pilots to exercise adequate vigilance to detect and avoid each other. The failure of the pilots may have been due to the limitations of human vision and the inherent difficulties of perceiving, recognizing, and effectively avoiding a collision. Contributing to the accident was the failure of the pilot of N96402 either to keep clear of the New York Terminal Control Area or to avail himself of the traffic advisory capability of the New York Terminal Radar Approach Control. Also contributing to the accident was the failure of the controller to observe the potential conflict and to adequately convey traffic information to N3827C.

17. Key Words midair collision; terminal control area; general aviation; IFR-VFR traffic mix; altimeter encoder; scanning techniques and procedures; visual detection		18. Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161	
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CONTENTS

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

Adopted: June 28, 1983

MIDAIR COLLISION OF
NORTH AMERICAN ROCKWELL AERO COMMANDER MODEL 560E, N3827C
AND CESSNA 182Q, N96402
LIVINGSTON, NEW JERSEY
NOVEMBER 20, 1982

SYNOPSIS

About 1614 e.s.t., on November 20, 1982, a North American Rockwell Aero Commander Model 560E, N3827C, and a Cessna Model 182Q, N96402, collided in midair about 2,000 feet over Livingston, New Jersey, and crashed. The weather was clear at the collision altitude, and both airplanes were operating under visual flight rules. The accident occurred in the controlled airspace of the New York Terminal Control Area. Shortly before the collision, the pilot of N3827C had advised a New York Terminal Radar Approach Control controller of his location and altitude. There was no evidence that the pilot of N96402 had radio contact with an air traffic facility. The pilot and the passenger in N3827C were killed; the pilot of N96402, who was the airplane's only occupant, also was killed.

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INVESTIGATION

History of the Flight

On the morning of November 20, 1982, the owner of N3827C, a white with blue trim North American Rockwell Aero Commander Model 560E, flew the airplane from Teterboro Airport, New Jersey, to Blairstown Airport, New Jersey, for minor maintenance at the airport repair station. The pilot was joined by a friend at the Blairstown Airport for the return flight to Teterboro. The airplane departed Blairstown about 1600, 1/ operating under visual flight rules (VFR). The pilot did not file a flight plan.

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

At 1608:47, N3827C (radio call "27 Charlie") contacted the Snapy arrival controller of the New York Terminal Radar Approach Control (TRACON), and the pilot requested a practice ILS (instrument landing system) approach to runway 6 at Teterboro Airport. (See figure 1 and appendix A.) When asked by the controller to identify his position in relation to a navigational fix, the pilot stated that he was about 7 miles southeast of the Sparta VOR (Very High Frequency Omnidirectional Range). After the pilot set the discrete code assigned by the controller in his transponder, the controller identified N3827C's location as 1 mile west of the Moree radio beacon. The controller advised the pilot that N3827C was in radar contact. The pilot was further advised of the current altimeter setting and was requested to fly a heading of 170 degrees. The pilot acknowledged the altimeter setting and the heading change. At 1611:37, N3827C's altitude, based on transmissions from the mode C encoder in its transponder, was shown on radar to be 1,900 feet. At 1612:02, the controller asked for the airplane's altitude and the pilot responded, "We are right now at two point oh [2,000 feet] sir." Because 2,000 feet was the lowest authorized altitude to the ILS localizer, the controller then transmitted, "Okay, maintain 2,000, numerous targets in your 12 o'clock position, one showing 1,000 feet, altitude unverified, the others altitude unknown." At 1612:17, N3827C replied, "Okay, roger sir, that's Caldwell Airport."

At the time of these transmissions, N96402, a white with red trim Cessna 182Q, was about 7 nautical miles away, at a point that would have been between the 1 to 2 o'clock positions in relation to the pilot's view from the cockpit of N3827C. N96402 had departed Kupper Airport, Manville, New Jersey, about 1600 for a flight to Ramapo Valley Airport near Spring Valley, New York. The airplane was equipped with a 4096-code transponder, which was in use and which caused N96402 to appear as a VFR radar target on air traffic control (ATC) equipment; however, because N96402 did not have mode-C altitude reporting equipment, the airplane's altitude was not shown on the radar. The pilot, who was unaccompanied, apparently intended to fly a direct course, VFR, between the airports. He did not file a flight plan, and there is no evidence that he made radio contact with any Federal Aviation Administration (FAA) facility during his flight. The airplane was equipped with a two-way radio capable of communicating with ATC facilities. When interviewed, the controller handling N3827C said that there were numerous targets in the area at that time, but that he could not recall the movements of the VFR targets, nor did he recall having seen the radar returns of any conflicting traffic. N96402's pilot had flown the direct course several times, and he had marked his intended route on a New York Area chart. His course line passed through the New York Terminal Control Area (TCA) and touched the perimeter boundary where the TCA floor lowers from 3,000 feet mean sea level (m.s.l.) to 1,800 feet m.s.l. (See figure 1.)

At 1612:33, the pilot of N3827C identified his airplane type to the controller. There were no more transmissions from N3827C. Starting at 1613:59, an emergency locator transmitter (ELT) sounded continuously in the New York TRACON until 1614:16.

Several ground witnesses saw N3827C and N96402 collide in midair about 1614. They stated unanimously that both airplanes appeared to be in level flight when first sighted, with N96402 slightly above N3827C, and that moments before colliding, N96402 banked steeply. The witnesses did not agree on the direction of N96402's attempted evasive maneuver. The point of collision was about 1 mile to the right of the course from Manville to Spring Valley that N96402's pilot had marked on his New York Area chart. The chart was found in the airplane wreckage.

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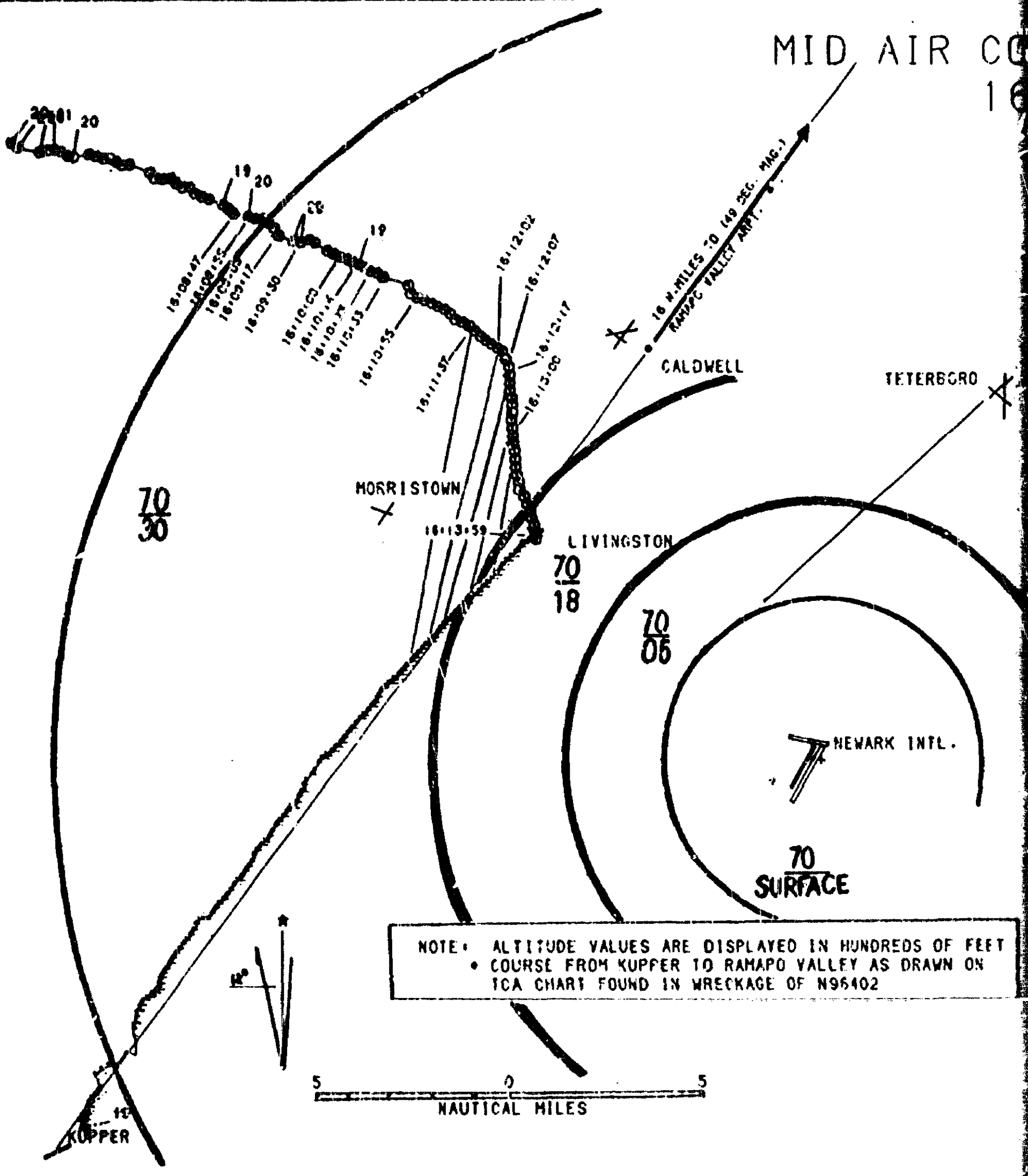
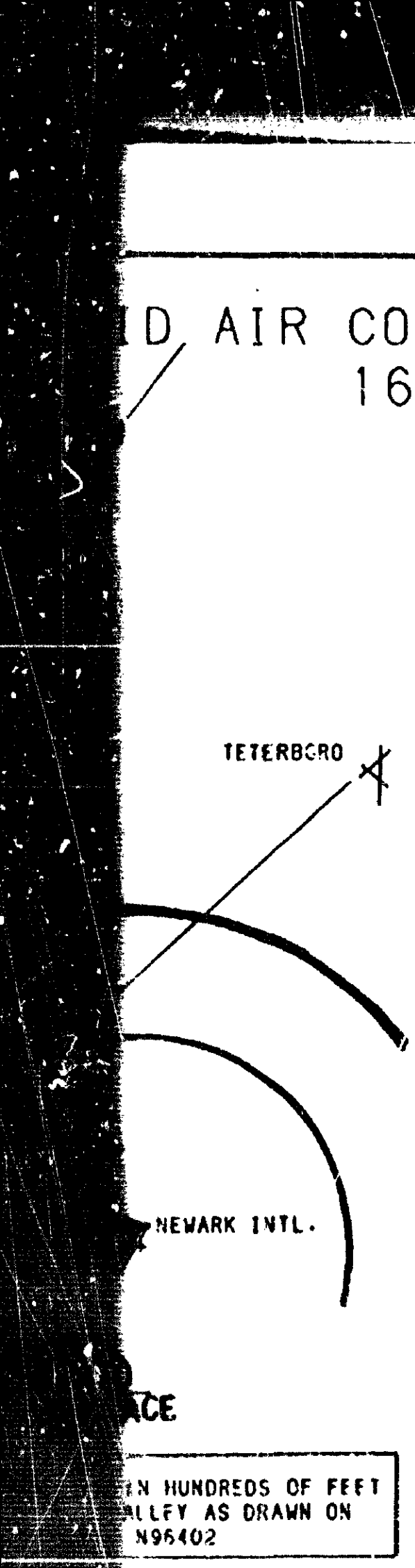

CALDWELL
TETERBORO
MORRISTOWN
LIVINGSTON
NEWARK INTL.
70
30
70
18
70
06
70
SURFACE
KUPPER
5
0
5
NAUTICAL MILES
NOTE: ALTITUDE VALUES ARE DISPLAYED IN HUNDREDS OF FEET
• COURSE FROM KUPPER TO RAMAPO VALLEY AS DRAWN ON
TCA CHART FOUND IN WRECKAGE OF N96402

ID AIR COLLISION AT LIVINGSTON N.J. 12-17-82
16:03:48.0-16:13:59.0

SELECTED EXCERPTS FROM ATC TRANSCRIPT
NEW YORK TRACON
- 0 -

LEGEND: SNAPY - ARRIVAL CONTROL
SNA OR - SNAPY OVER RIDE (INTREPHONE)
TWR OR - TOWER OVER RIDE (INTERPHONE)
N3627C - AERO COMMANDER N3627C



16:08:47	N3827C	NEW YORK CENTER THIS IS TWIN COMMANDER THSE
16:08:53	SHAPY	TWO SEVEN CHARLIE NEW YORK.
16:09:55	N3827C	YES SIR IF YOU'RE NOT TOO BUSY SIR OUR DESTI AND WE DO THAT ILS GOING INTO TETERBORO FULL
16:09:03	SNAPY	WELL IF YOU TELL ME YOUR POSITION WE MAY BE
16:09:06	N3827C	OKAY SIR WE'RE JUST ABOUT FIVE MILES AH NORT
16:09:17	SNAPY	AH TWO SEVEN CHARLIE CAN YOU GIVE ME YOUR PO
16:09:22	N3827C	OKAY I THIN THAT'S A NEGATIVE MY DME IS OUT WHERE WE'RE COMIN UP ON HOLD ON PLEASE.
16:09:30	SNAPY	OKAY.
16:10:01	N3837C	NEW YORK CENTER TWO SEVEN CHARLIE OVER.
16:10:04	SNAPY	TWO SEVEN CHARLIE GO AHEAD.
16:10:05	N3827C	YEAH WE'RE APPROXIMATELY SEVEN MILES SOUTH E
16:10:14	SNAPY	OKAY TWO SEVEN CHARLIE SQUAWK CODE FIVE ONE
16:10:20	N3827C	YOU WERE CUT OUT SIR SAY AGAIN.
16:10:23	SNAPY	OKAY ALRIGHT TWO SEVEN CHARLIE SQUAWK CODE F
16:10 33	N3827C	SQUAWKING FIVE ONE ZERO ONE.
16:10:55	SNAPY	TWO SEVEN CHARLIE COULD YOU SQUAWK IDENT NOW
16:10:58	N3827C	SQUAWK IDENT ROGER .. TWO SEVEN CHARLIE IDE
16:11:37	SNAPY	AND TWO SEVEN CHARLIE YOUR'RE RADAR CONTACT RADIO BEACON ELY HEADING OF ONE SEVEN ZERO V ALTIMETER THREE ZERO FIVE ZERO.
16:11:49	N3827C	THREE ZERO FIVE ZERO ALTIMETER HEADING ONE S
16:12:02	SNAPY	TWO SEVEN CHARLIE WHAT'S YOUR ALTITUDE.
16:12:04	N3827C	WE ARE RIGHT NOW AT TWO POINT OH SIR.
16:12:07	SNAPY	OKAY MAINTAIN TWO THOUSAND AH NUMEROUS TARG POSITION ONE SHOWING A THOUSAND FEET ALTITUD
16:12:17	N3827C	OKAY ROGER SIR THAT'S CALDWELL AIRPORT.
16:12:21	SNAPY	OKAY .. AND YOUR TYPE AIRCRAFT TWO SEVEN CH
16:12:25	N3827C	THAT'S LIGHT AIRCRAFT RIGHT SIR.
16:12:28	SNAPY	NO YOUR TYPE AIRCRAFT WHAT TYPE AIRCRAFT ARE
16:12:33	N3827C	I'M SORRY SIR WE'RE A FIVE SIXTY E TWIN AERO
16:12:35	SNAPY	OKAY.
16:13:00	SNP OR	TETERBORO NEWARK INBOUND.
16:13:03	TWR OR	TETERBORO.
16:13:05	SNP OR	OKAY I'VE GOT A VFR INBOUND (UNINTELLIGIBLE) BE A PRACTICE ILS.
16:13:14	TWR OR	OKAY THANK YOU.
16:13:59		BACKGROUND SOUNDS OF E.L.T. CONTINUOUS TILL

Figure 1.—Collision tracks and excerpts from ATC transcript.

STON N.J. 12-17-82
9.0

EXCERPTS FROM ATC TRANSCRIPT
NEW YORK TRACON
- 0 -

D: SNAPY - ARRIVAL CONTROL
SNA OR - SNAPY OVER RIDE (INTREPHONE)
TWR OR - TOWER OVER RIDE (INTERPHONE)
N3627C - AERO COMMANDER N3627C

⏻ N3827C
⚠ N96402

RK CENTER THIS IS TWIN COMMANDER THREE EIGHT TWO SEVEN CHARLIE OVER.
VEN CHARLIE NEW YORK.
R IF YOU'RE NOT TOO BUSY SIR OUR DESTINATION AIRPORT IS TETERBORO
DO THAT ILS GOING INTO TETERBORO FULL STOP.
F YOU TELL ME YOUR POSITION WE MAY BE ABLE TO WORK IT OUT.
SIR WE'RE JUST ABOUT FIVE MILES AH NORTHEAST OF LAKE HOGATOCONG.
SEVEN CHARLIE CAN YOU GIVE ME YOUR POSITION IN RELATION TO A VOR IN THE AREA.
THIN THAT'S A NEGATIVE MY DME IS OUT RIGHT NOW LET ME JUST SEE
WE'RE COMIN UP ON HOLD ON PLEASE.

ORK CENTER TWO SEVEN CHARLIE OVER.
VEN CHARLIE GO AHEAD.
WE'RE APPROXIMATELY SEVEN MILES SOUTH EAST OF SPARTA VOR SIR.
TWO SEVEN CHARLIE SQUAWK CODE FIVE ONE ZERO ONE AND IDENT.
ERE CUT OUT SIR SAY AGAIN.
ALRIGHT TWO SEVEN CHARLIE SQUAWK CODE FIVE ONE ZERO ONE FOR IDENTIFICATION.
KING FIVE ONE ZERO ONE.
VEN CHARLIE COULD YOU SQUAWK IDENT NOW.
K IDENT ROGER .. TWO SEVEN CHARLIE IDENT.
WO SEVEN CHARLIE YOUR'E RADAR CONTACT ONE MILE WEST OF THE MOREE
BEACON FLY HEADING OF ONE SEVEN ZERO VECTORS PRACTICE ILS SIX
ETER THREE ZERO FIVE ZERO.
ZERO FIVE ZERO ALTIMETER HEADING ONE SEVEN ZERO ROGER.
EVEN CHARLIE WHAT'S YOUR ALTITUDE.
E RIGHT NOW AT TWO POINT OH SIR.
MAINTAIN TWO THOUSAND AH NUMEROUS TARGETS IN YOUR TWELVE O'CLOCK
ICH ONE SHOWING A THOUSAND FEET ALTITUDE UNVERIFIED THE OTHERS ALTITUDE UNKNOWN.
ROGER SIR THAT'S CALDWELL AIRPORT.
.. AND YOUR TYPE AIRCRAFT TWO SEVEN CHARLIE.
S LIGHT AIRCRAFT RIGHT SIR.
UR TYPE AIRCRAFT WHAT TYPE AIRCRAFT ARE YOU FLYING.
ORRY SIR WE'RE A FIVE SIXTY E TWIN AERO COMMANDER.

BORO NEWARK INBOUND.
BORO.
I'VE GOT A VFR INBOUND (UNINTELLIGIBLE) HE'S A COMMANDER HE'LL
PRACTICE ILS.
THANK YOU.
ROUND SOUNDS OF F.A.A. CONTINUOUS TILL 2114:06.

ATC transcript.

Both airplanes crashed in a residential area. The occupants of the airplanes were killed. No one on the ground was injured or killed, and there was no substantial ground property damage. The accident site coordinates were estimated to be 40°47'9" N and 74°19'50" W, about 15 miles southwest of Teterboro Airport.

Meteorological Information

At the time and point of collision, the weather was clear. The reported weather at Teterboro Airport at 1550 was:

> ceiling--estimated 4,000 feet broken, 20,000 feet overcast; visibility--11 miles; weather—none; temperature--51° F; dew point--45° F; wind—030 degrees at 4 knots; altimeter--30.54 inches; remarks—breaks in overcast.

The reported weather at nearby Newark Airport was similar; however, at 1650, Newark also reported a 2,500-foot scattered cloud layer. Low altitude winds over the area were easterly at 9 to 15 knots. Pilot reports throughout the afternoon indicated that light to moderate turbulence existed at 2,000 to 4,500 feet over the northwestern New Jersey area. At 1613, near Teterboro Airport, the sun was about 12 degrees above the horizon, at an azimuth of 213 degrees.

Wreckage and Impact Information

The airplanes impacted the ground about 1,500 feet apart in the Township of Livingston, New Jersey. Debris from N96402's engine cowl assembly and from N3827C's empennage was scattered between the main wreckage sites. Before impacting the ground, both airplanes had struck trees adjacent to occupied houses.

The right wing of N96402 was extensively battered, and the left wing was consumed by fire. With the exception of damage to the engine and cowl assembly, no obvious midair collision damage was found. The lower skin of the nose cap assembly and the left cowl flap also had blue paint marks which matched the blue-painted surfaces of N3827C.

N3827C impacted the ground in an inverted position. There was no fire damage. The fuselage was relatively intact, except for the empennage section which had separated from the fuselage. The right side of the fuselage in the separation area had red paint marks which were similar to the red-painted surfaces of N96402. Several pieces of the empennage were found in the area beneath the collision point. The vertical fin was found battered and torn. The left stabilizer, which had separated at the base, contained cuts which were representative of propeller slashes. One cut consisted of a longitudinal slice that cut through the entire length of the stabilizer at an angle of 35 degrees to the airplane's centerline. The slice continued about 2 inches into the upper leading edge of the left elevator. The left elevator had separated from the stabilizer at the hinge and torque tube attachment point.

Both altimeters in N3827C were set at 30.50 inches Hg, which was the setting given to the pilot by the controller. The altimeter in N96402 was damaged and unreadable.

The ELT from N96402 was recovered from the wreckage; it had been burned. The ELT from N3827C was not found.

Personnel Information

N3827C's pilot held commercial pilot certificate No. 151261073 issued on July 6, 1982. He also held airplane multiengine land and instrument ratings, with airplane single-engine land, private privileges only. He had accumulated about 730 hours, 150 hours of which had been flown in the 6-month period before his last medical examination. He had 77 hours of instrument flight time. His second-class medical certificate was issued on May 19, 1982. The certificate contained the limitation that the "Holder shall wear correcting glasses for near and distant vision while exercising the privileges of his airman certificate." The investigation did not reveal if the pilot was wearing glasses when the airplanes collided.

N96402's pilot held private pilot certificate No. 51306429, issued January 4, 1981. He was rated for airplane single-engine land. His third-class medical certificate was issued May 20, 1983, without waiver or limitations. On that date, he stated that his total flying time was about 200 hours and that he had flown 50 hours in the past 6 months. The pilot's logbook, which was found in the wreckage, indicated that on November 14, 1982, he had a total of 248 hours.

The controller handling N3827C was hired by the FAA in August 1981 and completed training at the FAA Academy in January 1982. By July 1982, he had checked out on three radar positions in the New York TRACON as a full performance level (FPL) controller. His most recent medical certificate was issued in March 1982.

Medical and Pathological Information

Postmortem examinations of the pilots disclosed no evidence of factors which would have detracted from their ability to operate their airplanes. Examination also disclosed that the airplane occupants died as a result of trauma from the impact.

Air Traffic Control Procedures

Basic ATC procedures as applied to the national airspace system are set forth in Air Traffic Control Handbook 7110.65C, an FAA publication. The handbook states that the primary purpose of the ATC system is to prevent a collision between IFR airplanes operating in the system and to organize and expedite the flow of traffic. In addition to the primary ATC function to IFR users of the system, there is a capability, with certain limitations, to provide additional services. The provision of additional services, such as radar traffic advisories, is not optional on the part of the controller, but rather is required when the work situation permits. In the subject accident, the controller stated that his workload was light during the time he was in communication with N3827C.

A Terminal Control Area (TCA) consists of controlled airspace, extending upward from the surface or higher to specified altitudes, within which all aircraft are subject to the operating rules and equipment requirements of Title 14 of the Code of Federal Regulations (CFR), Part 91. The geometric design of a TCA is referred to as "an upside-down wedding cake" because the ceiling or upper limit of the TCA is normally uniform and the floor of the controlled airspace is at a higher altitude in increments from the center of the TCA, with the base layer at the center of the TCA being the smallest in diameter. (See figure 1.) Within the TCA, aircraft are provided with positive separation by the controlling ATC facility. Each TCA location is designated as either a Group I or a

Group II TCA and includes at least one primary airport around which the TCA is located. In the New York TCA, the three major airports--John F. Kennedy International Airport, La Guardia Airport, and Newark Airport--serve as the multiple centers of a common Group I TCA. The Livingston crash site is located within the portion of the New York TCA at a point where the TCA ceiling is 7,000 feet m.s.l. and the floor is 1,800 feet m.s.l.

The "Airman's Information Manual (AIM), Basic Flight Information and ATC Procedures," an FAA publication, provides information to pilots regarding TCA's. Chapter 3, section 3, paragraph 97a of the AIM states that, regardless of weather conditions, ATC authorization is required before a pilot may operate within a TCA, and pilots should not request such authorization unless their airplane is equipped with a two-way radio capable of communicating with ATC, a navigation receiver, and a 4096-code transponder with mode-C automatic altitude reporting equipment that replies to interrogations by transmitting pressure altitude information in 100-foot increments. Under the provision of 14 CFR Section 91.24(c)(2), ATC may authorize deviation from the requirement of an operating automatic pressure altitude reporting capability if the transponder is operating.

Chapter 3, section 3, paragraph 97b(2)(d) of the AIM states that:

> VFR non-TCA aircraft are cautioned against operating too closely to TCA boundaries, especially where the floor of the TCA is 3,000 feet or less or where normal VFR cruise altitudes are at or near the floor of higher levels. Observance of this precaution will reduce the potential for encountering a TCA aircraft operating at TCA floor altitudes.

While operating in a TCA, pilots of VFR airplanes are provided radar service, which includes separation from all aircraft operating within the TCA. However, as stated in Chapter 4, section 1, paragraph 165d of the AIM, this service does not relieve the pilot of his responsibility to see and avoid other aircraft.

The right-of-way rules of 14 CFR Section 91.67 state that when weather conditions permit, regardless of whether an operation is conducted IFR or VFR, each person operating an aircraft must maintain vigilance so as to see and avoid other aircraft. When a rule of 14 CFR Section 91.67 gives an aircraft the right of way, the pilot of another aircraft must give way to that aircraft and may not pass over, under, or ahead of it unless well clear.

Chapter 4, section 9, paragraph 406b of the AIM advises that controllers will issue an Aircraft Conflict Advisory immediately to aircraft under their control if they are aware of an aircraft not under their control that is at an altitude believed to place the aircraft in unsafe proximity to each other. Paragraph 406a warns pilots that this radar service is not a substitute for pilot adherence to safe operating practices, because the pilots must be aware that safety advisories are not always available and that many factors affect the ability of the controller to be aware of a situation in which unsafe proximity to another aircraft is developing.

The Flight Information Publication Policy contained in the preface to the AIM states that:

> It is a pilot's inherent responsibility that he be alert at all times for and in anticipation of all circumstances, situations and conditions which affect the safe operation of his aircraft. For example, a pilot should expect to find traffic at any time or place.

Chapter 4, section 9, paragraph 407a(1) of the AIM states that:

> When meteorological conditions permit, regardless of type of flight plan, whether or not under control of a radar facility, the pilot is responsible to see and avoid other traffic, terrain or obstacles.

Chapter 7, section 1, paragraph 605c of the AIM discusses scanning techniques, and Advisory Circular 90-48C, "Pilot's Role in Collision Avoidance," discusses psychophysiological factors affecting pilot vision.

Tests and Research

Probable Ground Tracks.—The probable ground tracks of the accident airplanes were reconstructed using the recorded radar data from the New York TRACON. (See figure 1.) The radar data were provided from an ARTS III system and contained beacon code radar returns in range and azimuth for all 1200 and 5101 coded targets. 2/ The data covered a time period of 19 minutes from 15:55 to 16:14. The range and azimuth values were measured in relation to the antenna site located at Newark International Airport. The geographical area covered by the data was from 210 to 330 degrees (magnetic) in azimuth and 0 to 30 miles in range. Radar returns at this facility are recorded approximately every 4.7 seconds.

The radar ground tracks showed that at 1608:47, when N3827C initially contacted the New York TRACON, the airplane was flying on a southeasterly heading at an altitude of 2,000 feet. About 1 minute later, the mode-C altitude encoder indicated that the airplane was maintaining 1,900 feet. Thereafter, N3827C's recorded altitude varied between 1,900 feet and 2,000 feet until 1611:39, more than 2 minutes before the collision, and no further altitude information was received. At 1612:04, the pilot told the controller that N3827C was ". . . right now at two point oh [2,000 feet] sir"; the radar data indicated 25 seconds earlier at 1611:37 that the airplane was at 1,900 feet. At the point of collision, N3827C was flying a course of about 180 degrees magnetic.

The radar returns of N96402 showed that the airplane maintained a northeasterly heading from the point of takeoff until the point of collision. The ground track was slightly west of the charted course marked on the pilot's chart until 1612:02, when the ground track crossed the charted track and continued slightly to the east. At the time of collision, the airplane was making good a track of about 62 degrees magnetic.

The radar beacon code for N96402 was identified by correlating it to N3827C's radar data and Kupper Airport, N96402's point of departure. The en route altitudes of N96402 were assumed because the airplane was not equipped with an altitude encoder device.

2/ Code 1200 is the common VFR transponder identifier, related to N96402, and code 5101 was the discrete code assigned to N3827C.

Cockpit Visibility Study.--A study was conducted to determine the physical limitations of visibility from the pilot seats of the two accident airplanes. The time histories of the airplanes' flight paths and airplane flight attitudes were used to calculate relative target locations, i.e., azimuth and elevation angles. These target locations were plotted on the composite of the binocular photographs shown in appendix B. (The binocular camera simulates the human eye and rotates about a vertical axis which represents the pivotal point about which the head rotates on the spinal column. The resulting photographs show the outline of cockpit windows as seen by each pilot and depict the target airplane as a series of points.) The shaded gray areas within the windows outline those areas of the window that are exposed only to monocular vision of the pilot. The data on the photographs in appendix B were produced by using specific eye reference points, ATC "smoothed" flight path radar data, and computed airplane attitudes. Because the maneuverability of both airplanes would have permitted short-term excursions about all three axes which could have gone undetected by the radar data, the information produced from the data is not precise.

About 75 seconds before the collision, the airplanes were separated by a distance of 5.7 statute miles (29,960 feet). The closure rate during this period was about 400 feet per second, or a speed of 236 knots. To N3827C's pilot, N96402 was at an azimuth of about 16 degrees right of the pilot's zero eye reference with little elevation. To N96402's pilot, N3827C remained at an azimuth of about 36 degrees left of the pilot's zero eye reference and about 5 degrees below his eye reference. As indicated by the binocular photographs, each airplane entered the monocular vision envelope of the other airplane's pilot about 45 seconds before the collision. From about 45 seconds before the collision until about 15 seconds before the collision, N3827C was obscured partially from the view of N96402's pilot by the left windshield post of N96402. From about 30 seconds before the collision until 15 seconds before the collision, N96402 was blocked from the view of N3827C's pilot by the windshield centerpost of N3827C. About 15 seconds before the collision, when the airplanes were separated by about 1.2 statute mile (5,435 feet), N3827C entered the binocular vision envelope of N96402's pilot, while N96402 would have remained within the monocular vision of N3827C's pilot. During the 107 seconds before the collision, while the distance between the aircraft closed from a range of about 7.76 statute miles (41,000 feet), the passenger of N3827C had the image of N96402 near his zero eye reference.

The target size of each airplane, expressed as a visual angle and related to slant range and time prior to collision, was computed as viewed by the pilots. From each pilot's vantage point, the visual angle (VA) of each airplane's foreshortened length (VAF) and width, i.e., wing span (VAW), were calculated for the last seven points depicted on the binocular photographs. The pitch, roll, and yaw attitudes of the airplanes were taken into account. (See appendix B.)

ANALYSIS

The pilots of both airplanes were properly qualified to operate their respective airplanes, and the air traffic controller was fully qualified to perform his duties. There was no evidence that before the collision there were any mechanical problems, system malfunctions, or communication difficulties involving either airplane.

The prevailing weather conditions in the collision area would not have interfered with the pilots' seeing each other. The pilots of both airplanes were required by regulation to "see and avoid" each other.

The pilot of N3827C had advised the TRACON controller that he was maintaining 2,000 feet, although 25 seconds before his advisory the altitude encoder signal was indicating an altitude of 1,900 feet at the New York TRACON. The Safety Board places no significance in the difference between the reported altitude and the received altitude. The airplane may have been at an altitude of slightly less than 1,950 feet, which would have caused the encoder to transmit 1,900 feet, or the difference could be attributed to the sea level barometeric corrections (QNH) applied to the pilot's altimeter and the ground-based altitude decoding equipment.

The pilot of N96402 was operating under VFR throughout the flight. There was no evidence that he had been in radio contact with any flight service station or tower facility along his route of flight. However, his airplane's transponder was transmitting the VFR identifier code, which could have identified his airplane as VFR traffic on radar. The controller said that there were numerous radar targets in the area, but that he could not recall the movements of any of the VFR targets. Although the target of N96402 would have been on the display, the controller apparently never recognized or perceived it as potential traffic for the aircraft that he was working.

N96402's track, as plotted on the pilot's New York Area chart, touched the TCA boundary where the 3,000-foot floor level lowers to 1,800 feet. The proximity of the pilot's marked route to the TCA boundary provided no margin for dead reckoning navigational error to ensure that the airplane would remain outside of the TCA airspace, unless the pilot flew through the area at an altitude well below 1,800 feet. The point of collision was about 1 mile east of the plotted course. The Safety Board believes that N96402 was operating too closely to the TCA airspace, especially considering the fact that the pilot elected not to communicate with the facility having jurisdiction over that airspace. The periphery of a TCA should be viewed with great caution as it is here that there is the greatest likelihood of intermingling of controlled and uncontrolled traffic.

At 1611:42, N3827C was issued a heading of 170 degrees. The turn was completed at some point between the 1612:07 radar "hit" and the 1612:12 radar hit. At 1612:07, the controller transmitted "okay maintain two thousand ah numerous targets in your twelve o'clock position one showing a thousand feet altitude unverified the other altitudes unknown." N3827C's pilot then transmitted "okay roger sir that's Caldwell Airport." At this point, Caldwell Airport would have been in N3827C's 9 o'clock or 10 o'clock positions, not the 12 o'clock position. The Safety Board believes that the pilot was not looking at the traffic called by the controller. This circumstance should have been recognized by the controller, and he should have clarified the position of the 12 o'clock traffic to the pilot. These targets were not evidenced on the ATC radar data recorder during the period, possibly because they were not transponder equipped. N96402 would have been between the 1 o'clock and 2 o'clock positions, at a range of about 7 miles. The Safety Board could not determine whether it was among the targets perceived by the controller. After N3827C completed its southerly turn and was established on a collision course with N96402, the controller did not identify the N96402 target as conflicting traffic to N3827C's pilot and, therefore, did not issue a further radar traffic advisory. The Safety Board notes that the recorded ATC radar data provide evidence that the target of N96402 was present on the controller's display. The Board believes that the controller could have and should have observed the potential conflict and issued an appropriate advisory. Since the controller states that he was continuously monitoring the radarscope, the Board cannot determine the reason the controller did not recognize the potential conflict along the edge of the TCA. The Board concluded that the collision potential was evident before either airplane crossed the horizontal TCA boundary.

Although there was no definitive evidence to confirm the collision altitude, there were several circumstances relating to the altitude question. The New York TRACON received the last encoded transponder altitude of N3827C at 1611:39, 2 minutes 20 seconds before the collision. At 1612:04, 1 minute 55 seconds before the collision, the pilot of N3827C told the controller that he was at 2,000 feet, and the controller then told the pilot to maintain that altitude, and, in the same transmission, called traffic. The pilot acknowledged by saying, "okay roger sir, that's Caldwell Airport." Because the pilot did not verbally repeat the altitude, it is not known if he received that part of the controller's transmission. However, the pilot's reply may have been a single statement, which responded only to the traffic advisory, or his statement may have been in two parts: (1) "Okay roger, sir, . . .", which could have been an acknowledgement of the altitude clearance and (2) ". . . that's Caldwell airport", which could have been in response to the advisory of the numerous targets at the pilot's 12 o'clock position. Normally, an instrument-rated pilot could be expected to maintain the last assigned altitude until directed by the controller to descend. In this case, the controller would not have descended the airplane farther until the airplane was established inbound on the ILS localizer and was past the Dandy Intersection. The pilot had this information on an instrument approach chart in his possession. At the time of the collision, N3827C had not reached the descent points. Thus, as the preponderence of evidence supports the conclusion that the collision occurred in the controlled airspace of the TCA, the Safety Board determines that the accident occurred within the boundaries of the TCA at an altitude of about 3,000 feet.

The collision damage to N3827C was consistent with witness accounts that the front of N96402 collided with the side of N3827C's rear fuselage and sheared off the latter's empennage. Paint transfer marks and inward crush damage on N3827C indicated that it was hit from the right (see appendix C). Propeller slicing across the rear fuselage and the left stabilizer of N3827C revealed that N96402's engine went across N3827C's tail section at a 55-degree angle. Based upon the ATC radar tracking data, the relative approach angle was 120 degrees, and the 55-degree propeller marks indicate that N96402's heading was turned significantly to the right when it struck N3827C's fuselage. This direction change is believed to have been due to the evasive maneuver by N96402's pilot and the slewing of N96402 after an initial collision between the right wings of the airplanes.

In view of the favorable weather conditions and the angles of approach, the Safety Board could not determine why both pilots did not see each other. The Board recognizes that although both pilots may have been scanning regularly for other traffic, they may have been distracted at a critical time by chart reading or cockpit functions that interrupted their outside scan pattern. Additionally, the pilot of N3827C may have been overconfident that the TRACON controller was protecting his airspace because his airplane had been radar identified, his altitude had been acknowledged, and he was flying in positive controlled airspace. Although the position of the sun at the time of the accident was low on the horizon and slightly to the right of the track of N3827C, the Safety Board believes that because of the high overcast, the glare of the sun would not have reduced the visual range normally available to the occupants of N3827C. The sun would have been behind the pilot of N96402, and it would not have affected his ability to see.

There was a very limited period of time (107 seconds) for target detection. Assuming that the pilots were devoting a reasonable amount of time to scanning, their failure to "see and avoid" may have resulted from the difficulties of target detection and recognition.

The physiology and performance of the eyes of a pilot involved in any in-flight aircraft collision are as significant as the physical evidence in explaining why targets go undetected. The limitations of the human visual system influence a pilot's ability to detect a target and explain why targets go undetected even though they appear in the pilot's area of vision. The limitations that could have applied to both pilots in this accident include visual acuity, conspicuity, target detection, target size, motion sensitivity, empty field myopia, and blind spot.

- o Visual acuity. Minimum visual acuity is defined as the smallest detail that the human eye is capable of resolving at a specified distance. It is influenced by the rate of motion, viewing time, and target travel distance.

The relative size and viewing angles involved in this accident are illustrated in the binocular photographs in appendix B. It should be noted that the binocular photographs produced for this accident used specific eye references, "smoothed" airplane flight paths, assumed altitudes, and computed airplane attitudes and were not derived from precise data. Therefore, some uncertainty is involved. The composite of binocular photographs presented in appendix B is only a baseline for a discussion of visibility factors in this accident.

- o Conspicuity. With reductions in contrast, conspicuity of a target decreases. The contrast of an airplane against its background is a function of the reflectance of the airplane surface, the location of the sun, and atmospheric lighting.

In this accident, the contrast of the airplanes would have been good enough for each pilot to see the other airplane during the times the other pilot's airplane was in the vision envelope of the viewing pilot. The predominantly white airplanes would have been visible against the homogeneous background of the overcast sky.

- o Target Detection. Any airplane structure in a pilot's vision envelope acts as a powerful "accommodation trap," and traffic appearing along a line of sight close to a window post may be virtually invisible to the pilot. 3/

In this accident, during intervals several seconds before collision, both pilots were limited to monocular vision caused by the windshield framing, which minimized the ability of the pilots to detect the other traffic.

- o Target Size. Target detection is directly related to target size when recognition of its location, its luminance contrast, its shape, and amount of background clutter are constant. The human eye can detect targets as small as .02° (1 min) of arc under static conditions with 100 percent contrast. Target size must be considered as a factor in any in-flight collision accident.

3/ Roscoe, S. N., Aviation Psychology, The Iowa State University Press, 1980; "What You See Is Not Always What You Get," Dr. R. A. Akov, Approach Magazine, U.S. Navy, February 1983.

The visual angles of the subject airplanes would have caused the airplanes to be relatively small targets along the collision tracks, and at Point 1 and Point 2 of the binocular photographs (see appendix B), the opposing targets were in the monocular vision of both pilots. The cockpit visibility study indicated that during the 45-second period before the collision, the detection of N96402 was restricted by the windshield centerpost in the vision envelope of N3827C's pilot, and that during the 15-second period before the collision, the image of N3827C was unrestricted in the forward vision envelope of the pilot of N96402; however, in the prior 30-second period, N3827C was in only the monocular vision of N96402's pilot. During the last 30 to 45 seconds before collision, neither pilot had a totally unobstructed view of the other airplane, at least until the target size filled the windshield at some time between 15 seconds and collision. During the 107 seconds before the collision, the passenger in N3827C had the image of N96402 in full view near his zero eye reference.

It is significant that the N96402 target remained near the zero eye reference of N3827C's passenger during the time that N96402 was within normal visual range. If the passenger had been looking for other airplanes, either on his own or by direction of the pilot, he might have seen N96402 in time to avert the collision. It is also noteworthy that by leaning forward to look around the windshield posts, both pilots would have increased their opportunity to see the other airplane in their full vision envelope.

- o Motion Sensitivity. Peripheral vision, although lacking the necessary acuity to recognize or identify objects, does have motion sensitivity. Thus, the eye will sense the peripheral motion and fixate on the target by the required eye and head movements so that the target is viewed foveally.

In this case, the binocular photographs (see appendix B) indicate that relative motion of the accident airplanes was not significant and both targets remained relatively stationary in the vision envelopes of the pilots during the last 60 seconds before the collision.

- o Empty Field Myopia. This phenomenon can occur when a pilot searches a homogeneous field, such as when flying during a hazy overcast day, over water or snow, at night, or at high altitudes. During this phenomenon, the eyes tend to relax their focus to a resting accommodation distance within the cockpit.

This type of myopia may have occurred in this accident as both targets would have been viewed against the homogeneous overcast sky.

- o Blind Spot. A defect of the human eye is located where the optic nerve attaches to the retina. This defect is normally compensated for as one eye can see objects in the blind spot of the other. However, a problem arises when viewing targets near obstructions at angles of 45 degrees or more without head movement. The only way to alleviate the problem is for the observer to turn his head so that his field of vision is always within 45 degrees of center.

If at times, as in this accident, a pilot's sight was limited to monocular vision and the target of concern was in the blind spot of the eye, target detection capability would be minimized at least, and possibly eliminated.

A safe flight environment requires all pilots, whether they consider themselves to be VFR or IFR, to exercise the utmost vigilance to identify and react to potentially hazardous traffic. As the Safety Board has stated previously, 4/ the fundamental rule of cockpit discipline is vigilance for other traffic. The criticality of this responsibility is emphasized by the midair collision accident data from 1957 through 1982, when there were a total of 678 midair collisions, which resulted in 1,550 fatalities. (See appendix D.) General aviation aircraft were involved in 608 of these accidents. In 1982, there were 36 midair collisions throughout the United States which resulted in 59 fatalities.

A recent National Aeronautics and Space Administration study 5/ on near midair collisions found that one-half of 78 near midair collisions in TCA's involved one airplane not known to ATC. The report stated that many pilots under radar control believe that they will be advised of traffic that is in a potential conflict. These pilots tend to relax their visual scan for another airplane until warned of its presence, and when warned of a conflicting airplane, they tend to look for it to the exclusion of scanning for other traffic.

In many midair collisions, including this accident, if both airplanes had been equipped with altitude encoders, the controller would have been better able to recognize the potential conflict of the two airplanes, and the controller could have warned the IFR pilot of the potential conflict with the VFR traffic. The installation of an altitude encoder in N96402 might have prevented this accident. The Safety Board encourages owners of airplanes that are not equipped with encoders to install the altitude-reporting devices as an effective safety measure and to operate the encoder routinely. In any event, pilots of airplanes without encoders should comply with the advice contained in Chapter 3, section 3, paragraph 978(2)(d) of the AIM which states that pilots of airplanes without encoders should maintain wide separation from the boundaries of positive controlled airspace because even if they are observed by the controller, their airplanes may not be considered by the controller as conflicting traffic.

Since 1969, the Safety Board has expressed concern regarding the problems of midair collisions and has conducted special studies and public hearings. To date, the Board has issued 74 safety recommendations to prevent midair collisions (see appendix E). However, regardless of the improved operating environment provided to separate airplanes in visual flight conditions, midair collisions continue to occur as evidenced by the annual collision record. Steadfastly, the Safety Board has emphasized that the primary responsibility to avoid collision rests with the individual pilot.

In 1969, the Safety Board conducted a public hearing into the midair collision problem. At this hearing, witnesses drew attention to the fact that, unlike the programs of the military, there was no required or optional training of civilian pilots in techniques to look for and to perceive other aircraft. At that time, the Board recommended that the FAA require pilots to be given ground training in scanning programs to optimize aircraft detection and thus make the time the pilot is looking outside the cockpit more productive. The Board further recommended on a priority basis that detection training equipment be developed and made available to private pilots (Recommendation A-70-8). The FAA rejected these proposals and the Safety Board classified the recommendation as "Closed--Unacceptable Action."

4/ "Aircraft Accident Reports Brief Format, Issue No. 4," NTSB 1981.
5/ "A Study of Near Midair Collisions in U.S. Terminal Airspace," Billings, Grayson, Hecht and Curry, National Aeronautics and Space Administration TM 81225, August 1980.

In February 1971, the Safety Board recommended that the pilot training requirements in the Federal Aviation Regulations be amended to require the addition of scanning techniques to the training syllabus (Recommendation A-71-12). In response to this safety recommendation, the FAA issued an advance notice of proposed rulemaking (ANPRM) to solicit public comments concerning the subject training. In an interim response to the Board, the FAA stated that its analysis of the public comments was not complete, but that the majority of those responding either were opposed to the proposal or recommended that further action not be taken until additional research and development was accomplished. Further, the FAA stated that a research program would be necessary to validate the transfer of training to actual flight operations and permit the development of appropriate training methods and aids. The FAA stated that research was currently in progress and that development efforts involved detailed human factors studies relative to scanning, detection, evaluation, and selection of the appropriate maneuver. The findings of the program were to be applied to general aviation pilots, flightcrew training, and procedural revisions. On April 23, 1971, based on the stated intentions of the FAA, the Safety Board classified the recommendation as "Closed—Acceptable Action." However, to date, further FAA action on the safety recommendation has not been forthcoming.

The Safety Board recognizes that the FAA emphasizes the potential hazard of a midair collision and the importance of out-of-cockpit vigilance through flight instructor clinics, air carrier and air taxi evaluations, and biennial flight reviews. In the FAA's Advisory Circular, AC90-48C, Pilot's Role In Collision Avoidance, the FAA characterizes the Aircraft Owners and Pilots Association's (AOPA) program called "Take Two and See" as ". . . an excellent educational program designed to inform pilots on effective visual scan techniques." The Board also considers this to be an excellent program. However, in 1973, as a result of its investigation of a midair collision, 6/ the Board recommended that the FAA:

> Establish a requirement for pilots to be trained in the techniques of time sharing between visual scanning for airborne targets and cockpit duties. (A-73-28)

In 1974, this recommendation was classified by the Board as "Closed—Unacceptable Action" after the FAA did not act to establish such a requirement. The Safety Board notes the fact that the FAA has continued to stress the importance of scanning, but the Board believes that the FAA has not provided enough emphasis on specific techniques of scanning such as those contained in the AOPA program "Take Two and See." The Board believes that this type of information and the information already contained in Advisory Circular AC90-48C should be included in FAA publications such as "Flight Training Handbook," "Instrument Flying Handbook," "Pilot's Handbook of Aeronautical Knowledge," or the AIM to the extent that there would no longer be a need to publish the information separately in a less popular, seldom-read format. The Board considers this to be as important as the familiar subjects of map reading, weather symbology, and pilotage.

6/ Aircraft Accident Report—"North Central Airlines, Inc., Allison Convair 340/440 (CV-580), N90858, and Air Wisconsin, Inc., DHC-6, N4043B, near Appleton, Wisconsin, June 29, 1972" (NTSB-AAR-73-9).

The system of providing separation is not error-proof, nor in all probability will it ever be. Conflicting traffic, particularly near the boundaries of a TCA, may be a threat detectable only by pilots, and then only if they are looking for it. There may be one common denominator to all midair collisions, and that factor might be described as pilot complacency particularly when an airplane is under positive control. The Safety Board emphasizes as an essential part of a collision avoidance program that separation can be maintained most effectively by pilots who recognize that outside scanning must be an aggressive procedure. Target recognition is a difficult task, and pilots must learn to train themselves to use head and body movements as well as eye movements in a planned scanning pattern to overcome the limitations on target detection in order to be able to take timely evasive action.

CONCLUSIONS

Findings

1. The airplanes were certificated, equipped, and maintained in accordance with Federal regulations and approved procedures.

2. About 2 minutes before the collision, the New York Terminal Radar Approach Control radar ceased recording transmissions from the altitude encoder of N3827C. N96402 was not equipped with an altitude encoder.

3. The pilots were certificated properly. There was no evidence of preexisting medical or physiological problems that might have affected their performance.

4. The radar controller was qualified as a full performance level controller. He also was medically qualified.

5. The weather was clear at the collision altitude.

6. The airplanes were operating under visual flight rules. N3827C was being radar vectored by the New York Terminal Radar Approach Control for a practice ILS (instrument landing system) approach to runway 6 at Teterboro airport.

7. The pilot of N96402 did not have radio contact with an air traffic facility.

8. The cockpit visibility study indicated that during the 45-second period before the collision, the detection of N96402 was restricted by the windshield centerpost in the vision envelope of N3827C's pilot, and that during the 15-second period before the collision, the image of N3827C was unrestricted in the forward vision envelope of the pilot of N96402; however, in the prior 30-second period, N3827C was in only the monocular vision of N96402's pilot.

9. During the last 30 to 45 seconds before collision, neither pilot had a totally unobstructed view of the other airplane, at least until the target size filled the windshield at some time between 15 seconds and collision.

10. During the 107 seconds before the collision, the passenger in N3827C had the image of N96402 in full view near his zero eye reference.

11. The circumstances of this accident involve problems associated with the limitations of human vision and the inherent difficulties of perceiving, recognizing, and effectively avoiding a collision with another airplane.

12. If both airplanes had been equipped with altitude encoder devices, the controller would have been better able to recognize the potential conflict of the two airplanes.

13. The controller could have and should have observed the potential traffic conflict and issued an appropriate advisory.

14. The Safety Board determined that the collision occurred in the controlled airspace of the New York Terminal Control Area.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the pilots to exercise adequate vigilance to detect and avoid each other. The failure of the pilots may have been due to the limitations of human vision and the inherent difficulties of perceiving, recognizing, and effectively avoiding a collision. Contributing to the accident was the failure of the pilot of N96402 either to keep clear of the New York Terminal Control Area or to avail himself of the traffic advisory capability of the New York Terminal Radar Approach Control. Also contributing to the accident was the failure of the controller to observe the potential conflict and to adequately convey traffic information to N3827C.

RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board recommended that the Federal Aviation Administration:

Consolidate information on visual scan techniques in Advisory Circular AC90-48C, "Pilots Role In Collision Avoidance," and information such as that contained in the Aircraft Owners and Pilots Association's program "Take Two and See," regarding visual scan techniques, in one or more publications that are referred to by pilots on a continuing basis. (Class II, Priority Action) (A-83-54)

Include questions regarding visual scanning techniques for airborne targets in written examinations for pilot licenses. (Class II, Priority Action) (A-83-55)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JIM BURNETT
Chairman

/s/ PATRICIA A. GOLDMAN
Vice Chairman

/s/ FRANCIS H. MCADAMS
Member

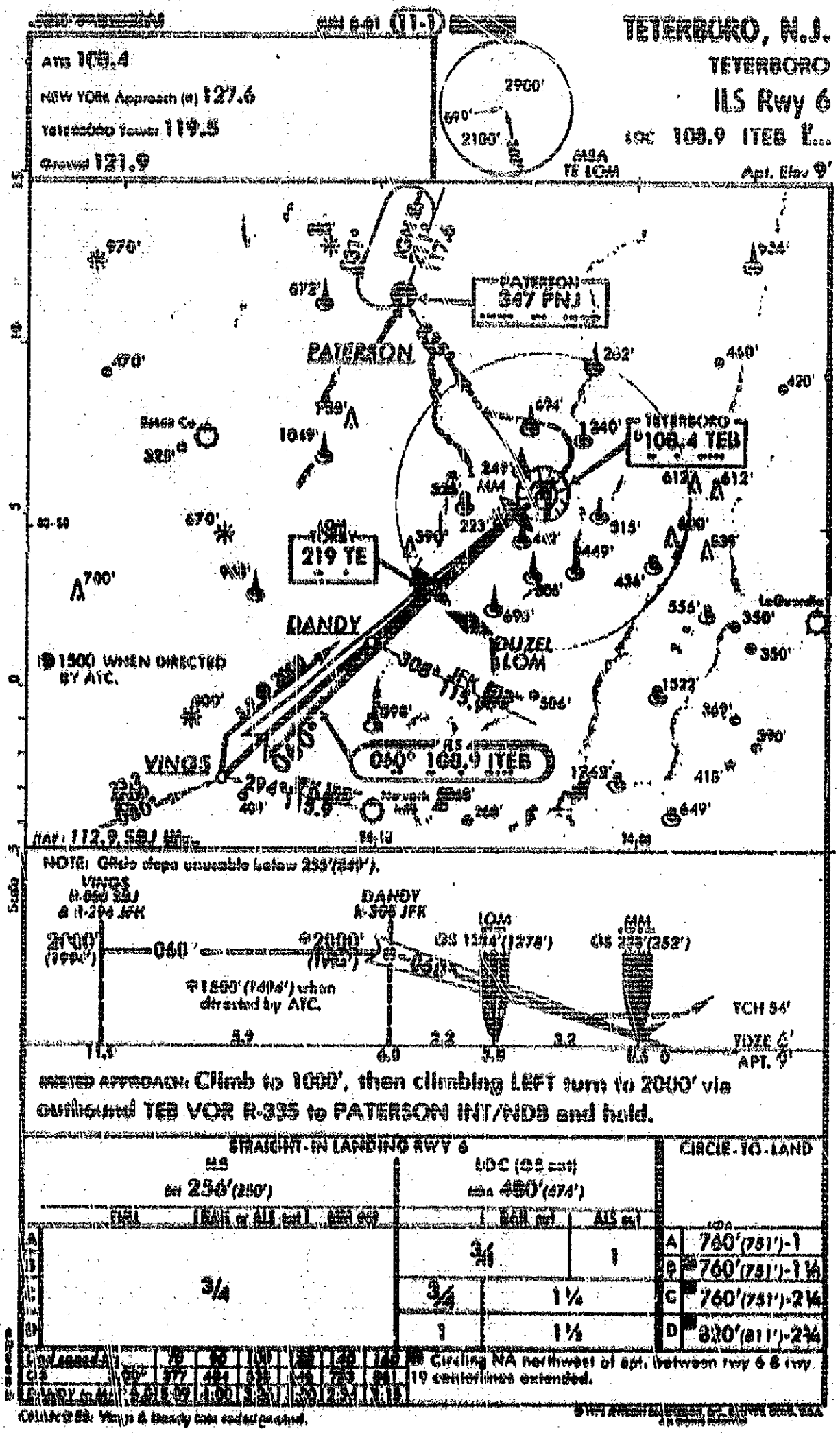
/s/ G. H. PATRICK BURSLEY
Member

/s/ DONALD D. ENGEN
Member

June 26, 1983

APPENDIX A

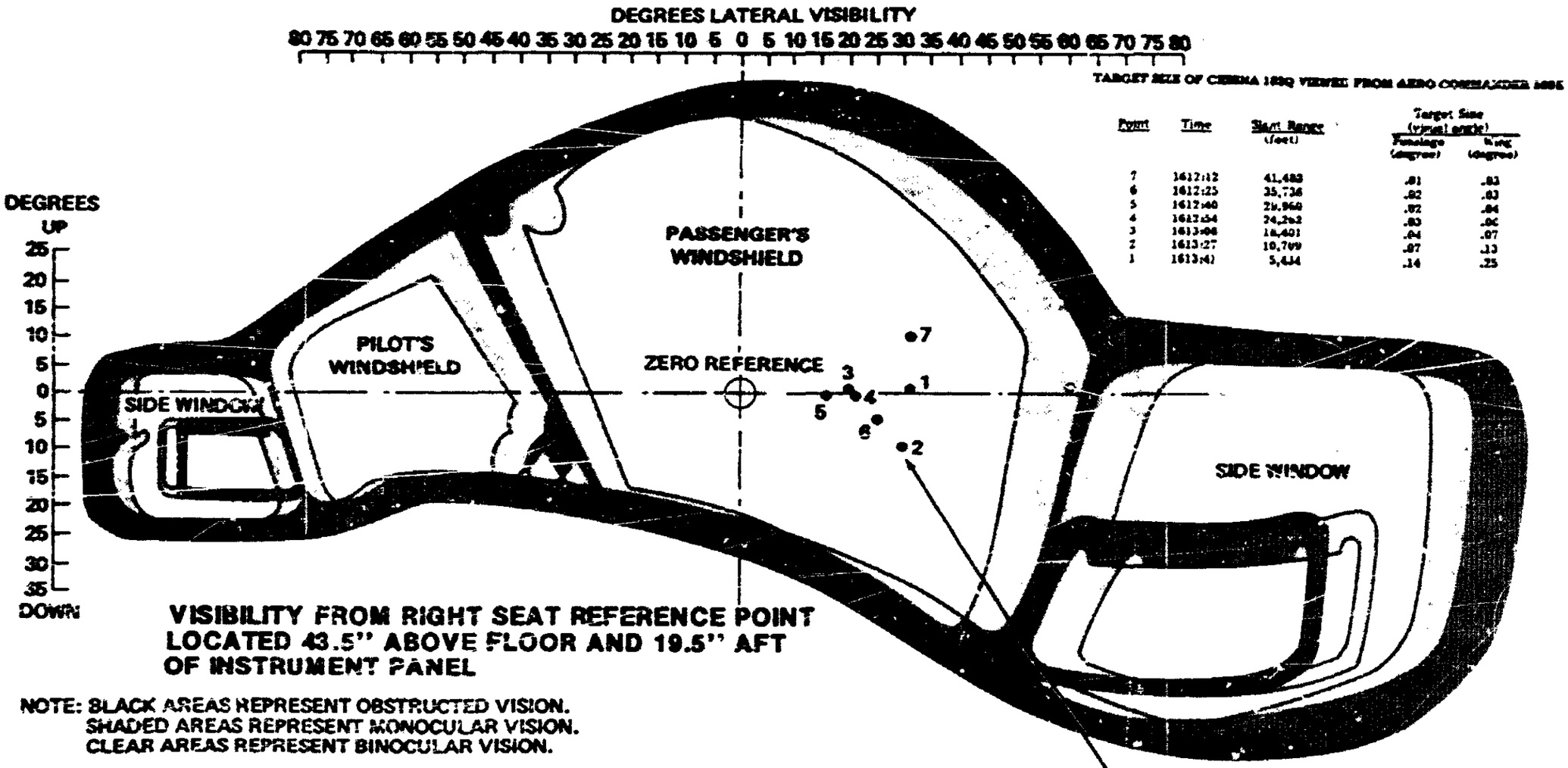
APPROACH CHART FOR ILS RUNWAY 6
TETERBORO, NEW JERSEY



"ILLUSTRATION ONLY - NOT TO BE USED FOR NAVIGATIONAL PURPOSES"

APPENDIX B

BINOCULAR PHOTOGRAPHS



TARGET SIZE OF CESSNA 180Q VIEWED FROM AERO COMMANDER 560E

Point	Time	Slant Range (feet)	Target Size (visual angle) Fuselage (degrees)	Target Size (visual angle) Wing (degrees)
7	1612:12	41,488	.81	.83
6	1612:25	35,736	.82	.83
5	1612:40	29,960	.82	.84
4	1612:54	24,262	.83	.86
3	1613:08	18,401	.84	.87
2	1613:27	10,709	.87	.13
1	1613:41	5,434	.14	.25

VISIBILITY FROM RIGHT SEAT REFERENCE POINT LOCATED 43.5" ABOVE FLOOR AND 19.5" AFT OF INSTRUMENT PANEL

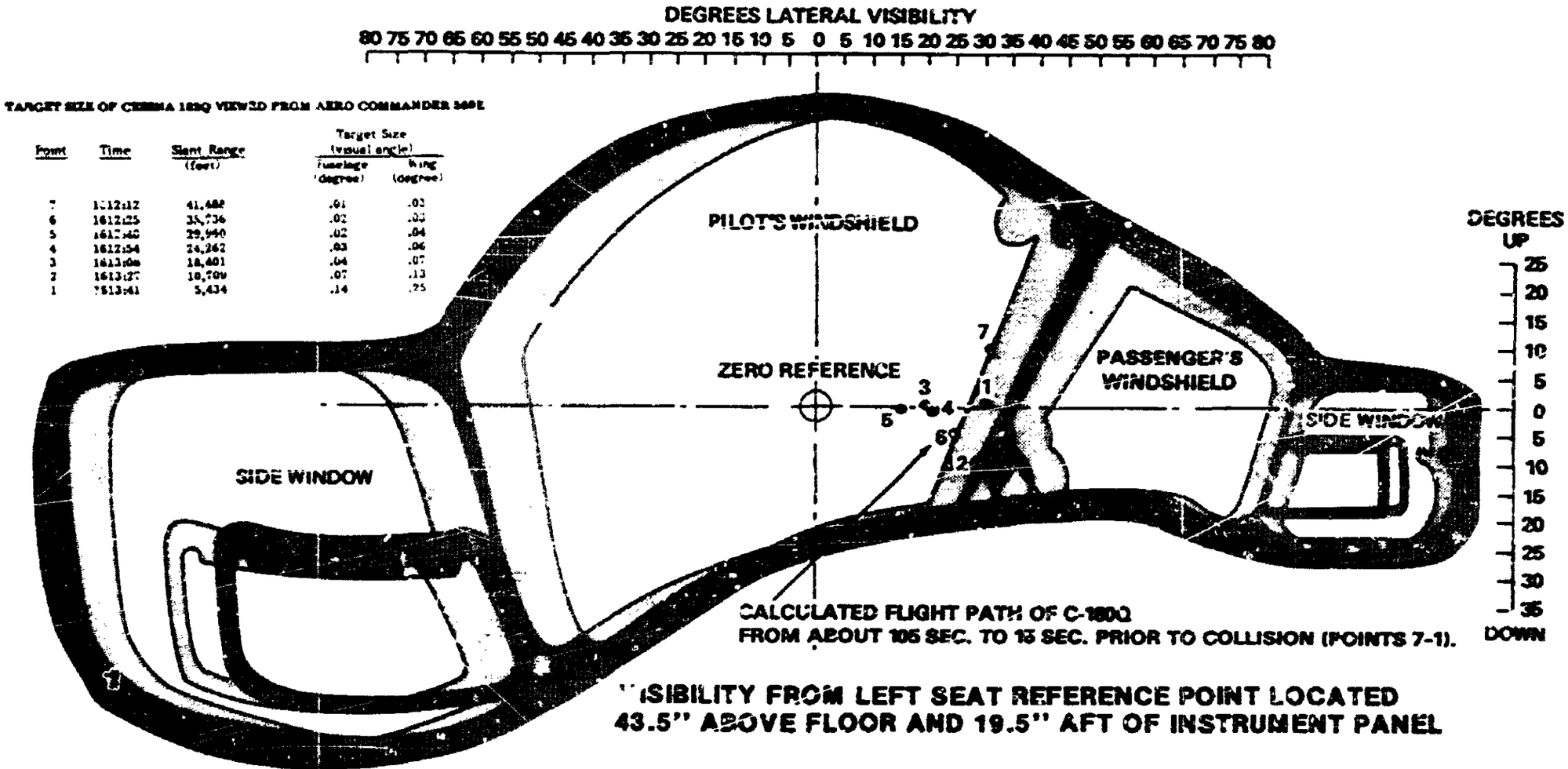
NOTE: BLACK AREAS REPRESENT OBSTRUCTED VISION.
SHADED AREAS REPRESENT MONOCULAR VISION.
CLEAR AREAS REPRESENT BINOCULAR VISION.

THE ACCURACY OF THESE ILLUSTRATIONS IS LIMITED BY THE PROCESS BY WHICH THE ILLUSTRATIONS WERE PRODUCED. THAT IS, THE ILLUSTRATIONS WERE PRODUCED FROM TRACINGS OF THE ORIGINAL BINOCULAR PHOTOGRAPHS.

CALCULATED FLIGHT PATH OF C-180Q FROM ABOUT 105 SEC. TO 15 SEC. PRIOR TO COLLISION (POINTS 7-1).

COCKPIT VISIBILITY
AERO COMMANDER 560E
VIEWING CESSNA 180Q

APPENDIX B



TARGET SIZE OF CESSNA 180Q VIEWED FROM AERO COMMANDER 560E

Point	Time	Slant Range (feet)	Target Size (visual angle) Fuselage (degree)	Wing (degree)
7	1:12:12	41,488	.01	.03
6	1612:25	35,736	.02	.03
5	1612:40	29,960	.02	.04
4	1612:54	24,262	.03	.06
3	1613:08	18,601	.04	.07
2	1613:27	10,709	.07	.13
1	1613:41	5,434	.14	.25

VISIBILITY FROM LEFT SEAT REFERENCE POINT LOCATED
43.5" ABOVE FLOOR AND 19.5" AFT OF INSTRUMENT PANEL

NOTE: BLACK AREAS REPRESENT OBSTRUCTED VISION.
SHADED AREAS REPRESENT MONOCULAR VISION.
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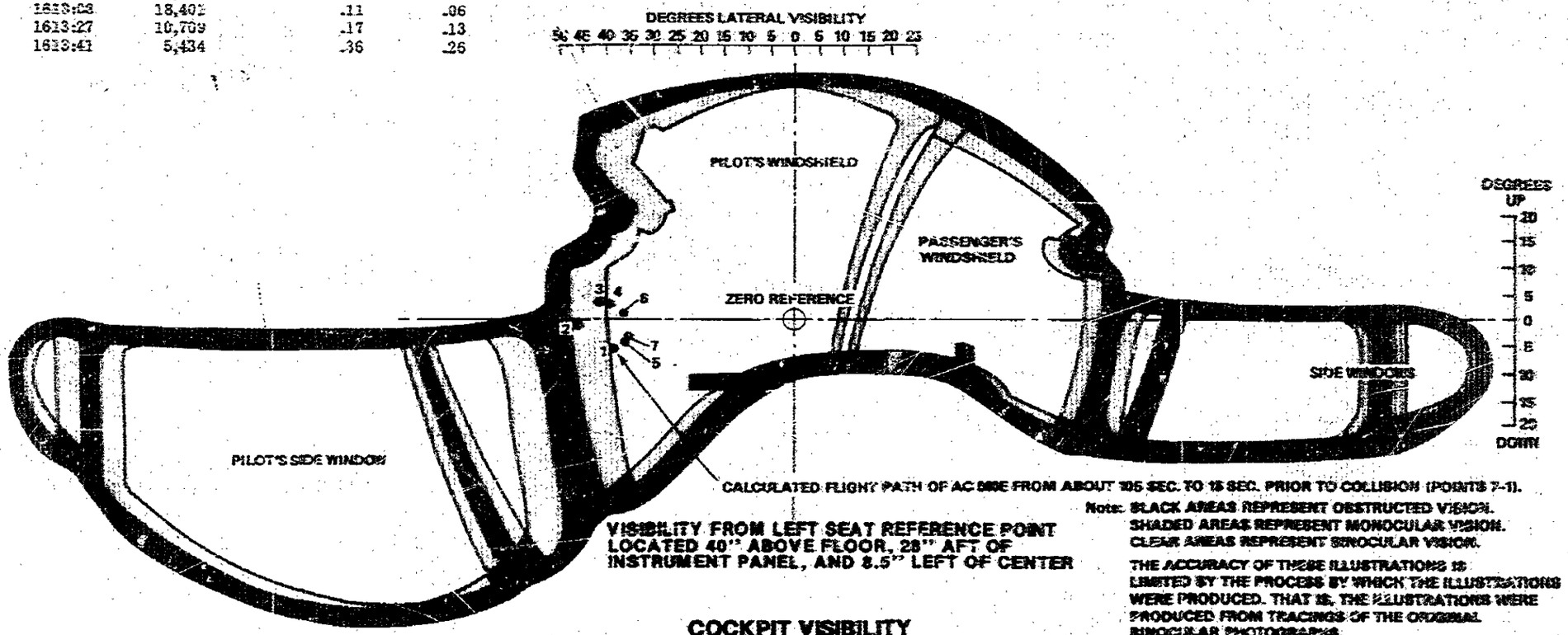
COCKPIT VISIBILITY
AERO COMMANDER 560E
VIEWING CESSNA 180Q

TARGET SIZE OF AERO COMMANDER 560E VIEWED FROM CESSNA 182Q

Point	Time	Slant Range (feet)	Target Size (visual angle) Fuselage (degree)	Wing (degree)
7	1612:12	41,333	.05	.03
6	1612:25	35,736	.06	.03
5	1612:40	29,960	.07	.03
4	1612:54	24,262	.08	.04
3	1613:08	18,402	.11	.06
2	1613:27	10,709	.17	.13
1	1613:41	5,434	.36	.25

APPENDIX B



VISIBILITY FROM LEFT SEAT REFERENCE POINT LOCATED 40" ABOVE FLOOR, 28" AFT OF INSTRUMENT PANEL, AND 8.5" LEFT OF CENTER

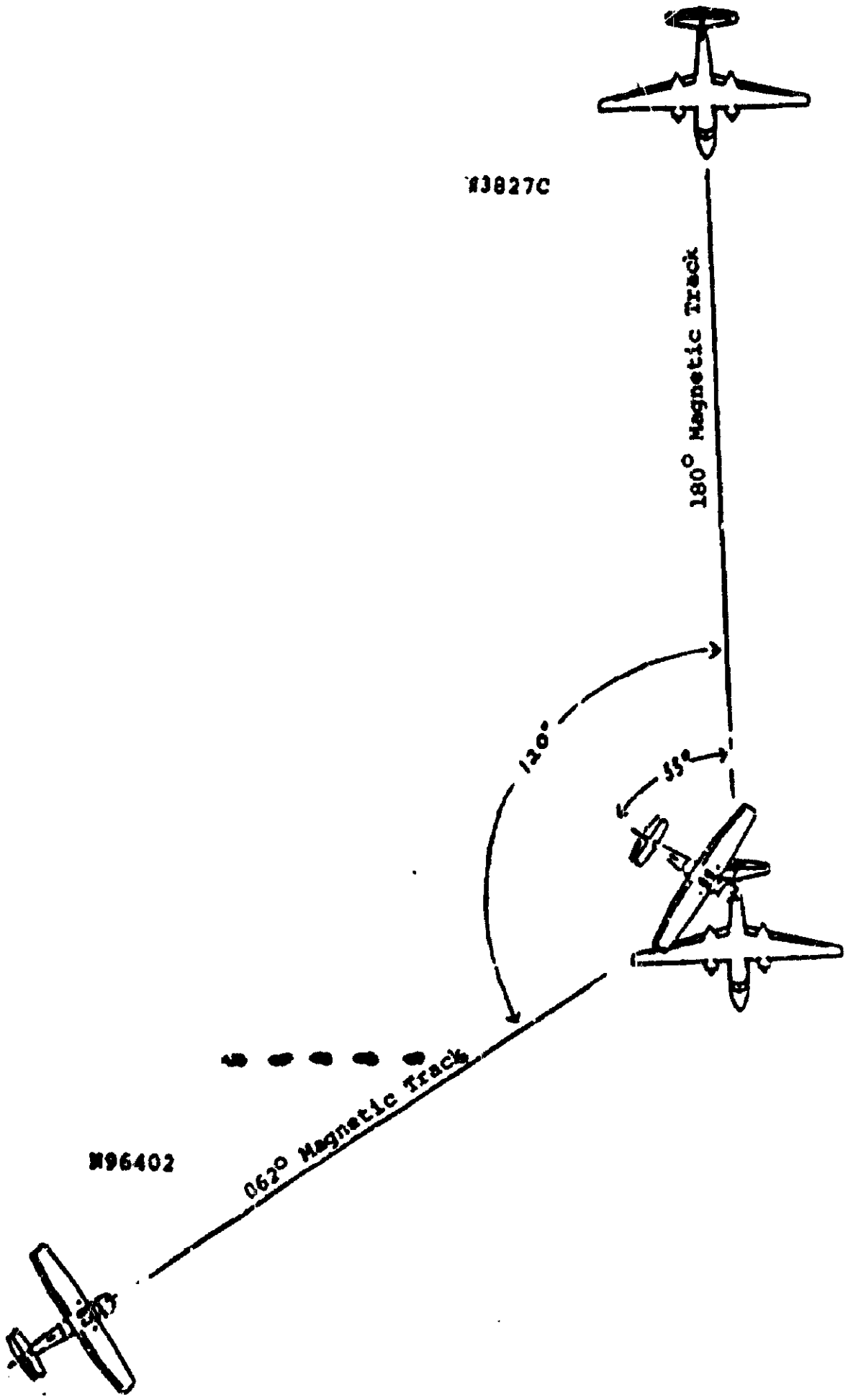
Note: BLACK AREAS REPRESENT OBSTRUCTED VISION.
SHADED AREAS REPRESENT MONOCULAR VISION.
CLEAR AREAS REPRESENT BINOCULAR VISION.

THE ACCURACY OF THESE ILLUSTRATIONS IS LIMITED BY THE PROCESS BY WHICH THE ILLUSTRATIONS WERE PRODUCED. THAT IS, THE ILLUSTRATIONS WERE PRODUCED FROM TRACINGS OF THE ORIGINAL BINOCULAR PHOTOGRAPHS.

COCKPIT VISIBILITY
CESSNA 180Q
VIEWING AERO COMMANDER 560E

APPENDIX C

RELATIVE AIRPLANE POSITIONS AT IMPACT



APPENDIX D

1957-1982 MIDAIR COLLISION ACCIDENT RECORD

MIDAIR COLLISION ACCIDENTS
U.S. CIVIL AVIATION

1957-1983

Year	Accidents Total	Accidents Fatal	Number Fatalities	Number of Accidents by Segments of Aviation Involved: Air Carrier / Air Carrier	Air Carrier / Gen. Aviation	Air Carrier / Military	Gen. Aviation / Military	Gen. Aviation / Gen. Aviation
1957	15	6	19 a/	0	0	1	4	10
1958	16	12	86	0	0	2	2	12
1959	13	10	20	0	0	0	3	10
1960	26	10	152 b/	1	4	0	2	19
1961	20	10	22	0	0	0	0	20
1962	19	9	27	0	0	0	5	14
1963	13	3	6	0	0	0	2	11
1964	15	7	12	0	0	0	2	13
1965	27	14	30	1	0	0	1	25
1966	27	11	33	0	1	0	1	25
1967	26	20	157	0	2	1	3	20
1968	37	23	69	0	3	0	1	33 c/
1969	28	12	122	0	3	0	2	23 c/
1970	37	21	55	0	0	0	5	32 c/
1971	32	20	96	0	3	1	1	27
1972	25	13	41	0	1	0	0	24 c/
1973	24	12	29	0	0	0	0	24
1974	34	19	48	0	0	0	2	32
1975	29	13	47	0	0	0	1	28
1976	31	24	64	0	0	0	1	30
1977	34	17	41	0	0	0	0	34
1978	35	23	189 d/	0	1	0	1	33
1979	25	14	34	0	0	0	1	24
1980	24	19	45	0	0	0	1	24
1981	30	13	47	0	0	0	1	29
1982	36	14	59	1	2	0	0	33
TOTAL	678	369	1,550	3	20	5	43	608

a/ Includes 3 persons on ground
b/ Includes 6 persons on ground
c/ Includes 1 U.S. general aviation vs foreign aircraft
d/ Includes 7 persons on ground

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D.C. 20594
January 24, 1983

APPENDIX E

PREVIOUS SAFETY BOARD MIDAIR COLLISION RECOMMENDATIONS

In July 1969, the National Transportation Safety Board issued a special accident prevention study entitled "Midair Collisions in U.S. Civil Aviation." The study of 38 midair collisions, which occurred in calendar year 1968, involved 76 aircraft; 24 of the 38 collisions resulted in 71 fatalities--all occupants of general aviation aircraft. As a result of this study, the Board issued 14 recommendations on July 23, 1969.

On November 4, 1969, the Safety Board convened a public hearing for the purpose of inquiring into the cause and prevention of midair collisions. The Board, sitting en banc, heard the testimony of 26 witnesses, including representatives of the United States Government, the aviation industry, and members of the public. As a result of this hearing, the Board issued 4 recommendations on June 30, 1970, and 11 recommendations on February 22, 1971.

On June 7, 1982, the Safety Board adopted a special study entitled "Midair Collisions in U.S. Civil Aviation 1969-1970." This study updated the 1968 midair collision study and included a review of the 1969 and 1970 midair collision accidents. As a result of this study, the Board issued 10 recommendations on September 21, 1972.

Since 1969, in addition to the 39 recommendations issued as a result of these special studies and the public hearing, the Safety Board has issued 35 other recommendations to minimize the hazards of midair collisions and to emphasize to the aviation community the inherent dangers of the "see and avoid" environment. At least seven of these safety recommendations apply to this accident.

A-71-12: Amend the pilot training requirements in the Federal Aviation Regulations to require the addition of scanning techniques to the training syllabus.

A-71-51: 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 area. Consideration should be given to making the request for such service a mandatory procedure.

A-72-157: Develop a total midair collision prevention system approach to include training, education, procedures, ATC equipment and practices, and the development of collision avoidance systems and proximity warning instruments that are cost feasible to the general aviation community.

A-73-28: Establish a requirement for pilots to be trained in the techniques of time sharing between visual scanning for airborne targets and cockpit duties.

A-73-32: Expedite the development and issuance of national standards for systems to provide protection from midair collisions so that the industry can proceed without further delay to develop and market economically viable hardware.

A-79-74: Prescribe a method to insure that all general aviation pilots are tested periodically on ATC radar procedures, radar services, pilot/controller relationships, and ATC clearance as appropriate to their operations.

As a result of responsive actions taken by the FAA, the Safety Board classified Safety Recommendations A-71-12, A-71-51, and A-72-157 as "Closed--Acceptable Action," classified A-73-32 and A-79-74 as "Closed--Acceptable Alternate Action," and classified A-70-3 and A-73-28 as "Closed--Unacceptable Action."

*U.S. GOVERNMENT PRINTING OFFICE : 1980 O-321-870/13