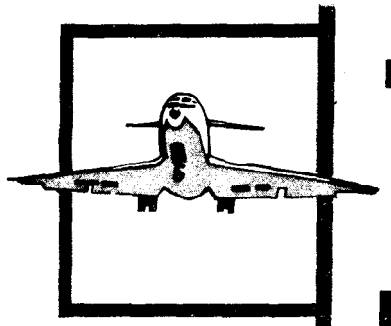

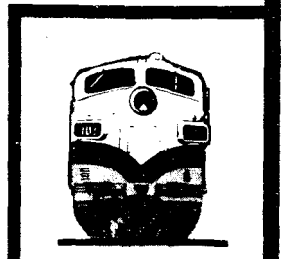

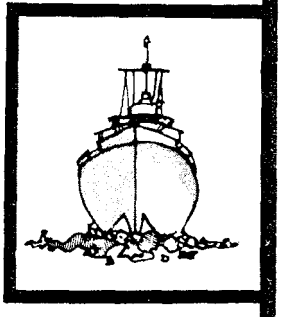

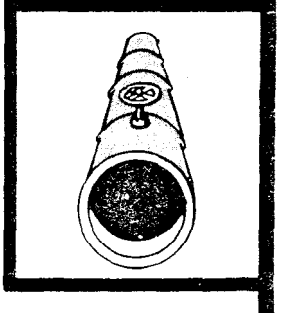

PB87-9 10405

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

MIDAIR COLLISION OF NABISCO BRANDS, INC., DASSAULT FALCON, DA50, N784B AND AIR PEGASUS CORPORATION PIPER ARCHER, PA28-181, N1977H FAIRVIEW, NEW JERSEY NOVEMBER 10, 1985

NTSB/AAR-87/05

UNITED STATES GOVERNMENT

TECHNICAL REPORT DOCUMENTATION PAGE

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15. Supplementary Notes		

16. Abstract On November 10, 1985, about 1722 Eastern standard time, a Nabisco Brands, Inc., Dassault Falcon, DA50 jet and an Air Pegasus flying club Piper Archer, PA28-181, collided about 1,500 feet over the towns of Fairview and Cliffside Park, New Jersey. The DA50 was cleared for a standard instrument approach procedure in visual meteorological conditions and was in a left turn to position itself on the downwind leg to runway 19 at the Teterboro Airport, and the PA28 was transiting the airport traffic area from west to east when they collided. The accident occurred 4 1/2 miles east-southeast at the edge of the airport traffic area in visual meteorological conditions., Both airplanes had been in radio contact with the Teterboro control tower. The flightcrew, the only occupants aboard the DA50, and the pilot and two passengers onboard the PA28 were killed. The DA50 crashed into an apartment building killing one resident and seriously injuring two bystanders.

The National Transportation Safety Board determines that the probable cause of the accident was a breakdown in air traffic control coordination which resulted in an air traffic conflict and the inability of the DA50 flightcrew to "see and avoid" the other aircraft due to (1) an erroneous and inadequate traffic advisory and (2) the physiological limitations of human vision and reaction time at night. Air traffic control management contributed to the accident by failing to insure that controllers were following prescribed procedures and by failing to recognize and correct operational deficiencies.

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CONTENTS

EXECUTIVE SUMMARY

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The major safety issues addressed in this report concern the management and coordination of air traffic within a complex airspace design and operational environment with a mix of small general aviation and larger turbojet aircraft, and the effectiveness of the "see and avoid" concept in a high density air traffic situation.

Safety recommendations concerning these issues were made to the Federal Aviation Administration.

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

Adopted: May 4, 1987

MIDAIR COLLISION OF NABISCO BRANDS, INC., DASSAULT FALCON, DA50, N784B AND AIR PEGAGUSCORPORATION,PIPER ARCHER, PA28-181, N1977H FAIRVIEW, NEW JERSEY NOVEMBER 10, 1985

1. FACTUAL INFORMATION

1.1 History of the Flight

On November 10, 1985, a Nabisco Brands, Inc., Dassault Falcon, DA50, N784B, was scheduled to pickup five company executives at the Teterboro Airport (TEB), Teterboro, New Jersey, at 1800 E.s.t. 1/ for a flight to Toronto, Canada. At 1639, the pilot of the DA50 filed an instrument flight rules (IFR) flight plan with the Poughkeepsie flight service station (FSS) for a flight from Morristown, the company's flight department headquarters, to Toronto with a stop at TEB. The leg from Morristown to TEB, a distance of about 16 nautical miles (nmi), was requested to be flown at 3,000 feet with a proposed departure time of 1730. The pilot informed the FSS specialist that he had already obtained all pertinent weather and notices to airman (NOTAM) information for the flight.

At 1654:35, the captain of the DA50 requested his IFR clearance to TEB from the clearance delivery ground controller in the Morristown Airport Traffic Control Tower. About 1 minute after the controller told the flightcrew ". . .clearance on request. . ." the controller asked for their proposed departure time and was informed that it was 1730. At 1704:45, the crew asked if they could begin their taxi while waiting for their clearance and were instructed to taxi to runway 23 and were given an altimeter setting of 30.15 in.Hg. In less than a minute, they were asked their final destination and the crew replied, "TEB."

At 1707:35, the flight was given the following clearance, ". . .cleared to TEB via the after departure, direct Chatham, radar vectors to intercept the VOR-DME Alpha approach into TEB, maintain two thousand, departure frequency will be one one nine point two, squawk forty three sixty two." The clearance was read back correctly by the crew, and at 1709:50 the clearance delivery/ground controller told them that their release had been received and that they could contact the local controller. At 1710:10, the departure controller at the New York Terminal Radar Approach Control (TRACON) facility at Westbury, New York, informed the TEB control tower coordinator that the DA50 was departing en route to TEB. The coordinator acknowledged the coordination call by stating his operating initials, "lima golf." At 1710:37, the Morristown local controller cleared the airplane for takeoff. The first officer flew the airplane from the right seat.

1/ All times herein are Eastern standard time based on the 24-hour clock.

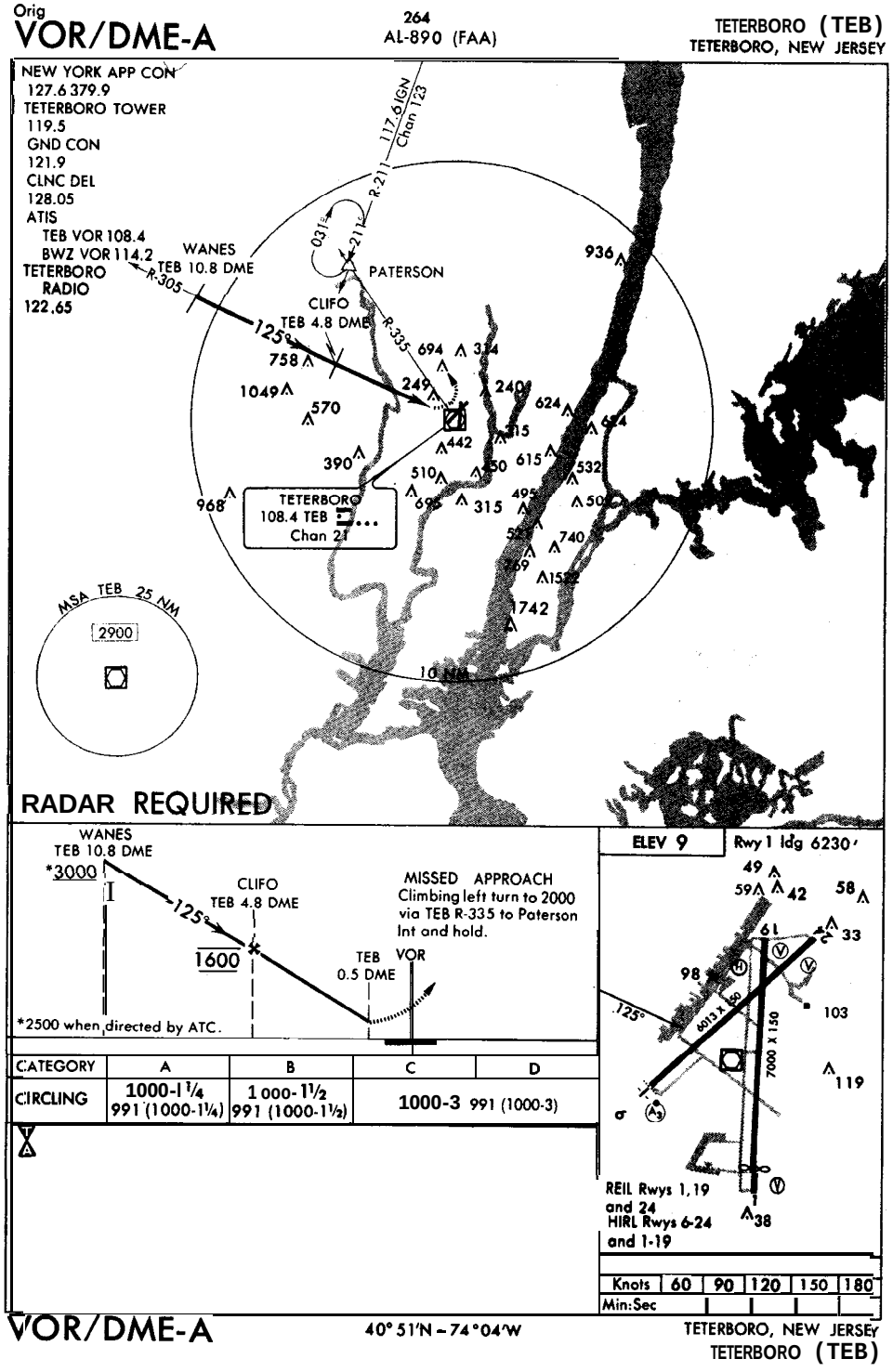


Figure l.-TEB VOR/DME-A instrument approach procedure chart.

At 1712:02, the DA50 crew was in contact with the departure controller and was instructed to activate the "ident" feature of the transponder and to maintain 2,000 feet. Seven seconds later, the controller transmitted, " Falcon seven eight four bravo is radar contact two south of Morristown. Start a left turn now, heading zero eight zero." At 1712:52, the controller stated, ". . .you are on vectors for a VOR DME alpha approach TEB, and, ah, good visibility, ah, correction. Good VFR visibility two zero, winds are two four zero at eight, VOR DME alpha approach, overhead the airport, left traffic for runway one niner." The captain acknowledged the information.

Following the transmission, the departure controller coordinated the DA50's flight to pass through the Essex County airport traffic area 2 miles east of the Essex Airport. At 1715, the controller told the DA50 flightcrew that they were following a twin Cessna (N68734) to TEB and to reduce their airspeed to 180 knots. He further advised that their turn for final approach would occur ". . .just outside of CLIFO [final approach fix] ." About 4 minutes later the speed was reduced to about 180 knots.

Meanwhile, Piper Archer, PA28-181, N1977H, had departed the Essex County Airport at 1713; the distance between Essex County and TEB is 10 nmi. It was operating under visual flight rules (VFR) without a flightplan and the pilot did not tell the control tower his intentions after departure nor was he required to do so. The airplane proceeded eastbound, and at 1716:39 the pilot reported to the Essex County control tower that he was clear of the area and requested a frequency change.

In the interim, the Newark sector departure controller had advised the DA50 crew of two VFR aircraft, one 4 miles at its 12 o'clock position westbound at 2,500 feet and the other about 2 miles eastbound at its 11:30 position at 1,800 feet. According to the cockpit voice recorder (CVR) in the DA50, the crew sighted both VFR aircraft. The following is the CVR record of the conversation between the captain (CAM-l) and first officer (CAM-L) associated with the traffic observations for the times indicated:

Time	Crew	Conversation
1716:29	CAM-l	There's the twenty five hundred foot traffic - and there's the nineteen hundred foot traffic.
1716:32	CAM-2	They're all over the place today.
	CAM-l	Yeah, yeah nice day. Everybody's out.
	CAM-2	Yeah.
1716:37	CAM-l	Another one down low up ahead here.
1716:42	CAM-l	It's the ones below the horizon that are hard to see.
	CAM-2	Yeah.
1716:45	CAM-l	They can get you, too.

At 1716:55 the departure controller transmitted, "Falcon seven eight four bravo is three miles west of CLIFO, turn right heading zero, niner zero two thousand until on the TEB three zero five radial cleared VOR DME alpha approach." (See figure 1.) The captain correctly read back the clearance. At 1717:29, he stated, "They're everywhere. . . ." Twelve seconds later, the controller stated, ". . . that was obviously not

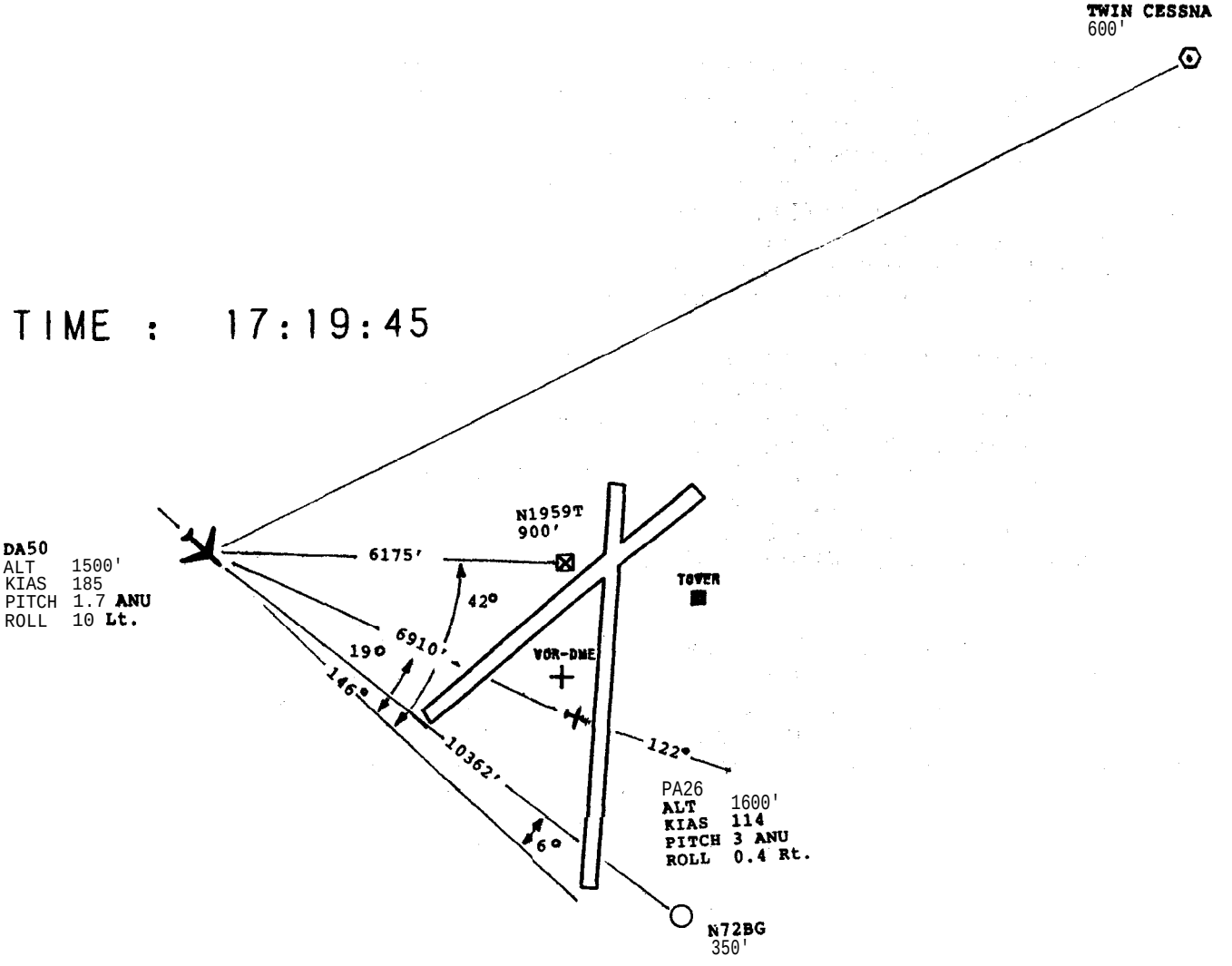


Figure P.-Radar positions of aircraft at 1719:45.

you're overhead the field, sir?" The captain said, "Yes, sir." At 1720:05, the controller then said, "Okay, plan number three following traffic turning downwind abeam the tower, additional traffic is at your one o'clock westbound at one point five." At this time the DA50 was about wings level on a heading of 121° at about 163 knots indicated airspeed (KIAS). The captain stated, "We're lookin' eight four bravo." (See figure 3.) At 1720:14, the DA50's speed had been reduced to 151 KIAS when a right turn was started. Immediately, the controller stated, "Okay, sir, you're closing on him. He's, uh, light aircraft at, uh, your one to twelve o'clock, westbound.** (See figure 4.) At the same time the controller was giving the crew the additional traffic, the first officer called to the captain, "Flaps twenty. Gear down before landing checklist,** and then the captain said, "You're eat'em up." This comment was immediately followed by the sound of the landing gear warning horn at 1720:19. At the same time the DA50 established a 5° right bank and maintained it for 41 seconds while the speed was decreasing.

One second later, another airplane called the controller for takeoff, but the local controller transmitted, "Seven seven hotel, traffic is a Falcon jet overtaking you from your, ah, six o'clock, ah [unintelligible] ." (See figure 5.) An immediate response came from another airplane north of the airport that stated, "Uh, roger sir, ABC towers." (According to the CVR, at 1720:39, the captain stated, "Another one down low." The first officer responded with a word that was unintelligible, and then the captain stated, "Beneath him," and the first officer said, "I see him" which ended at 1720:42.) At 1720:41, the controller said, "Eight four bravo, you have the traffic sir," and the captain replied, **Affirmative.** The controller then stated, "Okay, sir, maintain visual." (See figure 6.) The crew did not acknowledge the instruction.

The controller then turned his attention to the other traffic. At 1720:50, the CVR picked up the sound of a whistle in the cockpit, followed 10 seconds later by the first officer stating, "What kind of Cessna is that?" and the captain replied, "I don't know, I'll ask him." At this point the DA50 is almost wings level, rolling out of the slight right turn. (See figures 7 and 8.) However, there were five other immediate transmissions over the frequency between the controller and three other airplanes, one of which was N1959T which was cleared to make a short approach and land. N1959T acknowledged at 1721:19. The following are the final events recorded by the CVR up until the time of the collision.

Time	Ident.	Transmission
1721:21	CAM-2	Let's go full flaps.
1721:22	CAM-1	Hey watch out, this guy's comin' right at us.
1721:25	PA28	TEB tower Cherokee one nine seven seven hotel clear to the east.
1721:26	CAM-1	Go down.
1721:28	CAM-1	Naw, go up.
1721:28	LC *	Seven seven hotel roger, frequency change approved.
1721:30	CAM	Sound of impact.

* Local Controller

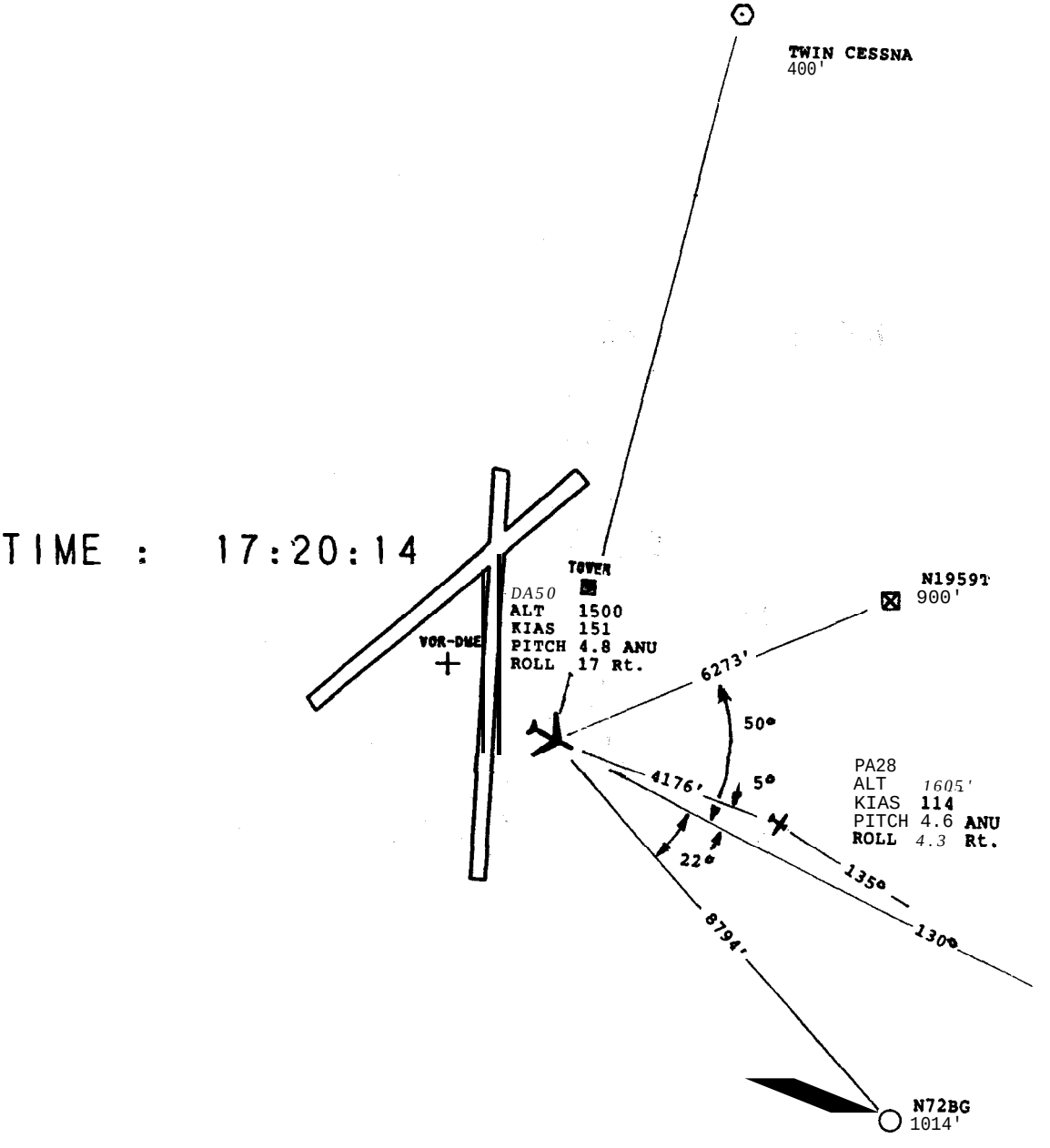


Figure 4.-Radar positions of aircraft at 1720:14.

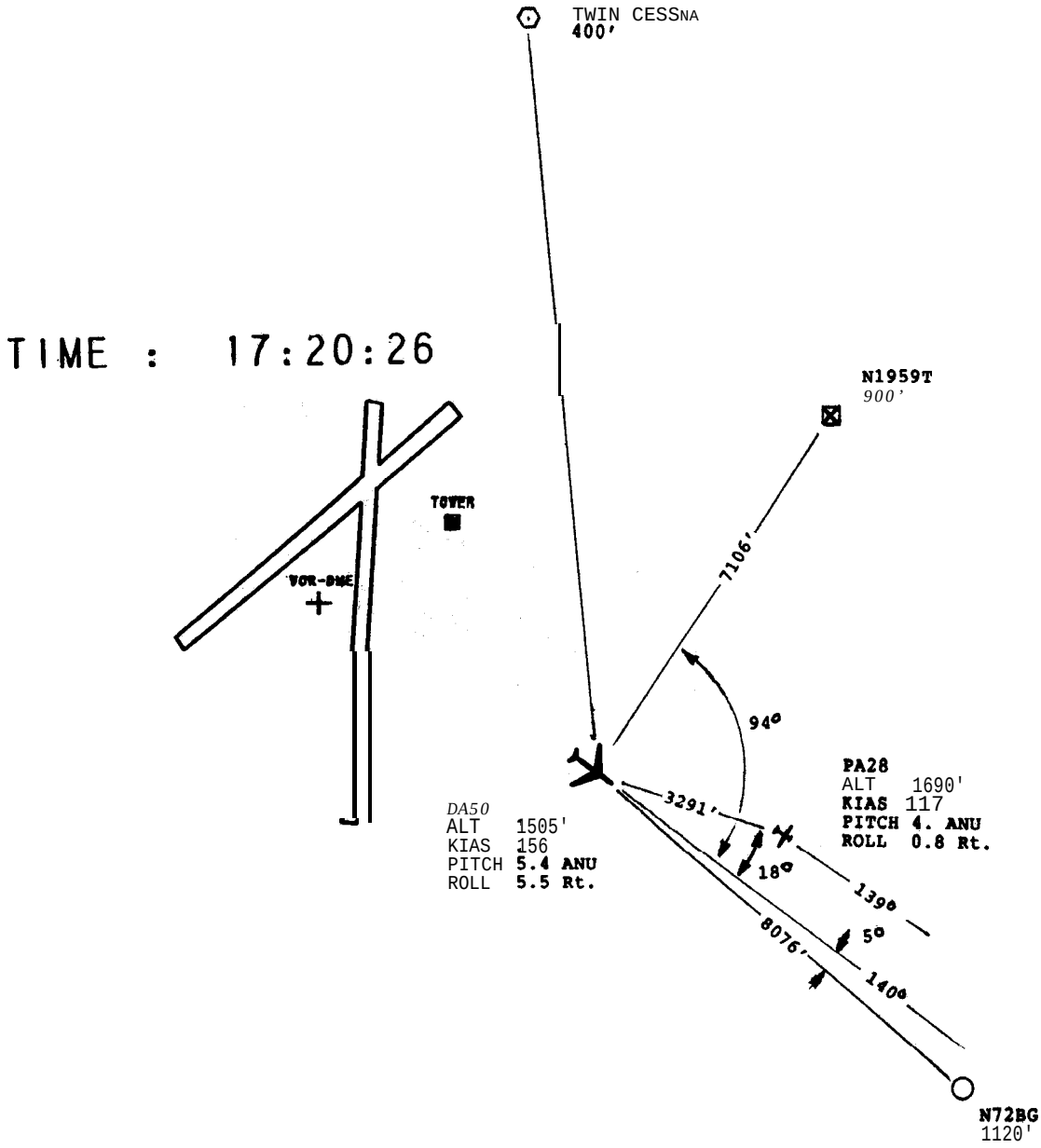


Figure 5.-Radar positions of aircraft at 1720:26.

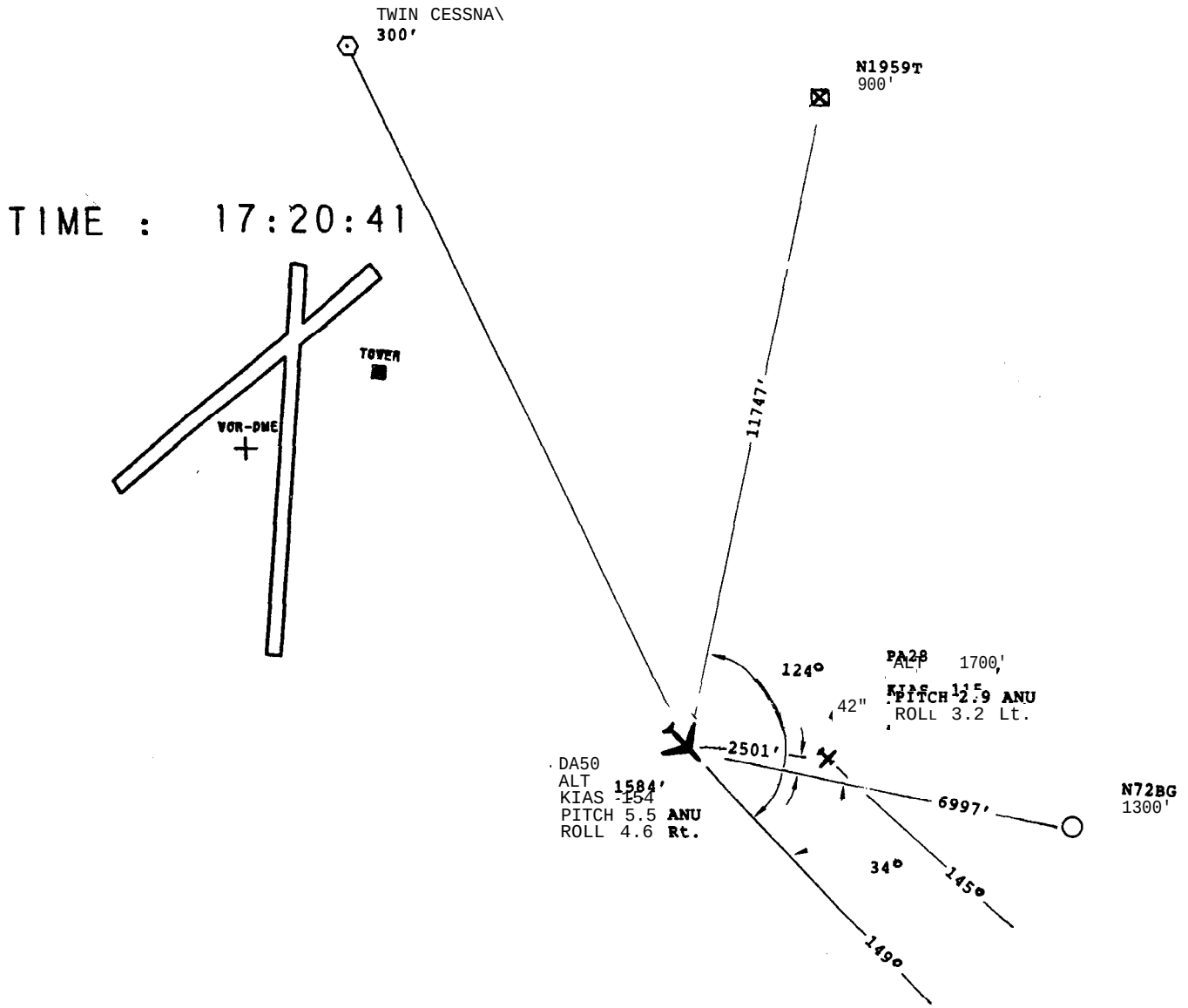


Figure 6.-Radar positions of aircraft at 1720:41.

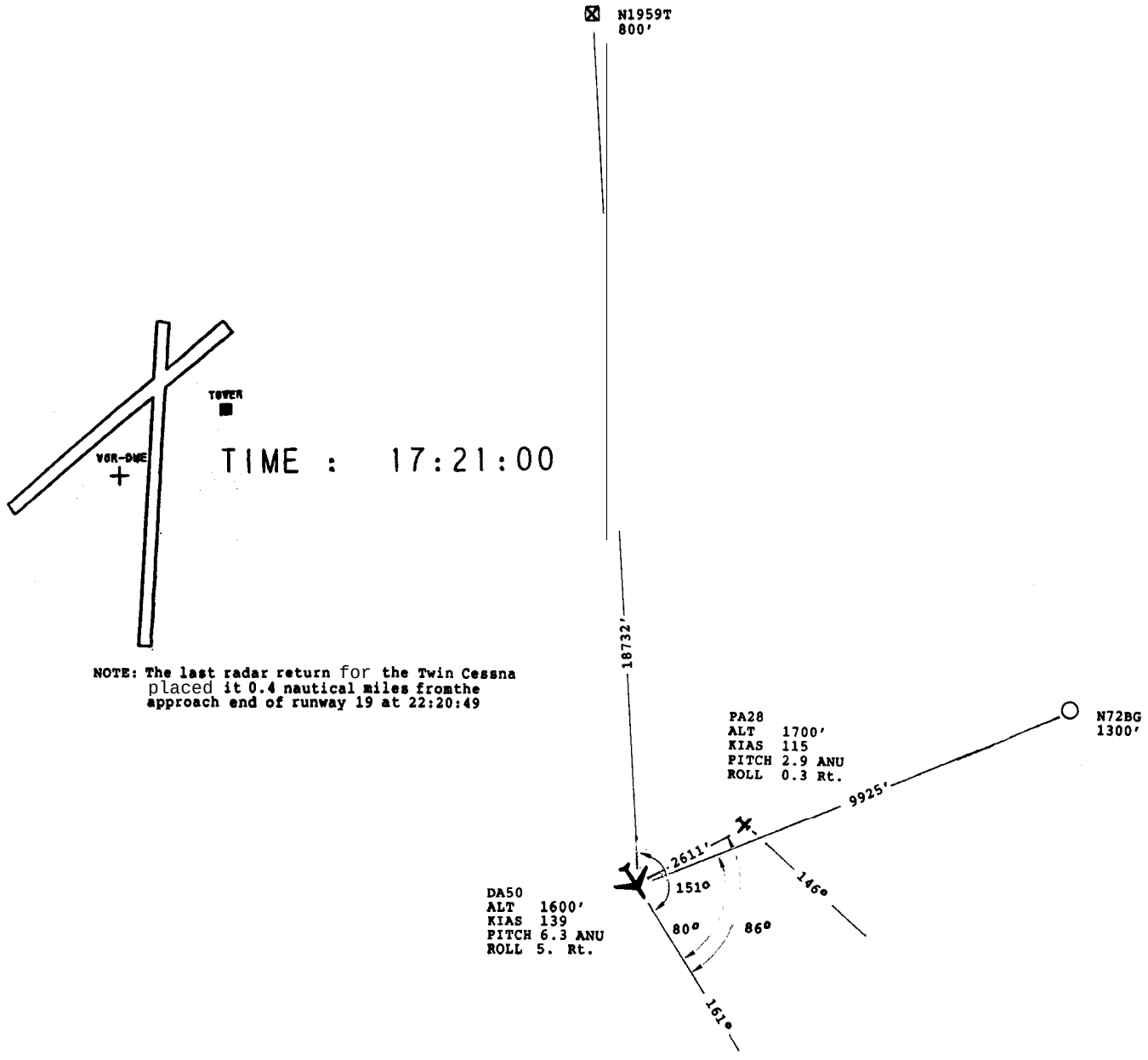


Figure 7.—Radar positions of aircraft at 1721:O0.

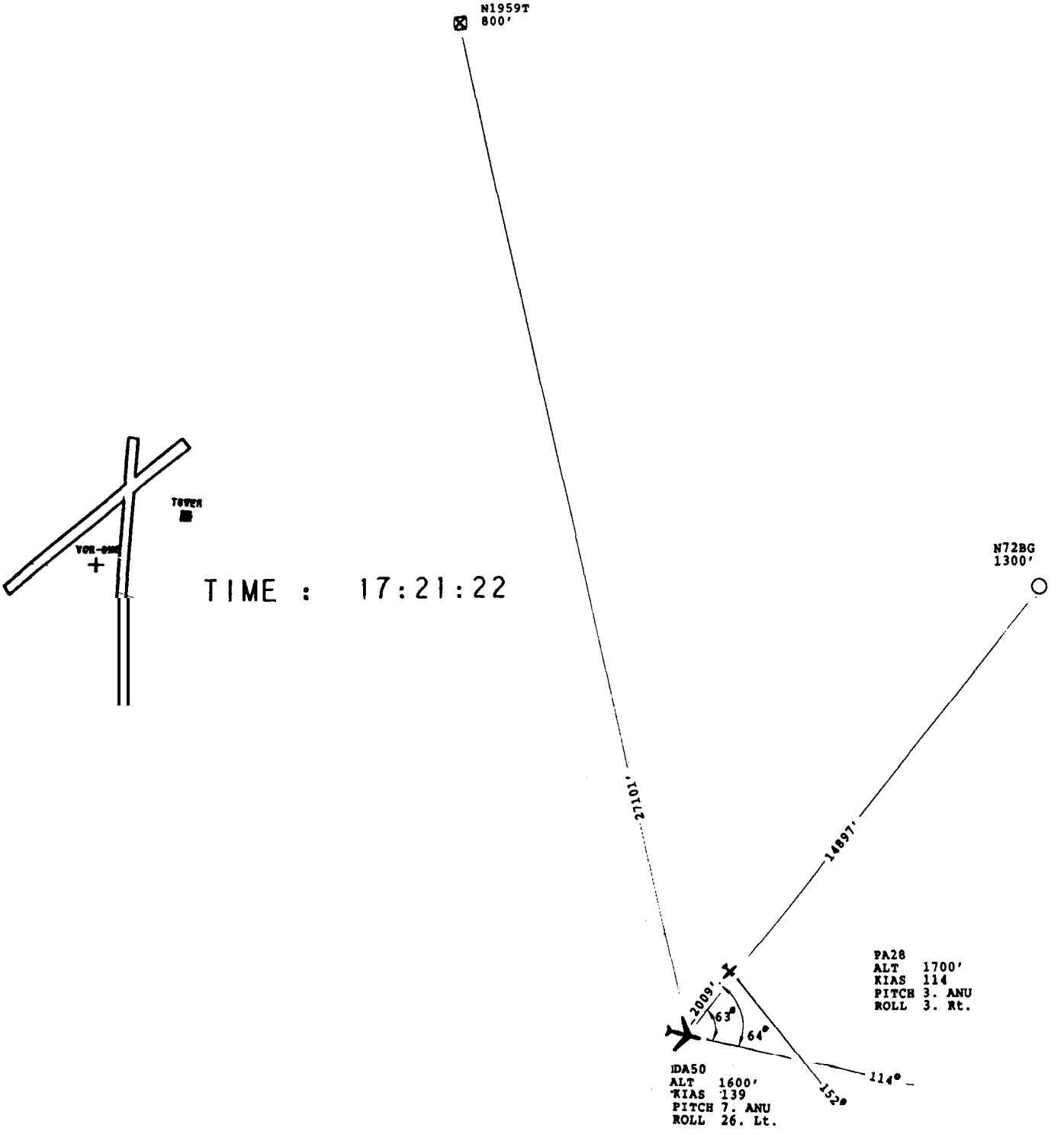


Figure 8.-Radar positions of aircraft 1721:22.

The collision took place between an altitude of 1,500 to 1,600 feet over the city of Fairview, New Jersey, about 4.5 miles east-southeast of the TEB airport at the edge of the airport traffic area and 400 to 500 feet above the floor of the New York terminal control area (TCA) for LaGuardia (coordinates 44° 48'58"N latitude, 73° 59'54"W longitude). (See figure 9.) Witnesses who saw both airplanes before the collision stated that both had lights on and were in about level flight. They said that the DA50 had made a left turn and was flying in a northerly direction and the PA28 was flying east at the time of the collision.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Other	Total
Fatal	3*	2	1**	6
Serious	0	0	2**	2
Minor	0	0	0	0
None	0	0	0	0
Total	3	2	3	8

* Includes the two pilots on board the DA50 and one pilot on board the PA28.

** Bystanders.

1.3 Damage to Aircraft

Both airplanes were destroyed by the in-flight collision and ground impact forces and postimpact fire.

1.4 Other Damage

Three houses were destroyed, several other buildings were damaged severely, and several automobiles were damaged severely or destroyed.

1.5 Personnel Information

1.5.1 The Pilots

All of the pilots and ATC personnel were qualified in accordance with current regulations. (See appendix B.)

The DA50 captain held an Airline Transport Pilot certificate and the appropriate class and type rating for the Dassault, DA50. He had a total pilot time of 8,265 hours about 817 hours of which were flown in the DA50. He held a current first class medical certificate with a waiver for distant vision (20/200 corrected to 20/20 bilaterally) which required that he wear corrective lenses.

The DA50 first officer held an Airline Transport Pilot certificate with the appropriate class rating for the DA50. He did not have a type rating in the airplane nor was he required to have had such a rating as a first officer. He had a total pilot time of 4,500 hours about 143 hours of which were flown in the DA50. He held a first class medical certificate with no limitations.

The previous flight for both the captain and first officer was conducted on November 7, 1985, and concluded at 0025 on November 8.

Figure 9.—New York VFR terminal area chart.

The pilot of the PA28 held a private pilot certificate with the appropriate class rating for the airplane he was flying.,. He had a total pilot time of 269 hours, 92 hours of which were flown in the PA28 and 76 hours of which were flown at night. He had successfully completed the written examination for an instrument rating on June 22, 1985, but failed the flight test on September 30, 1985. His performance was unsatisfactory in "tracking" during instrument landing system (ILS) and VHF omnidirectional range (VOR) instrument approaches and procedures. He had additional instruction and was approved for re-examination by his instructor on October 6, 1985, but did not retake his flight test. He held a current third class medical with the limitation that he wear corrective lenses while flying.

1.5.2 The Air Traffic Control Specialists

There were six air traffic control specialists involved in providing arrival air traffic service including the Newark departure controller. The positions staffed in the TEB control tower at the time of the accident were local control, ground control, flight data/clearance delivery, coordinator, and supervisor. Except for the supervisor who was hired by the FAA in 1958, all of the other controllers were hired after 1981. However, the flight data/clearance delivery controller had 4 years experience in the military controlling traffic. All were medically qualified for duty and all described their previous day's activities as normal with sufficient time for rest, ' (See appendix B for more details on their qualifications and experience.

The local controller reported he was unable to certify at the New York TRACON as the result of the heavy traffic volume at that facility, and he was reassigned to TEB. His training documents pertaining to the New York TRACON were not retained, nor was there a requirement to do so according to FAA air traffic personnel.

1.6 Aircraft Information

The Dassault Falcon, DA50, N784B, was owned and operated by Nabisco Brands, Inc. It is a low, swept wing airplane powered by three Garrett Turbine Engine Company TFE-731-3-1C turbofan engines. It was within the maximum gross takeoff and landing weight limits and allowable center of gravity limits at the time of the accident. The airplane had been maintained in accordance with current Federal regulations. It was equipped with standard exterior position lights and an anticollision light including strobe lights on the fuselage and wingtips.

The Piper, PA28-181 Archer, N1977H, was owned and operated by Air Pegasus Corporation, a flying club. It is a small, low wing, single-engine airplane powered by an AVCO Lycoming 0-360-A4M four cylinder reciprocating engine and a fixed pitch Sensenich propeller. It was also within the weight and balance limitations of the airplane at the time of the accident and it was maintained in accordance with current Federal regulations. It was equipped with two King NAV/COMM transceivers. The No. 1 NAV was found tuned to the TEB VOR and the COMM was tuned to the local control tower frequency. The No. 2 NAV was tuned to the Newark Automatic Terminal Information Service (ATIS) frequency and the COMM was tuned to the Essex County local control frequency. The airplane was also equipped with standard exterior position lights with a red anticollision light mounted on top of the vertical stabilizer and strobe lights located on the wingtips.

1.7 Meteorological Information

The accident occurred about 40 minutes after official sunset and between surface weather observations at TEB. According to astronomical data, sunset was at 1642, civil twilight ended at 1712, and nautical twilight ended at 1747. The following data are the surface weather observations taken at the times indicated:

> 1650 - Record - 10,000 feet scattered, 25,000 feet thin scattered; visibility -20 miles; temperature--65° F; dew point- 49° F; wind-220 at 6 knots; altimeter setting-30.17 in.Hg.
>
> 1750 - Record - 10,000 feet scattered, 25,000 feet thin scattered; visibility-15 miles; temperature--63° F, dew point--51° F; wind-200 at 6 knots; altimeter setting-30.18 in.Hg.

Based on the available upper air data, the winds below 2,000 feet were essentially from a southwesterly direction at less than 20 knots.

1.8 Aids to Navigation

The VOR distance measuring equipment (DME) located on the TEB airport was operating at the time of the accident. There were no reported problems with the navigation aid. The standard instrument approach procedure used by the DA50 was the VOR/DME-A. It begins at WANES, 10.8 DME fix on the 305° radial of the TEB VOR at or above 3,000 feet, and continues inbound to the CLIFO final approach fix, 4.8 DME from TEB. There is a mandatory crossing altitude of 1,600 feet at CLIFO. The procedure is completed by making a left or right circling turn from overhead the airport. The minimum descent altitude for all categories of aircraft is 1,000 feet msl. (See figure 1.)

1.9 Communications

There were no reported problems with airborne or ground communications equipment. However, because there were several airplanes operating at TEB the evening of the accident, the radio frequency was congested. (For further information concerning communications see section 1.17.2.)

1.10 Aerodrome Information

The TEB airport elevation is 9 feet msl and it is equipped with two runways--runway 01-19 and runway 06-24. Runway 19 was in use; it is 7,000 feet long, 150 feet wide, and equipped with high intensity runway lights.

There is a VFR air traffic control tower (ATCT) located east of runway 19. (See figure 2.) The ATCT is classified as a Level II tower by the traffic density which exceeds 270,000 takeoffs and landings per year. The ATCT provides daily 24-hour traffic control service. It is equipped with a bright radar indicator tower equipment (BRITE IV) display unit, flight data entry printout equipment (FDEP), VHF and UHF radios, and a telecommunication system for landline communications. It also provides automatic terminal information service (ATIS) on the TEB VOR frequency -- the instrument approach procedure in use was broadcast on the ATIS. It is not equipped to display minimum safe altitude warnings (MSAW) or low level wind shear alerts (LLWAS). All of the equipment was reported to be functioning satisfactorily.

The ATCT is staffed with 1 air traffic manager, 4 supervisors, and 12 controller specialists. The FAA reported the level of staffing was normal for this facility.

The traffic pattern altitude for small aircraft is 1,000 feet above ground level (AGL) and 1,500 feet AGL for turbine-powered or large aircraft (over 12,500 pounds). Since runway 19 was in use at the time of the accident, a left hand traffic pattern was in effect.

1.11 Plight Recorders

Federal regulations do not require either airplane to be equipped with flight recorders. However, Nabisco Brands, Inc., equipped its DA50 airplane with a Sundstrand, Model AV577-C CVR. Its casing had extensive fire damage; however, the magnetic recording tape was undamaged. The recording quality was good and a transcript of the last 12 minutes of the recording was prepared. (See appendix C.)

1.12 Wreckage and Impact Information

The main wreckage sites of the airplanes were about 700 feet apart. (See figure 10.) The wreckage was distributed over a four by eight city block area. Most of the wreckage scatter was concentrated in a six block area around the intersections of Walker Street and Sixth and Seventh Streets in Fairview.

The main wreckage of the DA50 came to rest at 228, 230, and 232 Cliff Street in Cliffside Park. (See figure 11.) These three residences and the airplane were destroyed by the severity of the impact forces and subsequent fire. Two adjacent buildings and several automobiles were heavily damaged by fire and flying debris. One resident was killed at 228 Cliff Street and two bystanders were seriously injured. The left wing of the DA50 struck a light pole, landed at the intersection of Anderson Avenue and Kamena Street, and partially burned.

The main wreckage of the PA28 came to rest on the sidewalk in front of an apartment on Kamena Street in Fairview. It hit the ground from a near vertical descent. There was some impact damage and substantial fire damage to a porch and a nearby parked automobile. (See figure 12.) The engine with the propeller and spinner attached penetrated the roof of a cabana in a near vertical angle in the backyard of a residence on Third Street. No one was killed or injured from the wreckage of the PA28.

The accident sites were surveyed, and the wreckage was examined and documented and moved to TEB for further examination. The physical evidence showed that the leading edge of the left wing of the DA50 at about midspan collided with the right side of the engine compartment of the PA28. (For details of the collision reconstruction see section 1.17.4.)

Examination of the remnants of the various exterior lights from the DA50 did not establish whether they were on or off at the time of the accident. Only the PA28 rudder navigation light bulb and the right wing tip light bulb were recovered. The rudder light bulb was intact and showed no evidence that it was on at the time of the collision. The right wing tip light bulb filament was broken away from the support posts. However, scanning electron microscope examination of pieces of the filament that remained attached showed typical brittle fractures and no evidence of melted or resolidified filament material which would have indicated that the light was on. The Safety Board was not able to determine if the wingtip strobe lights were on at the time of the collision.

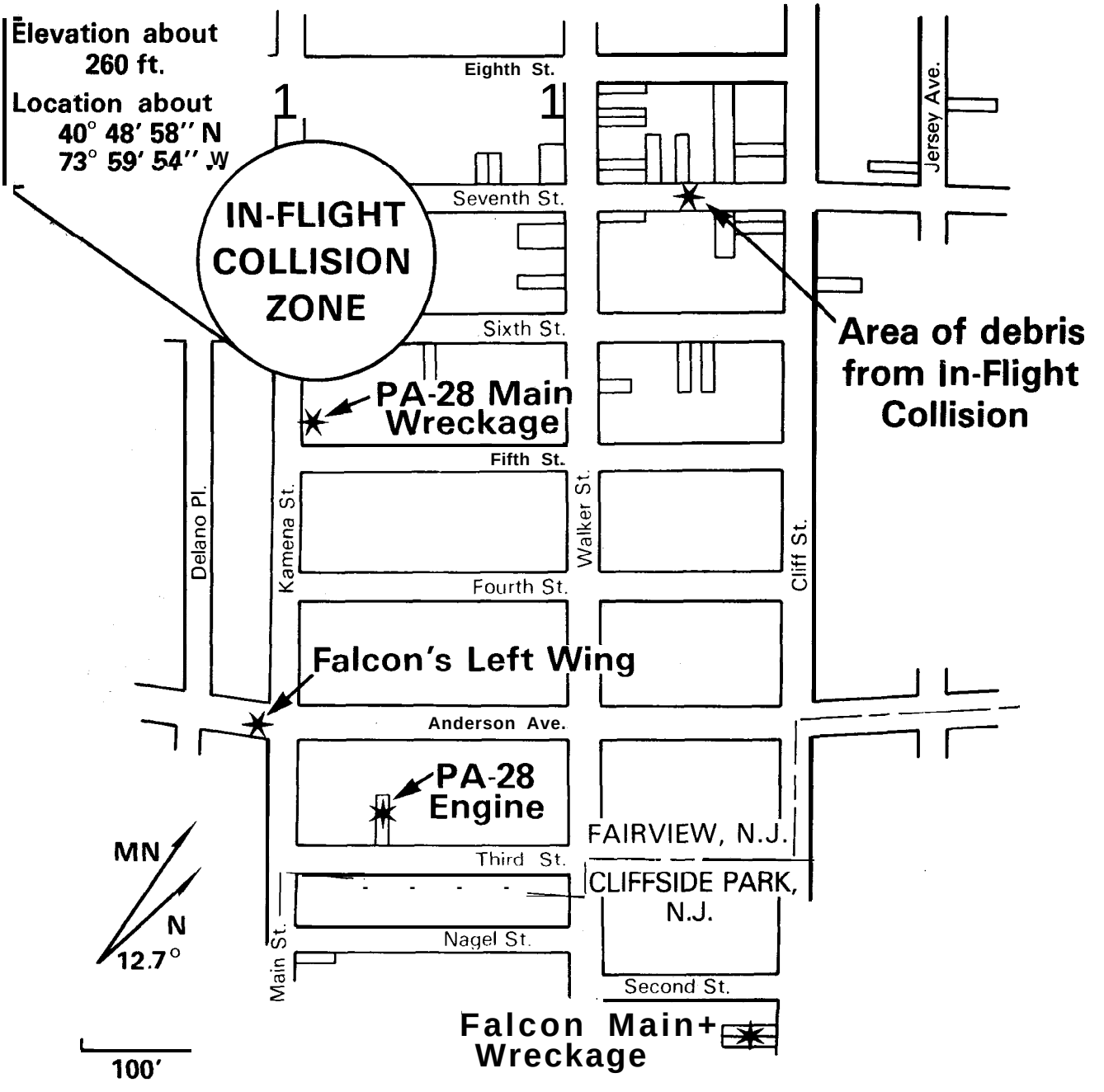


Figure lO.-Accident site location chart.

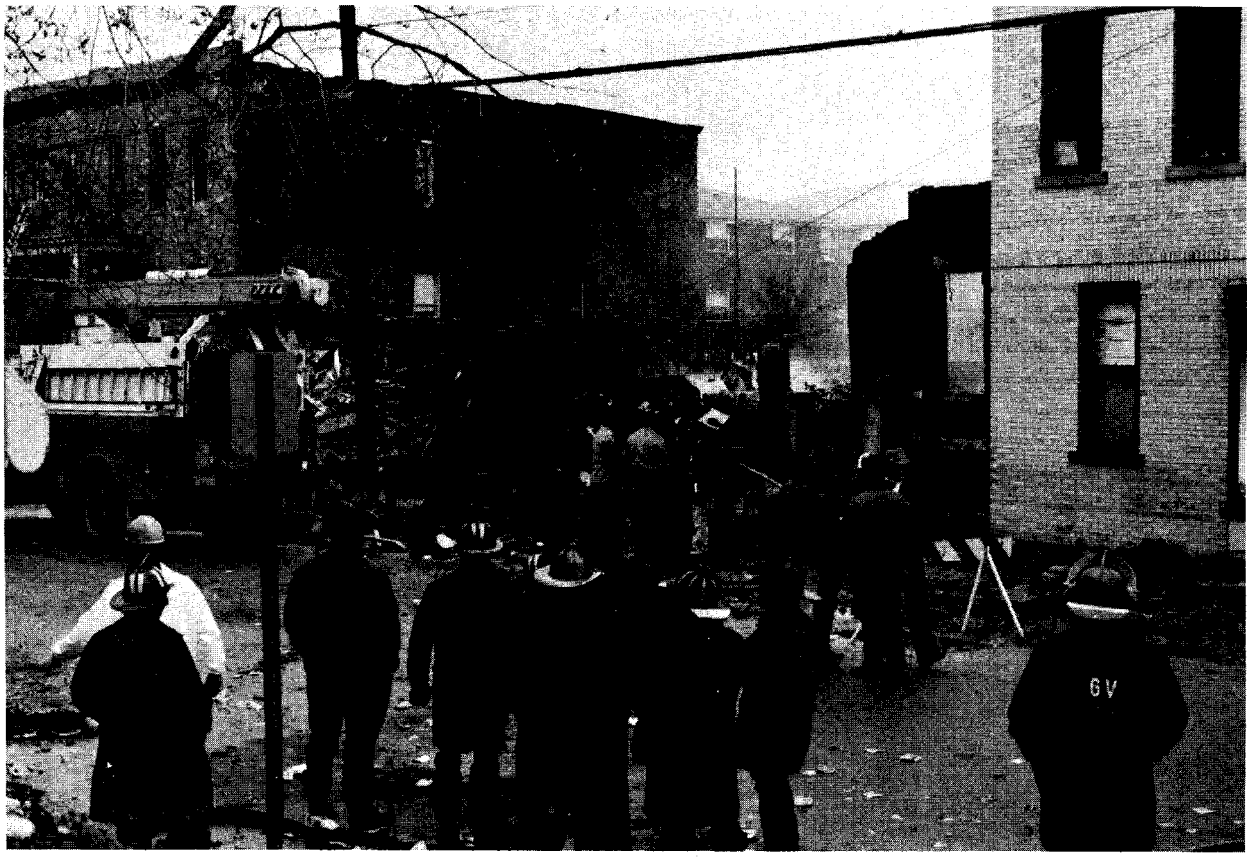


Figure 11.—The main wreckage site of the DA50 on Cliff Street, Cliffside Park, New Jersey.

1.13 Medical and Pathological Information

Postmortem examinations performed by the Bergen County Medical Examiner's office disclosed no evidence of pre-existing disease in any occupant of either airplane. The DA50 flightcrew sustained massive traumatic injuries as a result of the impact with the apartment building. The PA28 occupants also sustained massive traumatic injuries as a result of the in-flight collision.

The supervisor on duty in the TEB control tower at the time of the accident reported that he had suffered a heart attack and underwent a quintuple coronary by-pass operation 3 to 4 years before the midair collision. He stated that he was under daily medication. There were no reports or a record showing that he had experienced adverse side effects from the prescribed medication. He was medically certified for duty by the FAA's Eastern Regional Flight Surgeon's office.

Figure 12.-The main wreckage site of the PA-28 on Kamena Street, Fairview, New Jersey.

Toxicological samples obtained from the DA50 flightcrew were unsuitable for tests. The toxicological tests of the PA28 occupants were negative for alcohol and basic drugs.

The TEB coordinator was the only controller that provided a urine sample 5 days after the accident for toxicological examination. The tests were negative for alcohol and drugs.

1.14 Fire

The split and buckled panels of the left wing of the DA50 showed that the pressurized fuel cell exploded after the collision resulting in an in-flight fire in the left wing. A severe ground fire erupted at the crash site of the main wreckage of the DA50 and there was a substantial fire at the crash site of the PA28.

The Cliffside Park Fire Department responded to the crash site of the DA50 with 8 fire trucks, 2 aerials, 1 water tower platform, 4 rescue units, and 26 firefighters. The fire in the apartment building on Cliff Street was attacked with water only. A broken natural gas main in the destroyed building hampered efforts to extinguish the fire, and it was not brought under control until 8 to 9 hours later.

The Fairview Fire Department responded to the crash site of the PA28 with three fire trucks and a ladder truck. A fire truck from the Guttenberg Fire Department also was used. Four other companies and about 70 firefighters responded. Seven fire and rescue departments from the surrounding municipalities responded with a total of 160 to 180 rescue personnel. One 5-gallon can of foam concentrate with an 8 percent protein base was used to extinguish the fire which was concentrated in the cabin of the airplane. The-fire was brought under control in less than 15 minutes. The fire was confined to the airplane, to the facade of the apartment building, and to an adjacent parked vehicle.

Fairview and Cliffside Park did not have community disaster plans. Both communities depend on Bergen County and the State of New Jersey for large-scale disaster response planning and execution. Neither Bergen County nor the State of New Jersey disaster plans were activated because local authorities did not consider that the scope and magnitude of the emergency warranted activation of the plans. However, the State emergency management personnel responded to the scene and provided aid, personnel, and equipment on an "as needed" basis.

1.15 survival Aspects

The accident was not survivable.

1.16 Tests and Research

Not applicable.

1.17 Additional Information

1.17.1 Flight Operations

General.-The flight department at Nabisco Brands, Inc., was formed in 1966 to transport company personnel. The company operated four airplanes under the provisions of 14 CFR Part 91 (general operating rule) -- Learjet Models 35 and 55, and two

DA50's. The company employed 11 pilots, a director of flight operations, a chief pilot, 4 captains, and 5 first officers. All pilot flight training was accomplished by Flight Safety International at TEB. The company employed a maintenance manager and mechanics who perform routine maintenance and inspections of all their airplanes.

Flight Procedures.-The following is a summary of some of the pertinent procedures practiced by the company:

- IFR flight plans are normally filed for all passenger flights.
- The nonflying pilot will read back all ATC clearances and they will be acknowledged by the flying pilot.
- The challenge and response system is used when using the checklist.
- A speed of not more than 200 KIAS will be used in airport traffic areas when possible.
- It is recommended for the DA50 that a circling approach be flown with flaps 20°, gear down, at 140 KIAS, or Vref +20, whichever is greater, until aligned with the runway.
- Standardization - flightcrews are periodically observed on flights by designated additional crewmembers and evaluated on their conformance with standard company operating procedures.

The Director of Flight Standards for a large executive air fleet at TEB who employs about 100 pilots, reported that their procedures when flying the DA50 on the VOR DME approach are to extend the wing slats and set the flaps to 20° when passing WANES. They slow the airplane between 160 to 140 KIAS approaching CLIFO and cross the airport between 150 to 140 KIAS. They use 140 KIAS as a minimum maneuvering speed with 20° flaps and with slats extended.

Air Pegasus Corporation is a nonprofit flying club founded in November 1981 with three members and a Cessna 152. At the time of the accident, the club operated four airplanes -- a Piper PA28-151, PA28-181, PA28R-201, and the Cessna 152 under the rules of 14 CFR Part 91. Based at the Essex County Airport, Caldwell, New Jersey, it had 70 members. The club has designated instructors to check out new members in the airplanes and to checkout any member who has not flown within 60 days. The club publishes and distributes to all members a monthly newsletter containing operational and safety information. Aircraft maintenance is the responsibility of the club's vice president of maintenance and it is performed under contract with a maintenance facility at Essex County Airport.

Pilot Interviews.-According to a Nabisco Brands captain, the DA50 flightcrew had a good practice of scanning inside and outside the cockpit. He reported that, except for the taxi light, all the other exterior lights would have been on during the flight from Morristown to TEB according to company procedure. These would have included the fuselage and wingtip strobe lights, the anticollision light, navigation lights, landing lights, and probably the tail recognition light. He also stated that he noted in a review of the accident information that the DA50 crew was given a turn to the final approach

course well inside WANES which is 10.8 miles from TEB. It was his experience, even in visual meteorological conditions to be at least about 8 miles from the airport before being given the turn to intercept the final approach course.

According to a pilot friend of the PA28 pilot the customary procedure to follow when flying to the Hudson River from Caldwell would be to climb initially to 2,000 feet then descend to 1,800 feet to avoid entering the Terminal Control Area (TCA) from the west. Radio contact would be made with the TEB control tower about 5 to 6 miles before entering the airport traffic area. Before crossing the Passaic River west of TEB a descent to 1,500 feet would be made. The flight would proceed over the airport heading east and arrive at the Hudson River at 1,000 feet, 4 to 5 miles south of the George Washington Bridge and then turn right and head south to tour the area. The route would be reversed on the return flight.

The friend of the pilot reported that from his previous experience he considered the pilot to be vigilant and to have a good scan pattern inside and outside of the cockpit. He likely would have had all of the lights on while transiting the area including the landing lights. He said that the passengers had flown with the pilot before, but that the pilot would not have allowed either of them to fly the airplane unless they were qualified pilots which they were not. He also stated that 5 days before the accident the pilot told him about his bitterness toward the New York TRACON because they did not care about general aviation and were not cooperative about extending invitations to visit their facilities.

1.17.2 ATC Operations and Procedures

TEB underlies the New York (Group I TCA) and is bordered on the east by the LaGuardia Airport traffic area and to the south by the Newark International Airport traffic area. Of the nine Group I TCA's around the country, the New York TCA is the only one which has airspace extending to the surface of three major airports. Normally, TCA airspace extends to the surface at only one "primary" airport. The TCA airspace over TEB begins at 1,800 feet and extends up to 7,000 feet. The eastern edge of TEB's airport traffic area ends at the western edge of the Hudson River and it overlaps the TCA airspace for La Guardia which begins above 1,100 feet above the ground. The New York TRACON (Newark Sector) has approach control jurisdiction over the airspace between Morristown and TEB. An automated radar tracking system (ARTS IIIA) computer is used at the New York TRACON. This system has the capability to track all primary radar targets and transponder equipped aircraft. The computer displays alpha-numeric information on the radarscope at the controller% position. This information is recorded and stored on computer discs as part of the continuous data recording (CDR) feature in the facility.

The BRITE installed in the control tower at TEB is a closed circuit monochromatic television repeater which displays radar data from the antenna site located at the Newark airport. The TEB airport is depicted in relation to the Newark airport. The system displays primary and single slash transponder beacon information detected by the radar site. The BRITE does not display ARTS alpha-numeric data and does not incorporate range marks. The lack of ARTS digitized information precludes display of minimum safe altitude warning and conflict alert features.

Appendix 4 of the TEB Control Tower Order 7110.10A directs that the local controller may use the BRITE in accordance with FAA ATC Handbook 7110.65 as an aid in

providing traffic advisory services to aircraft operating in the airport traffic area. It further states that visual scanning shall remain the primary method of sequencing and separating traffic.

A "Letter of Agreement" (LOA) dated April 27, 1984, between the New York TRACON and the TEB control tower entitled "Interfacility Coordination Procedures and Responsibilities" required the TRACON to accomplish the following regarding aircraft under their control arriving at TEB:

1. Forward the following information to TEB 10 minutes before an aircraft's arrival estimate or as soon as possible-identification; aircraft type; type of approach if other than the primary approach in use; and runway if other than the primary runway in use.

2. Coordinate all IFR arrivals which will enter the airport traffic area from a direction other than from over the final approach fix in use.

3. Advise the tower when an arrival is 10 miles from the airport.

4. Transfer communications to the tower. prior to the final approach fix or entering the airport traffic area.

The TEB control tower is required to notify the New York TRACON of the following:

1. Visibility and wind changes not shown in current weather observations.

2. Airport conditions which may affect air traffic.

3. ATC instructions which will affect traffic under the TRACON's control.

Flight progress strips are used to post current data on air traffic movements and to record clearances required for control and for other ATC uses. These strips may either be handwritten or machine generated by a Flight Data Entry Printout equipment (FDEP). Handwritten strips are required to conform to the same format as machine generated strips. Each air traffic control facility can establish some data transmission parameters tailored to the local needs and capabilities of the facility, provided any deviations from national standards are written in facility directives.

The normal processing procedure for a flight into TEB includes the following steps:

1. Pilot files an IFR flight plan at least 30 minutes before estimated departure time (ETD).

2. The flight plan is forwarded to the New York air route traffic control center (ARTCC).

3. New York ARTCC transmits the departure flight plan in two ways:

   a. An FDEP strip is transmitted to the New York TRACON and the tower serving the departure airport if equipped with FDEP, 30 minutes before ETD.

   b. An ARTS flight plan is transmitted to the New York TRACON ARTS-IIIA computer 15 minutes 2/ before ETD.

4. Receipt of an FDEP departure strip constitutes ARTCC issuance of an IFR clearance as specified by the operational LOA. This means that a terminal facility (TRACON or tower) can issue an IFR departure clearance in accordance with the LOA. Departure clearances include discrete beacon code assignments.

5. When the aircraft departs and is squawking the appropriate beacon code, automatic radar target acquisition will normally occur on the ARTS radar display. This means that a flight data block automatically associates itself with the radar/beacon target on the radarscope.

6. A departure message is required by New York ARTCC to initiate subsequent computer processing for an active flight plan. This includes en route and arrival FDEP strips and ARTS flight plans distributed according to route of flight, altitude, and airspace boundary criteria (ARTCC data base).

7. A departure message can be initiated in one of three forms:

   a. ARTS generates an automatic departure message upon auto acquisition, provided ARTS has the flight plan from ARTCC; the aircraft transponder replies with the proper beacon code; and the ARTS properly tracks the aircraft.

   b. Transmitted to ARTCC by a controller making an entry with the FDEP.

   c. Activation via telephone to ARTCC.

The ATC sequence of events for the DA50 flight into TEB was as follows:

1. At 1639 the flightcrew filed an IFR flight plan with the Poughkeepsie FSS for a flight at 1730 from Morristown to TEB.

2. At 1654 the DA50 flightcrew requested its IFR clearance. Since Morristown was not equipped with an FDEP machine, it was not automatically notified of the flightplan. The Morristown clearance delivery controller requested the information from the TRACON via landline since the proposed departure time was more than 30 minutes away. However, the TRACON did not yet have the information from the ARTCC.

2/ Normal parameter - frequently reduced to 10 minutes by ARTCC during periods of heavy activity.

3. At 1706 the air traffic assistant at the TRACON contacted Morristown and provided the clearance from the flight strip after it was printed by the FDEP machine. Three minutes later the assistant gave the strip to the radar departure controller.

4. At 1710 the DA50 was cleared for takeoff. Ten seconds later the departure controller told the coordinator at TEB by landline that the DA50 "is inbound just rolling at Morristown *this* time . . . ." The coordinator acknowledged the report by giving his operating initials, 'lima golf."

5. At 1712:02 the departure controller established contact with the DA50. Automatic aquisition of the beacon target by the computer did not occur because the airplane departed earlier than planned and before the receipt of an ARTS flightplan from the ARTCC computer. He had to initiate a manual ARTS track of the airplane about 1 minute later. The lack of automatic aquisition negated all subsequent automatic ARTS functions and interfacility communication including transmission of an arrival strip at TEB.

At sometime after notification from the TRACON that the DA50 was departing Morristown, the TEB tower coordinator asked the clearance delivery controller to assume the responsibility for his position and left the tower cab about 1710 for the restroom. The tower coordinator did not "sign off" of his position in a log as required, nor did he provide a relief briefing in accordance with the prescribed checklist. He told the clearance delivery controller that there was no inbound traffic that the local controller did not know about.

The clearance delivery controller agreed to cover the position, but she did not sign the log to assume the position. At 1718:08, the departure controller told TEB, ". . .Falcon seven eight four bravo is a mile from CLIFO." The clearance delivery controller took the "progress report" and told the local controller of the report. She stated that she reported out loud to the local controller that the DA50 was at CLIFO. However, the local controller, who was wearing a headset did not hear the clearance delivery controller and was not aware the DA50 was inbound until 1719:54 when he asked who reported over CLIFO.

After the clearance delivery controller's report to the local controller, she stated she observed the ground controller get up, move over to the local controller, and reposition a flight strip which she assumed was for the DA50, implying that her coordination report had been accomplished. However, the ground controller did not recall getting up and moving a strip at that time. He did not write a strip until after the DA50 reported overhead. None of the controllers in the control tower reported knowing if a machine generated flight strip existed. In this case the coordinator was required to write a strip for use by the local controller at the appropriate time.

Upon learning of the DA50's position, the local controller described the PA28's position as 1 o'clock and westbound based on looking out the window of the tower cab and by observing the BRITE display. The PA28 was actually eastbound as it had been all during its transit through the airport traffic area. On another occasion the local controller informed the PA28 pilot that he was being overtaken by the DA50. However, either the transmission or the acknowledgement was blocked by another aircraft or the PA28 pilot did not acknowledge the transmissions as indicated by the record of ATC

communications. The DA50 was made aware again of the PA28's position when the local controller transmitted, "You're closing on him, he's, uh, light aircraft at, uh, your one to twelve o'clock westbound." The DA50 captain then reported that they had the traffic in sight. The local controller instructed the flightcrew to ". . . maintain visual," but they did not acknowledge the instruction. At 1721:50, the local controller asked N784B if it still had the traffic in sight, but there was no response from the aircraft.

The local controller testified that he would have cleared the PA28 to transit the area despite knowing about the DA50 inbound flight. He stated that all he needed was an inbound call at CLIFO in order to have provided adequate advisories for traffic sequencing. He admitted that he was surprised to learn about the location of the DA50 and that he was busy with other airplanes at the time. He characterized the traffic volume as moderate and building. He stated that he did not know which airplane the flightcrew was referring to when they called the traffic in sight at their initial call overhead the airport (1719:56). He stated it could have been the Twin Cessna, N1959T or the PA28.

The supervisor testified that under conditions of increasing air traffic he can decide to establish a second control frequency. The purpose of establishing two local control positions is to reduce frequency congestion and controller workload. This would take the form of a controller staffing an outer control position (an area 2 to 5 miles from the airport) and an inner control position which is normally staffed by the local controller. The outer control position would operate as a feeder position for arrivals into the airport and the arrivals would be assigned to the local (inner position) controller for sequencing into the traffic pattern. The implementation of this procedure on the evening of the accident would have required using the coordinator as the outer local controller, with the other controllers shifting positions and the supervisor taking over the flight data/clearance delivery position. The supervisor stated that it would take several minutes to implement the procedure and the change would be broadcast on the ATIS. Essentially he reported the procedure was not implemented because he was not aware of excessive workload on the local controller. In addition, he reported that ". . . everything seemed to be going normally and smooth. . . . Other than the normal Sunday night situation. . . it was after sundown, so our late evening Sunday arrivals were coming back."

The manager of the Terminal Procedures Branch of the FAA in Washington, D.C., testified that a decision to permit an aircraft to transit an airport traffic area is at the discretion of the local controller. It is a subjective decision based on the traffic conditions that exist at any particular time. Except for the fact that the flight progress strip was not given to the local controller until after the DA50 was overhead, the manager found nothing wrong with the way the coordination attempt between the facilities was accomplished. In his opinion, the absence of a strip should not have created difficulty for the controller because, "VFR tower controllers are not involved in the manipulation of strips . . .notepads is [sic] basically what they use . . . those are essentially used only as memory joggers. They are not how you sequence your traffic, but [are used1 for a planning tool . . . it is a valuable assistance to the controller to know something is going to occur."

FAA ATC Handbook 7110.65D, Chapter 3, Paragraph 3-11, Airport Traffic Area Restrictions, states, "If traffic conditions-permit, approve a pilot's request to cross an airport traffic area. . . ." When the manager was asked if he thought it would have helped the local controller to know about the DA50's inbound flight before he approved the PA28's overflight, the manager said, "In my opinion and based on my experience, I

would say no." Paragraph 3-90 of the handbook also provides the correct phraseology to be used to establish the sequence for landing aircraft. The order of the phraseology to use is: landing sequence number followed by a description and location of the traffic.

The TEB control tower was not equipped with interphone capability for controllers at the time of the accident. Since it was a small tower cab and controllers worked close together, they routinely coordinated traffic verbally with one another. Also, it was customary for them to log and manage VFR traffic using notepads. Flight strips were used primarily for IFR traffic.

Further investigation disclosed that the TEB controllers differed on the frequency, but they had experienced several instances where IFR inbound traffic was not previously coordinated in the tower, and several instances where aircraft would not make their initial call at CLIFO until over the airport. In addition, there was confusion over the terms and procedures regarding a compulsory reporting point. The supervisor was unclear about terminology and references in support of reporting requirements. Also, it was not routine for the controllers to sign on and off their positions during rotation or relief which was contrary to FAA Order 7210.42 of April 25, 1982. Moreover, there were no regular staff meetings to resolve these problems.

1.17.3 Radar Ground Track Plot and Cockpit Visibility Studies

Radar data recorded by the New York TRACON radar site located at the Newark International Airport were used to reconstruct the flight paths of both airplanes and to derive the cockpit visibility studies. The data was recovered from the ARTS-WA system and covered a period from 1700 to 1730. Airplane performance parameters were derived from processed radar data, meteorological data, and airplane information using a computer program. (Appendix D provides data on the probable ground tracks of both airplanes based on the radar data.)

In view of the fact that there were several other airplanes in the airport traffic area, the radar data was evaluated to determine whether any of these other airplanes could have been mistaken for the PA28 by the DA50 flightcrew. For example, the fightpaths of N68734, N1959T, and N72BG were examined to determine if they played a role in the sequence of events. Their flightpath time histories relative to the accident airplanes were determined from the same radar data. Examination of this data also revealed the presence of an unidentified aircraft flying in a northerly direction about 3 miles east of the collision about the time of the accident. The aircraft type could not be determined and no altitude information from the aircraft was available.

A cockpit visibility study was conducted to determine the visibility from the pilot seats of the DA50 and the PA28. To accomplish this, the viewing angles from the DA50 to the PA28, N1959T, and N72BG, and the viewing angle from the PA28 to the DA50 were calculated and plotted on the respective aircraft binocular fields of vision. 3/ The calculations were based on the flightpath and attitude time histories for each aircraft as derived from the recorded radar data. Since angles for each airplane were plotted in relation to the design eye reference (DER) points for each airplane%

3/ Photographs taken by a camera which uses two lenses to simulate the average interoccular distance between the human eyes. The photographs show the outline of cockpit windows as seen by the respective crewmembers when he turns his head fully. The shaded areas within the window outline indicate those areas of the window exposed only to monocular vision of the crewmember.

windshields, they are based only on a single-fixed eye position. Many potentially critical factors such as movement of the pilot's head, darkness, background clutter from ground and skyline lights, and airplane lighting were not addressed in these studies. (See figures 13, 14, and 15.)

The radar data showed that the PA28 had penetrated the TCA west of TEB while at 2,000 feet msl. The base of the TCA at this point is 1,800 feet msl. At 1717:25 when the PA28 pilot reported 10 miles west of the airport, he was actually 5 miles west. Its ground track gradually changed from 094° to 136°. The Mode C altitude was 1,650 feet (± 50 feet). Its average speed was about 115 KIAS and average ground speed was 123 knots. At 1718:39, the PA28 was about 2 1/4 miles west of the airport. The last eight radar returns indicated that the PA28 was in straight and level flight. The DA50 was on a ground track of about 130° passing CLIFO (about a mile to the northeast) at 1,700 feet and about 188 KIAS with a ground speed of about 194 knots. The DA50 turned slightly to the left as it passed over the airport at 1,500 feet at 1720. The speed was about 165 KIAS and gradually decreasing. The DA50 began a slight right turn at 1720:13 and overtook the PA28 passing about 1/2 mile to its right on a ground track of about 130° at 1,500 feet and about 140 knots. About 1721:02 the DA50 initiated a level left turn which was maintained until moments before the collision.

At the time of the collision at 1721:30, the DA50 was at a ground speed of about 155 knots and the PA28 ground speed was at about 115 knots. Based on the radar data the ground track angle between the two airplanes was about 45° and the rate of closure was 100 to 110 knots.

1.17.4 Collision Reconstruction

Damage to the right side cylinder rocker box covers of the engine in the PA28 was matched to the damage on the outboard left wing slat of the DA50. The propeller from the PA28's engine slashed through the DA50's left wing inboard of rib 12 at about a 75° angle. Black paint from the blade face (back of the blade) was found on the slat skin. The propeller cut through the front wing spar and one propeller blade separated 8 inches from the tip. The other blade struck but did not penetrate the upper center wing panel. Damage to the cabin door on the right side of the PA28 matched the outboard indentation in the left wing slat. The distance between the two separate slat indentations coincided with the distance between the PA28's engine and the top cabin door latch. Scratch marks on the lower surface wing panels and outboard flap of the DA50 indicated that the PA28 traveled under the DA50's left wing tearing off the outboard section of the outboard flap and destroying the top of the cabin of the PA28.

Since the radar data showed that the PA28 was in straight and level flight moments before the collision, it was estimated that it would have been in a 4°-noseup, wings level attitude. Based on the physical damage, the DA50 was in about a 21°-right bank relative to the PA28. The collision angle between the two aircraft, as indicated by the initial propeller slash mark, was about 75°. (See figure 16.)

Fire-damaged, bulged, and split wing panels showed that the pressurized fuel cell in the DA50's left wing exploded at the time of the collision at the point where the propeller cut through the wing spar. The damaged spar and upper wing panels destroyed the structural integrity of the wing box structure and the wing separated in an upward direction.

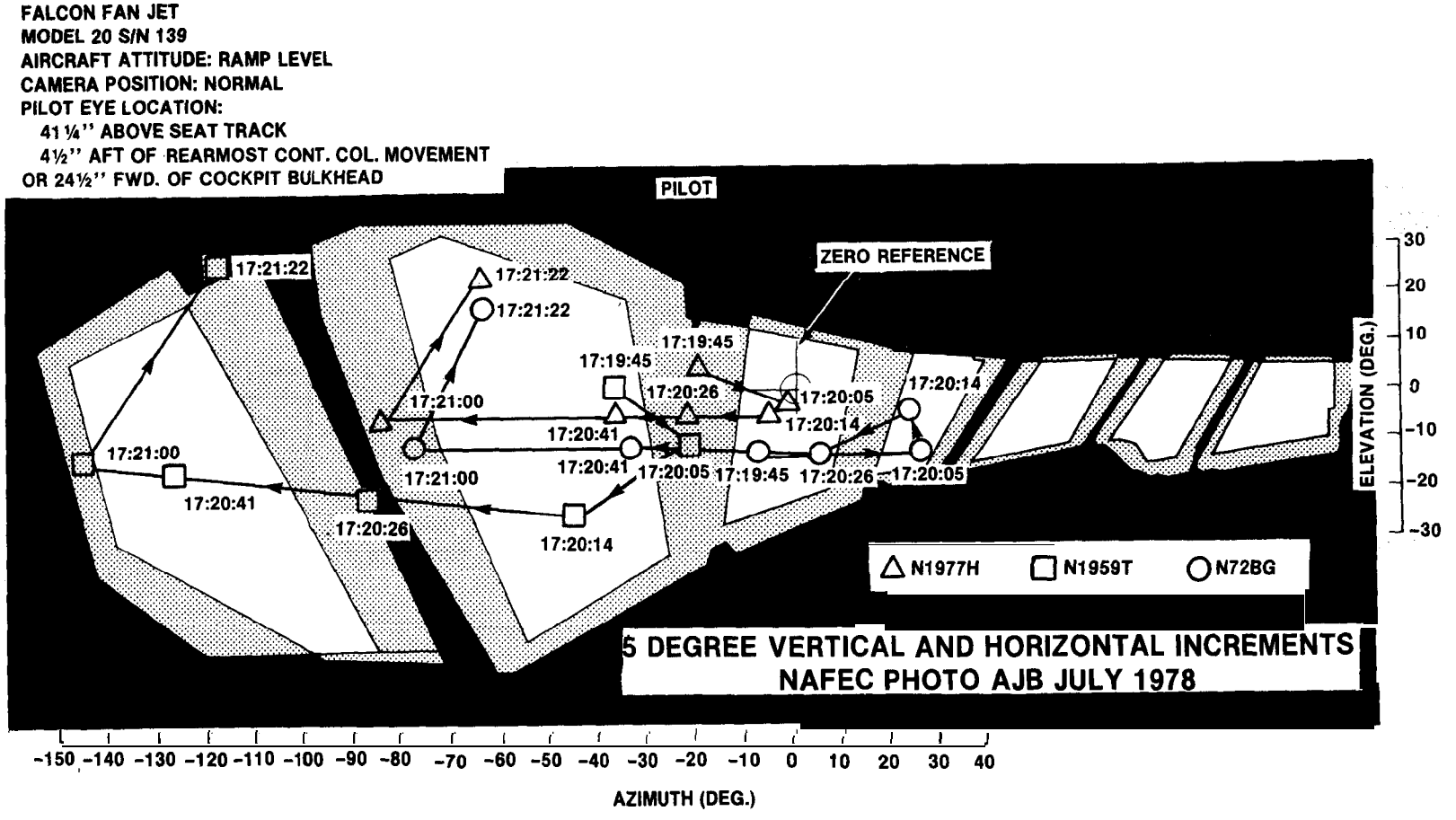


Figure 13.-Cockpit visibility study for the DA50 captain.

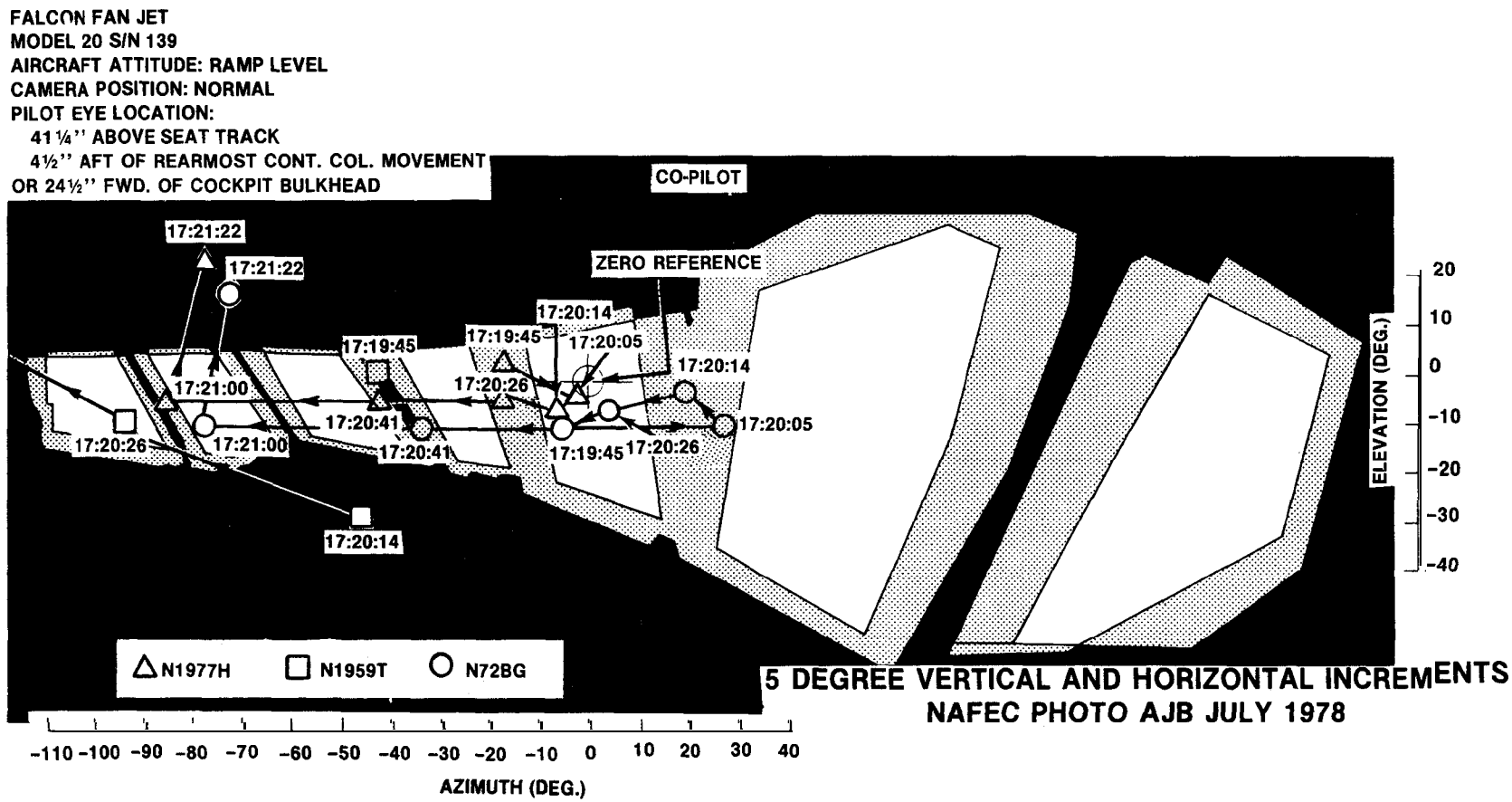


Figure **14.—Cockpit** visibility study for the DA50 first officer.

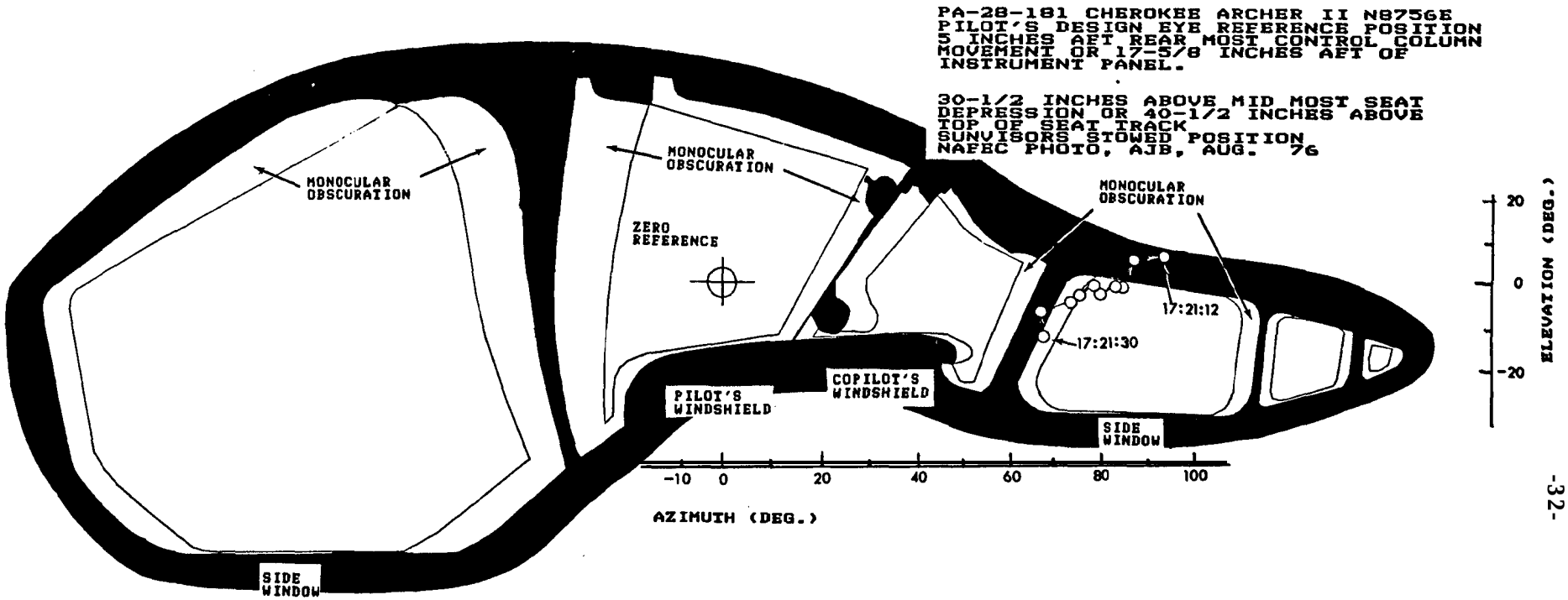


Figure 15.—Cockpit visibility study for the PA28 pilot.

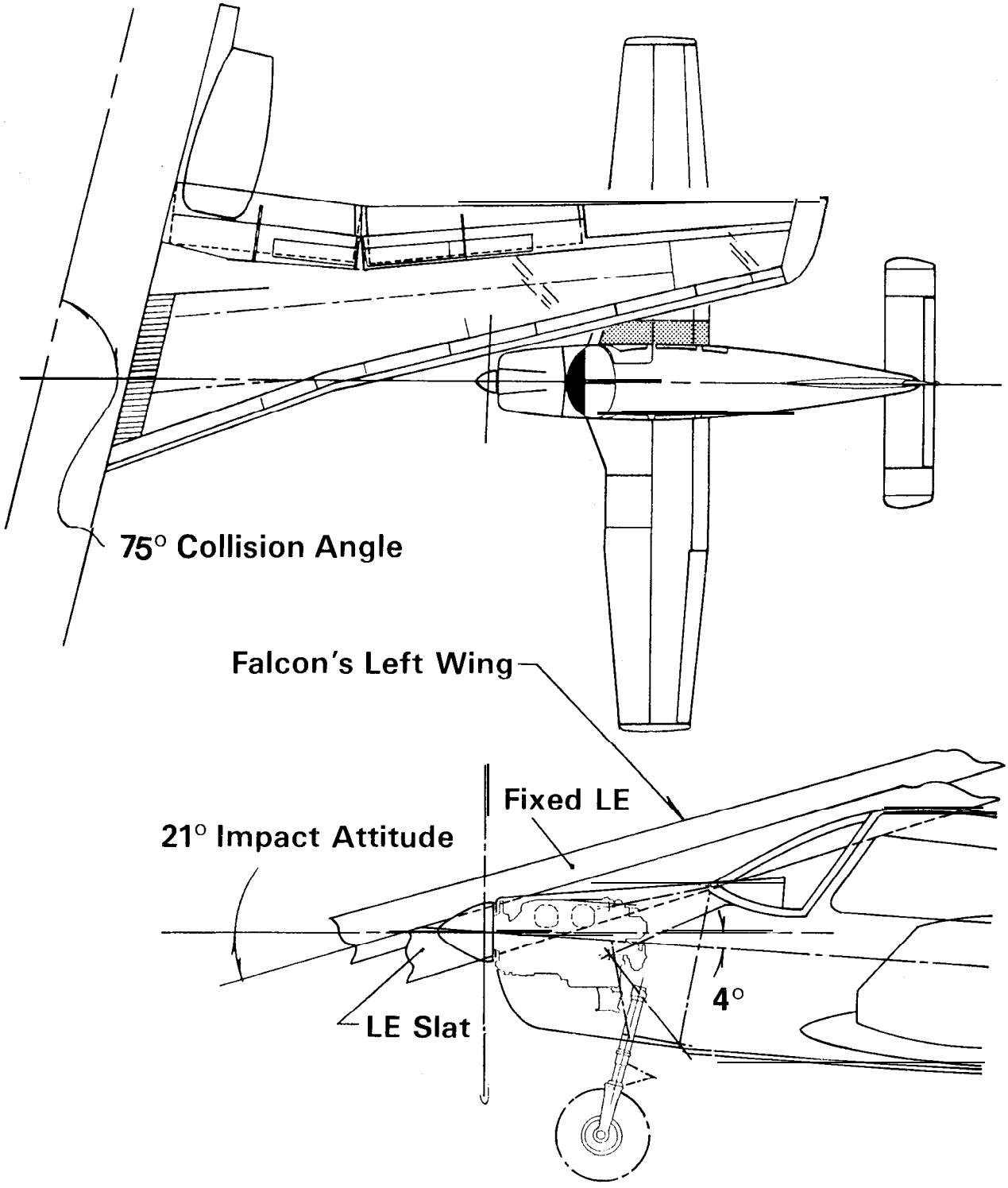


Figure 16.—Collision angle and relative impact attitude.

1.17.5 Collision Avoidance

Regardless of whether or not an aircraft is operated under IFR or VFR, 14 CFR Part 91.67, Operating and Flight Rules, requires that weather permitting, pilots shall maintain vigilance in order to "see and avoid" other aircraft. The aircraft with the right-of-way shall not be passed unless it is well clear of the other aircraft. In this accident, two right-of-way rules applied -- overtaking and converging. The aircraft that is overtaken has the right-of-way and the overtaking aircraft must alter its course to the right, and pass well clear of the other aircraft. In the case of two aircraft of the same category, that are converging at the same altitude, (except in a head-on situation) the aircraft to the other's right has the right-of-way.

In an attempt to alert and to assist pilots to maintain vigilance and to understand the "see and avoid" concept, the FAA published Advisory Circular (AC) 90-48C, "Pilot's Role In Collision Avoidance." It emphasizes the potential hazards and the basic problems related to human factors involvement in midair and near midair collisions. The AC discusses topics such as visual scanning techniques, airspace/flight rules/operational environment, use of communications equipment and air traffic advisory services, and airport traffic patterns. The FAA stresses that pilots "should be familiar with, and exercise caution, in those operational environments where they may expect to find a high volume of traffic. . .especially in the vicinity of major terminals and military bases." The AC recommends that pilots compensate for blind spots due to aircraft design and flight attitude by moving their heads and maneuvering the aircraft. It urges pilots to take advantage of air traffic advisory services available to VFR aircraft. It also reminds pilots about the controller's problems of visual acuity, aircraft conspicuity, and workload. Pilots cannot always expect timely traffic advisories from controllers since their primary responsibility is to separate aircraft and issue safety alerts (i.e., suggested headings and altitudes to avoid potential conflict) to aircraft under their control. Thus, the FAA states that traffic advisories are not a substitute for vigilance.

In addition, AC 90-48C references an attached distance-speed-time chart in recognition of the time required for a pilot to first detect conflicting traffic, make a decision, and take evasive action if necessary. (See appendix E.) The FAA estimates from military derived data that the time required to "see and avoid" is 12.5 seconds. The cognitive events to be accomplished within this time are target detection and recognition, judgement and decision, the behavioral avoidance action, and the time required for the aircraft to respond to the pilot's evasive action.

1.17.6 Physiological and Environmental Limitations

The physiological and environmental limitations that pertained to this accident were the ability of the pilots to have seen one another and to take evasive action under conditions of darkness in an airport traffic area and under control of a VFR tower. Factors which could have had an affect on pilot performance under these circumstances include the conspicuity of a target, task variables, distractions, stress, age, fatigue, and weather and light conditions. These factors can distract pilots from effectively using the "see and avoid" concept and can also adversely affect the performance of ATC's. Research data indicate that the human eye (20/20 vision as measured by the Snellen eye chart) is capable of identifying letters of the alphabet if these letters subtend

a visual angle 4/ of at least 0.08' or 5 minutes of arc. Letters are considered highly discriminable whereas target identification can be quite complex. Testimony from Dr. Stanley N. Roscoe, an aviation engineering psychologist, disclosed that for most people the eye does not focus at optical infinity when at rest in the dark or when looking into the sky as previously believed for many years. On the contrary, the eye focuses at a distance of about one arm length or about the distance to the instrument panel or windshield in an airplane. When focused at this short distance, the eyes become somewhat trapped at this focus when there is no texture or contrast in the background such as an empty sky when flying or at night. His research and experiments 5/ confirmed that under conditions of darkness, the eyes tend to focus in close. Since apparent size is directly related to the distance of focus, the closer in the focus, the smaller an object will appear to be and the higher it will appear in the visual field.

With the human tendency to focus the eyes too near at night, there is a loss of contrast in the visual field and a corresponding decrement in peripheral vision. The ability to focus and judge distance in the daytime is enhanced significantly because of the predominance of various texture gradients. As a result, it is much easier to determine another airplane's attitude and flightpath during the day than at night based upon visual cues. Although lights make an object more conspicuous at night, point light sources do not serve as a good stimulus for focus even if there are many lights such as in as city background. Therefore, position lights on an aircraft at night are not especially useful to a pilot in determining the aircraft's attitude and flightpath. Thus, a pilot must rely on relative motion to a large degree in making the determination at night.

Dr. Roscoe went on to report that target detection at dusk is particularly difficult because of the significant reduction in contrasts and texture and the illumination from lights are not in full effect. Since the accident took place over a large metropolitan area with a high illumination of the ground and skyline, with numerous point light sources, target acquisition and flightpath determination by the pilots would have been very difficult. He testified that a 12.5-second response time is nominal and reasonable under daylight conditions but not at night. In his opinion, it would take longer for a pilot to "see and avoid" another aircraft at night.

1.17.7 FAA Corrective Actions

Following the accident, the FAA had taken several steps to prevent a similar reoccurrence and to correct discrepancies at TEB. Among these were that VFR overflights must now be approved by the supervisor on duty. The use of flight data strips has been emphasized and the use of controller scratch pads is being phased out. A video map now has been incorporated into the BRITE display. By off-setting the radar site at Newark, TEB is located concentrically on the radar display which includes the specific TEB airspace boundaries. As a result of recommendations to a facility evaluation

4/ An angle subtended at the eye by the viewed object. Visual angle is a function of both size of the object measured perpendicular to the line of sight and the distance of the object from the eye. The angle is directly proportional to the size of the object and inversely proportional to the distance of the object.

5/ Roscoe, S.N., "When Day is Done and Shadows Fall, We Miss the Airport Most of All," Human Factors, 1979, 21, Vol. (6), pages 721-731; Roscoe, S.N., and Hull, J.C., "Cockpit Visibility and Contrail Detection" Human Factors, 1982, 24, Vol. (6), pages 659-72; and Roscoe, S.N., "Bigness Is in the Eye of the Beholder," Human Factors, 1985, 27, Vol. (6), pages 615-636.

conducted in September 1986, the control tower is in the process of acquiring their own discrete transponder beacon code for the control of VFR aircraft and implementing a new LOA with the New York TRACON, and the training program for the controllers is under new supervision.

1.17.8 Traffic Alert and Collision Avoidance System (TCAS)

The Safety Board has repeatedly advocated the use of airborne collision avoidance systems for all civil aircraft and noted in the report of a midair collision near San Luis Obiso, California, in August 1984, 6/ the progress of the FAA in developing a TCAS. In March 1982, Phase I testing ofprototype equipment was completed when airborne observers verified the accuracy and reliability of TCAS alerts. The operating crews of the test aircraft were not aware of the information and avoidance maneuvers recommended on the displays. Phase II testing was to have started in 1983 but was delayed because of the certification process required to approve the installation and use of TCAS in scheduled passenger service. Phase II testing involves the use of the TCAS equipment by regular air carrier line crews and began in March 1987.

Concurrent with the continuing development of TCAS II program, which provides vertical avoidance maneuvers for conflict resolution, TCAS III is emerging from the research and development stage. TCAS III adds the additional dimension of horizontal avoidance maneuvers to the conflict resolution.

Although the FAA currently plans to require TCAS only on 14 CFR Part 121 aircraft, it is believed that some operators of well-equipped corporate and general aviation aircraft will also purchase TCAS. An operating TCAS would undoubtedly have displayed a caution and warning based on information from the Mode C transponder on N1977H, and also given the crew of N784B a recommended avoidance maneuver.

2. ANALYSIS

2.1 General

Both airplanes were maintained in accordance with prescribed Federal regulations. There was no evidence of any discrepancies in either airplane that would have had a bearing on the accident.

The DA50 flightcrew were certificated and currently qualified to fly the DA50; both were experienced pilots. The fact that the first officer was flying the airplane was consistant with the company's policies and procedures. Postmortem examinations and other evidence disclosed no medical factors which would have affected adversely their ability to operate the airplane.

The pilot of the PA28 was certificated and currently qualified to fly the airplane. He was a less experienced pilot with 269 hours of flight time. Postmortem examination and other evidence revealed no medical factors which would have detracted from his physical ability to operate the airplane.

6/ For more detailed information read, Aircraft Accident Report--"Wings West Airlines Beech C-99, N6399U, and Aesthetec, Inc., Rockwell Commander 112TC, N112SM near San Luis Obispo, California August 24, 1984" (NTSB/AAR-85/07).

The New York TRACON controller and the four controllers in the TEB control tower involved with the handling of the DA50 were full performance level controllers and qualified according to existing Federal regulations and FAA policies and procedures.

In review of the facts, conditions, and the circumstances in the accident, the Safety Board considered the following elements in its analysis of the accident: (1) the air traffic coordination and management which resulted in the local controller being unaware of the DA50's inbound flight; (2) the complex air traffic situation created by the design of the TCA with respect to the TEB airspace and the authorization of VFR overflights at conflicting altitudes, and the mix between low and high performance general aviation aircraft; (3) the contribution of unclear or misleading traffic advisories; (4) the reliance on achieving visual separation with the use of the "see and avoid" concept in a high density air traffic airspace; and (5) the performance of the pilots in the conduct of their flights.

2.2 The Accident

The accident sequence of events began when the ARTS computer did not automatically acquire the DA50 after it departed Morristown because it left about 19 minutes earlier than proposed on the flightplan. As a result, the DA50's identification and flightplan was not listed in the departure controller% tabular list. Normally this would have occurred automatically. As a result, the departure controller was required to initiate a manual track of the airplane which provided an identification tag, but that action did not activate an automatic transmission of data on the DA50. Therefore, it did not generate a departure message to the central computer which, in turn, did not send a machine-generated flight strip to the TEB control tower. The Safety Board believes that the lack of a flight strip is significant in light of the events that led to the accident because it could have served as a backup and a reminder when the coordinator failed to alert the other controllers of the DA50's inbound flight.

Before the DA50 was released for takeoff at Morristown, the departure controller verbally coordinated the airplane's impending arrival with the TEB coordinator according to established procedures. There was no requirement for the controller to amend the departure time of the airplane, and he effected the necessary coordination with TEB by landline as required. Since radar coverage by the TRACON does not extend down to the runway at TEB, the departure controller was required to tell the flightcrew that radar service was terminated when he transferred control to TEB. However, because the DA50 crew reported to TEB that it had passed CLIFO, the controller's failure to do so was not considered a factor in the accident.

After receiving the initial call from the departure controller, the coordinator should have checked to see if a machine-generated strip was available. If one was not, it was his responsibility to prepare one before control of the DA50 was transferred to the TEB local controller. The coordinator's decision to ask the clearance delivery controller to cover for him while he was absent from the cab was proper and routine. However, he did not give a relief briefing to the clearance delivery controller, nor did she request a briefing. The clearance delivery controller should have been made aware of all the active traffic handled by the coordinator. The lack of a proper briefing on the part of both controllers was contrary to required procedures and precluded a second opportunity to the controllers to stop the sequence of events that led to the accident.

The clearance delivery controller also failed to insure that the local controller was aware of the DA50. If the ground controller had moved a strip over to the local controller, it would be reasonable to expect the clearance delivery controller to think that the ground controller heard her report and provided a strip to the local controller at that instant. Without physically positioning the strip herself or without receiving verbal configuration from either controller, she would have had no way of knowing that the strip pertained to the DA50. In fact, the strip the ground controller made up was not prepared until about 2 minutes later when the airplane was over the airport — too late to have permitted the clearance delivery controller to provide adequate sequencing by issuing advisories. In addition, the Safety Board believes that a breakdown in coordination occurred in the control tower which set the stage for the accident. In the Safety Board's opinion, the local controller may have been alerted sooner to a potential conflict between the DA50 and the PA28 if the coordination process had been timely, accurate, and complete.

At 1715, the DA50 flightcrew knew that they were following a Twin Cessna to TEB. About 3 minutes later, they were about 5 1/2 miles from the airport and were told that the traffic they were following was over the airport. This traffic was the Twin Cessna (N68734) and it was not considered a factor in the accident because of its distance from the other airplanes. At that time, the PA28 was about 30° to the right of and about 3 1/2 miles away from the DA50 and about the same distance away from the airport. Twenty-seven seconds later the pilot of the PA28 reported to the local controller that he was 1 mile west of the airport (he was more than 2 miles), and he was instructed to report clear of the airport traffic to the "west." The local controller was busy working six airplanes and the radio frequency was congested. This made it difficult for the DA50 captain to contact the tower at CLIFO. By the time radio contact was established, the local controller had already cleared N72BG for a downwind departure and cleared N1959T to be number two to land when it reported overhead the airport. Since the N1959T's landing sequence was not provided by the controller until 1719:45, it is probable that the flightcrew did not hear the controller's instruction to N1959T at this time because the captain was telling the first officer to slow it up at that moment. Therefore, the Safety Board believes that the DA50 flightcrew may not have been aware that the local controller had sequenced N1959T between them and the Twin Cessna. At this point, the PA28 was almost directly ahead of the DA50 and 1.7 miles away. N1959T was 1.4 miles from the DA50 and about 43° to the left. The Safety Board further believes that the number of other airplanes the local controller was handling and the radio frequency congestion that was generated detracted from his ability to prevent a conflict between the PA28 and the DA50 when it made its initial call.

Based on the radar data and cockpit visibililty study at 1719:45, when the DA50 was about a mile west of the airport, the Twin Bonanza, N1959T, and the PA28 were passing over the airport in front of and in the DA50 flightcrew's view. (See figure 17.) N1959T was about 40° to the left at 900 feet and the PA28 was about 20° to the left of the crew's DER at 1,600 feet on the horizon. The Beech Baron, N72BG, which had departed to the east after takeoff from runway 19, was located slightly to the left of the crew's DER, and to the right of the PA28 and slightly below the horizon at 350 feet. At 1720:05, when the local controller told the DA50 flightcrew that they were to plan to be number three and there was additional traffic at the one o'clock position westbound at 1,500 feet, N1959T was about 20° to the left of the crew's DER, the PA28 was directly ahead at the 12 o'clock position, and N72BG was 1.5 miles ahead at 873 feet, 25° to 30° to the right of the DA50 crew's DER or in about a 1 to 2 o'clock position. (See figure 18.)

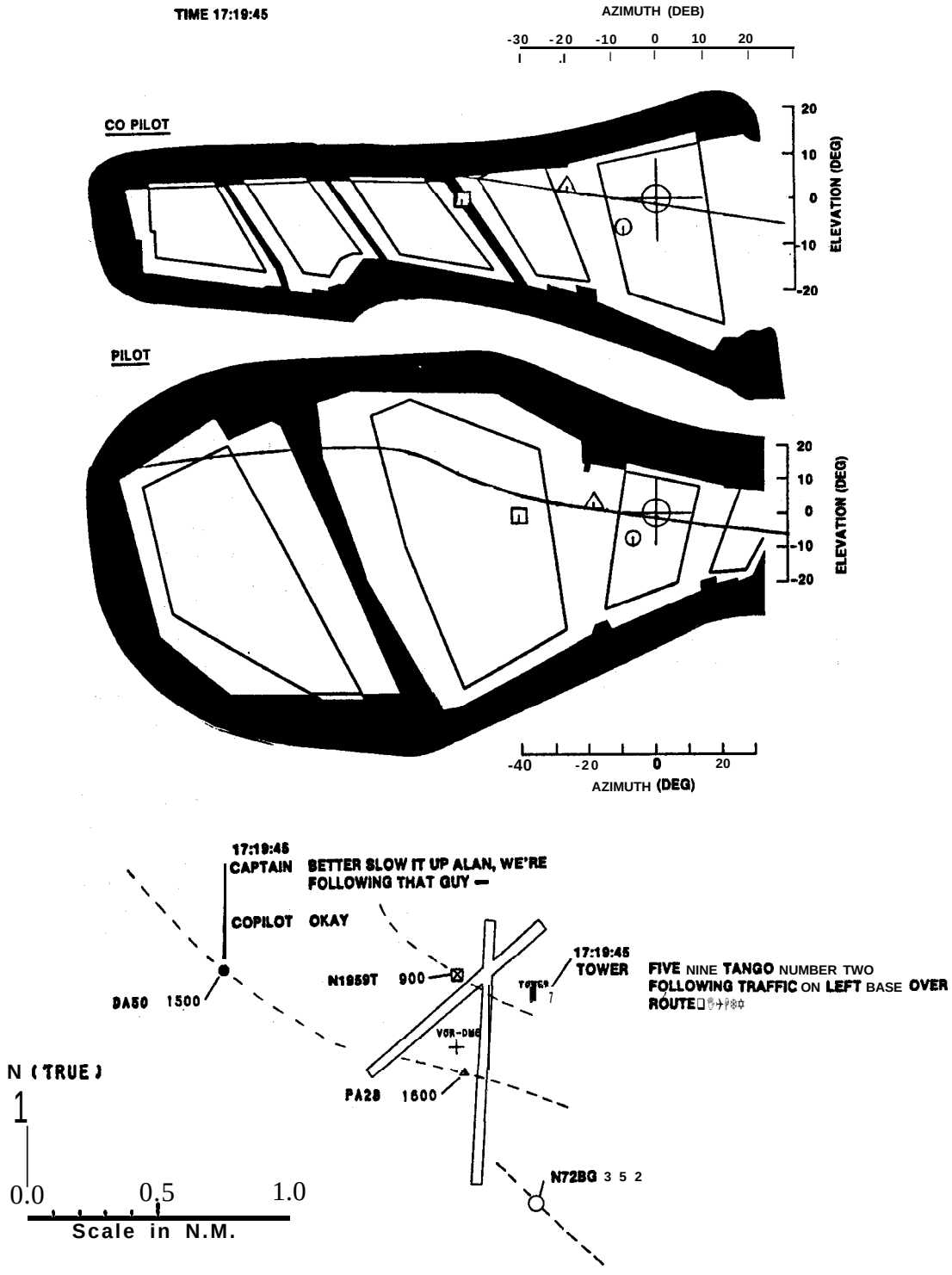


Figure 17.-Composite radar positions and cockpit visibility plot of aircraft at 1719:45.

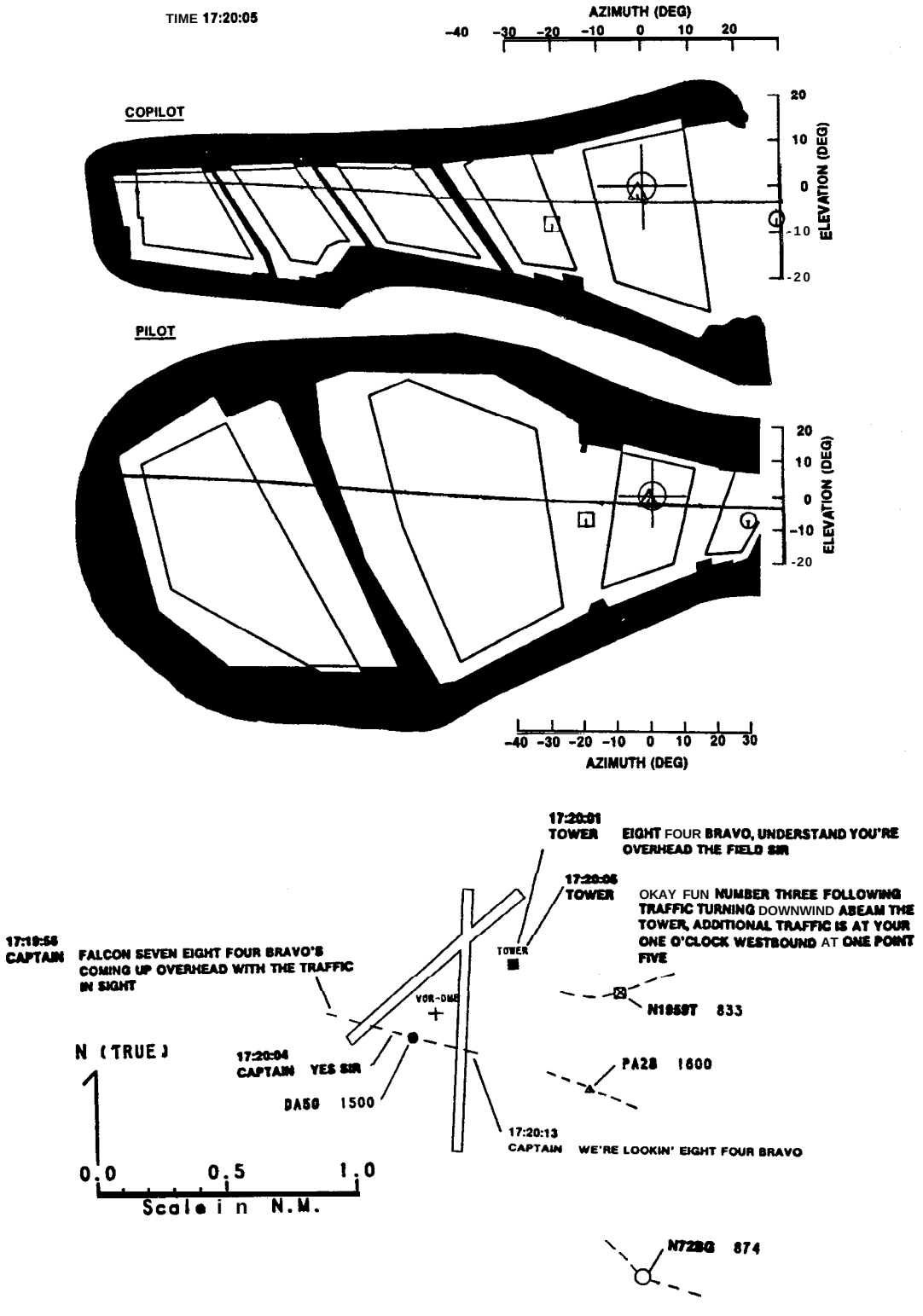


Figure 18.-Composite radar positions and cockpit visibility plot of aircraft at 1720:05.

Because the local controller was not aware of the DA50, he was surprised when the captain reported over the airport, but he managed to identify the DA50, sequence it with the other landing traffic, and issue traffic advisories. He sequenced the DA50 to be number three behind N1959T and correctly described N1959T's location as turning downwind abeam the tower. However, the local controller did not provide the proper description for N1959T, a Twin Bonanza, to the flightcrew. Furthermore, the controller erroneously reported the PA28 traffic as "westbound" in two instances 9 seconds apart — at 1720:05 and at 1720:14 and did not say that it was an overflight. (See figure 19.) At this time, N1959T was in view at about the 10 o'clock position slightly below the horizon about 1.2 miles away. The PA28 was in view just under a mile directly ahead. N72BG was about 30° to the right of the captain's viewing angle about 1.7 miles ahead and moving closer to a 1 o'clock position than the PA28. Actually, both N1959T and N72BG were turning to the downwind direction at this time. Also, at 1720:14, the DA50 made about a 15° right bank.

At 1720:26, when the local controller advised the pilot of the PA28 about the DA50 at his 6 o'clock position, all three airplanes were in view of the DA50 flightcrew. (See figure 20.) At 1720:41, when the local controller asked the DA50 flightcrew if they saw the traffic, N1959T was in view about 124° to their left almost 4 miles away traveling northbound on the downwind leg of the traffic pattern, the PA28 and N72BG appeared close together and in view about 40° to the left of their DER points, The PA28 was about 3/4 mile ahead just above the horizon and N72BG was slightly below the horizon about 1.3 miles away, and to the right of the PA28. (See figure 21.) About this time, when the captain acknowledged sighting what is believed he thought to be the "westbound" traffic, all three airplanes were in his view, and only N1959T was far to the left, out of the first officer's view. Twenty seconds later, both the PA28 and N72BG maintained their approximate positions relative to one another and moved to the left horizontally about 46°. N1959T moved horizontally to the left and out of the first officer's view. (See figure 22.)

At 1721:00, when the first officer asked "What kind of Cessna is that?" the PA28 and N72BG remained in view in about their same relative positions about 80° to the left of the crew's DER, but the PA28 was about 1/2 mile away and N72BG was about 1.6 miles away. Eight seconds before the collision when the captain said, "Hey, watch out, this guy's comin' right at us," the DA50 was in about a 30° left bank and the PA28 and N72BG were about 63° to the left and about 20° above the DER for the captain. They were not in the first officer's view. The PA28 was just above the horizon and N72BG was directly below the PA28 which was about 1/3 mile away or about 2,006 feet from the DA50. N1959T was out of the view of both pilots. (See figure 23.)

About 30 seconds before the collision, the DA50 was positioned about 109° to the right and about 1° below the DER for the PA28 pilot. Eight seconds before the collision, the DA50 was about 77° to the right and 1/2° below the DER.

The DA50 captain's acknowledgment of having observed the traffic at 1720:43 and the controller's instruction for the flight to "maintain visual" ended any further air traffic control efforts to sequence the traffic. This was considered a proper action based on prescribed ATC procedures. However, the local controller's failure to mention that the additional traffic was an eastbound overflight instead of "westbound" is considered to be a factor in the accident.

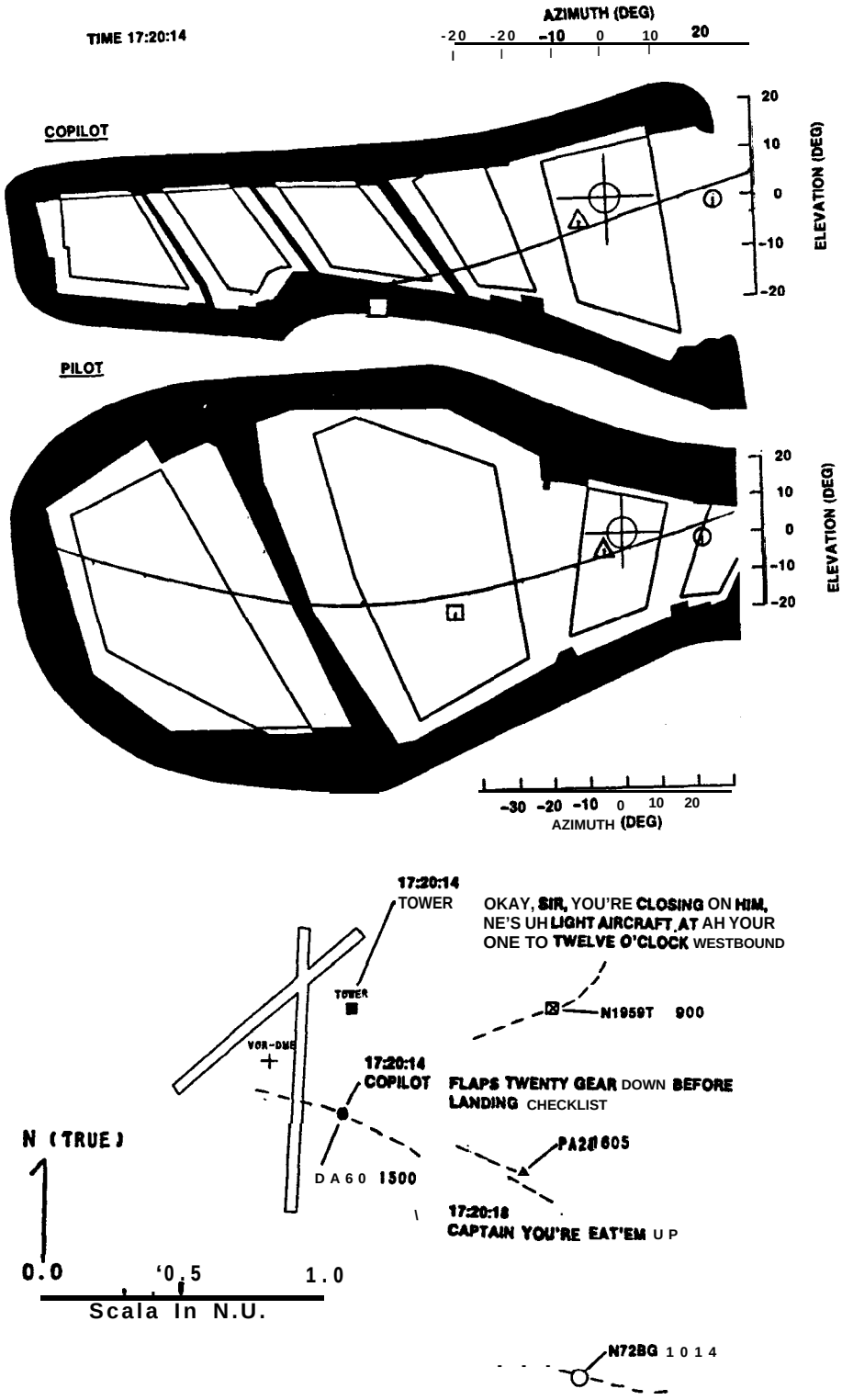


Figure 19.-Composite radar positions and cockpit visibility plot of aircraft at 1720:14.

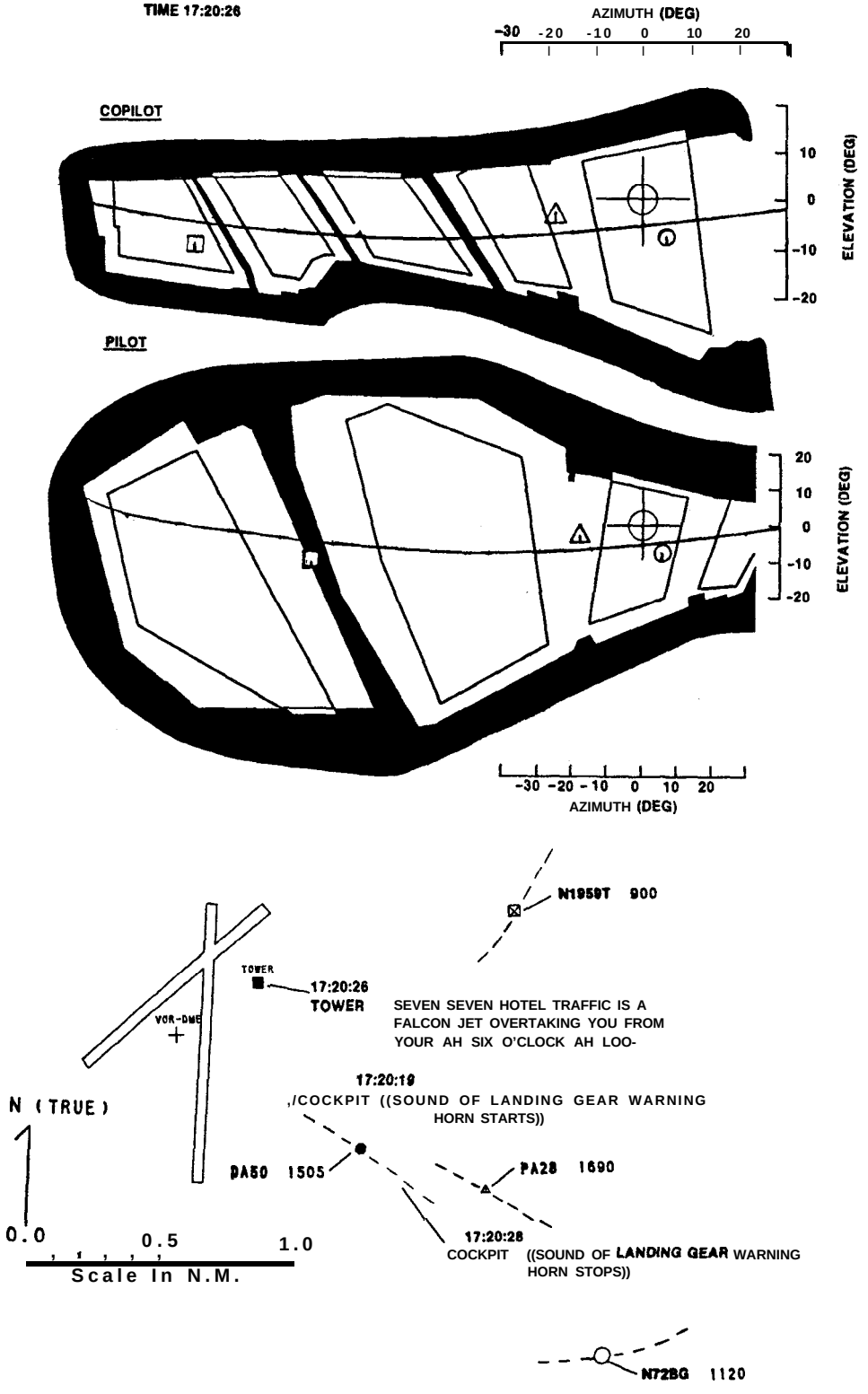


Figure 20.—Cockpit radar positions and cockpit visibility plot of aircraft at 1720:26.

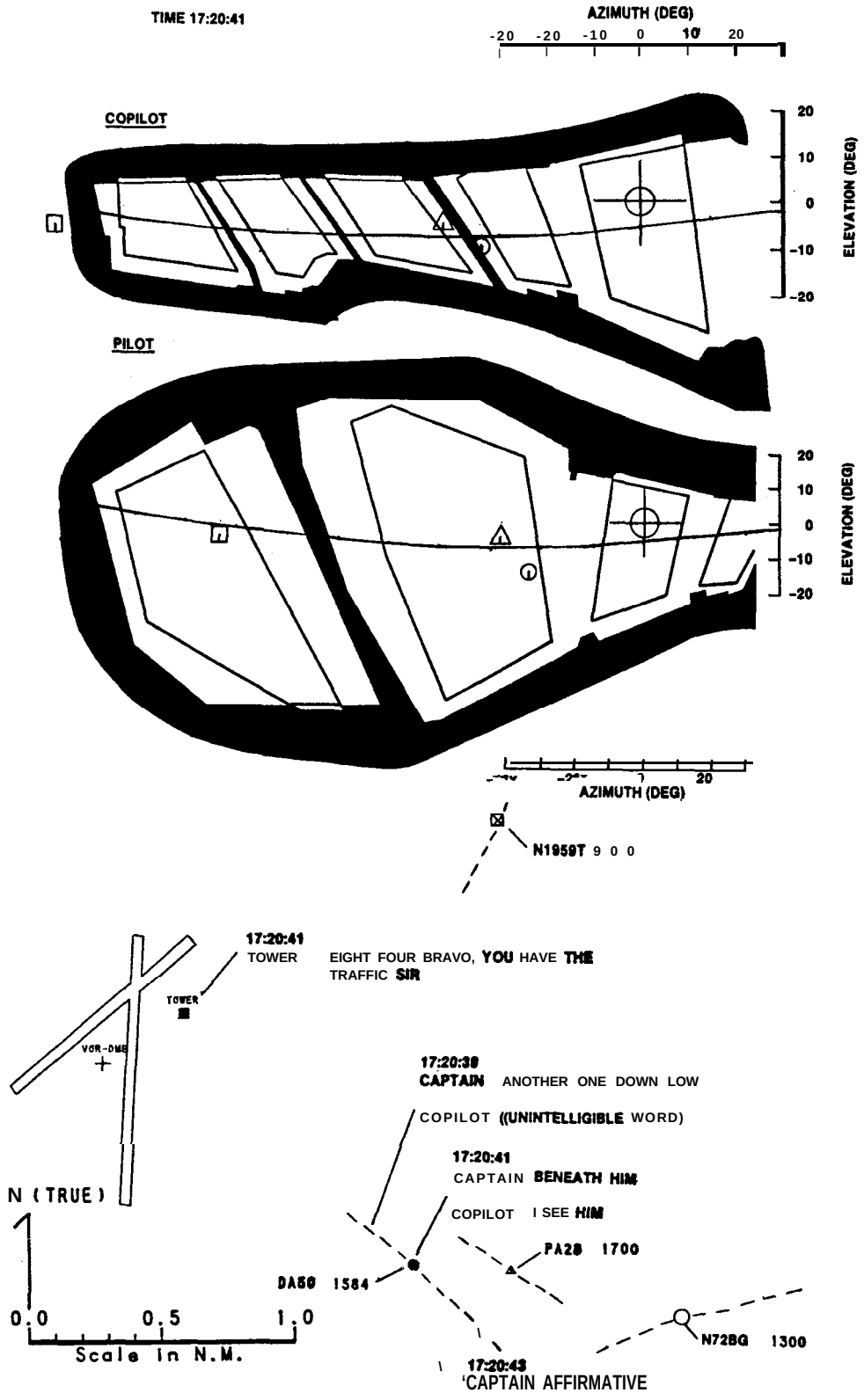


Figure 21.-Cockpit radar positions and cockpit visibility plot of aircraft at 1720:41.

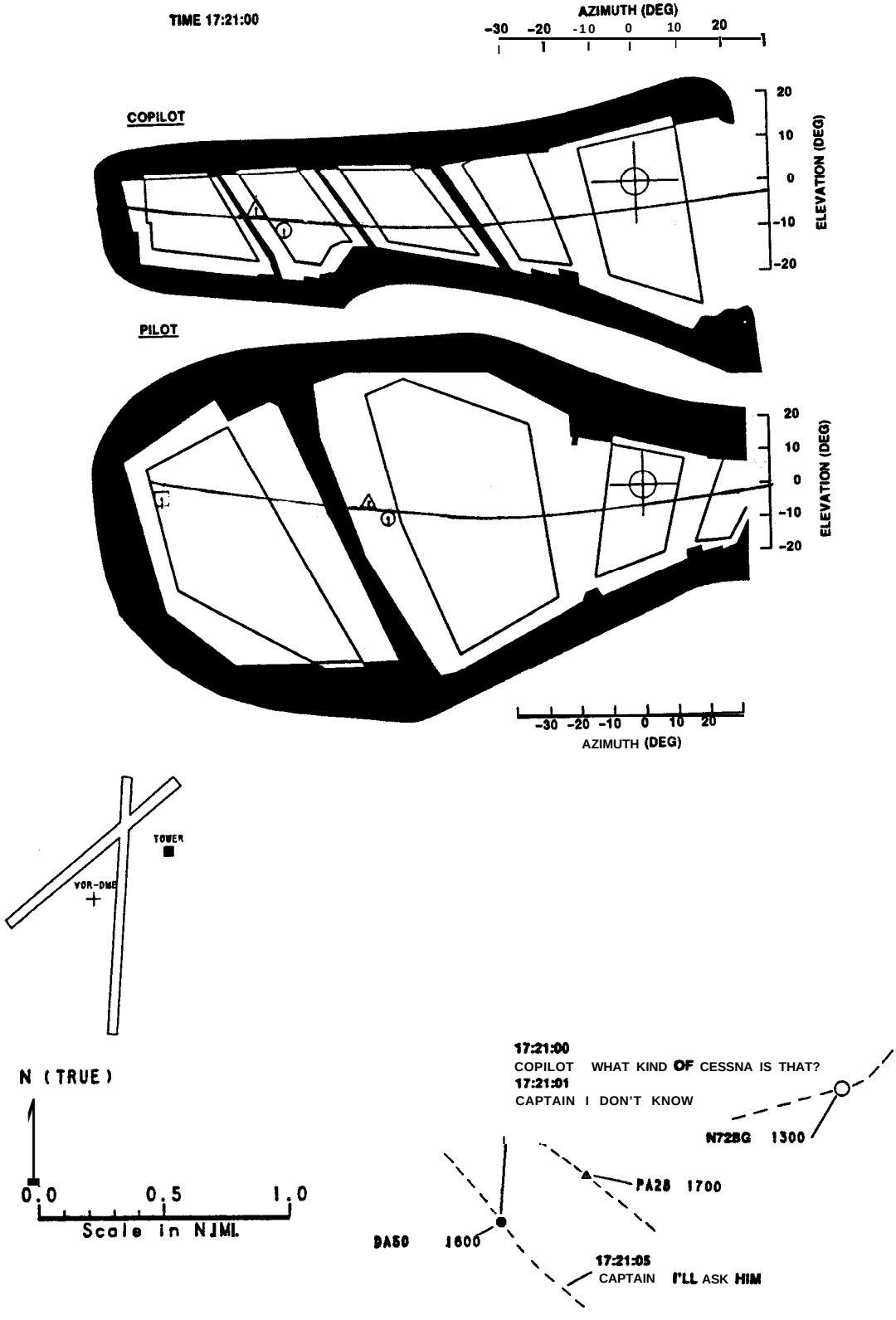


Figure 22.-Cockpit radar positions and cockpit visibility plot of aircraft at 1721:O0.

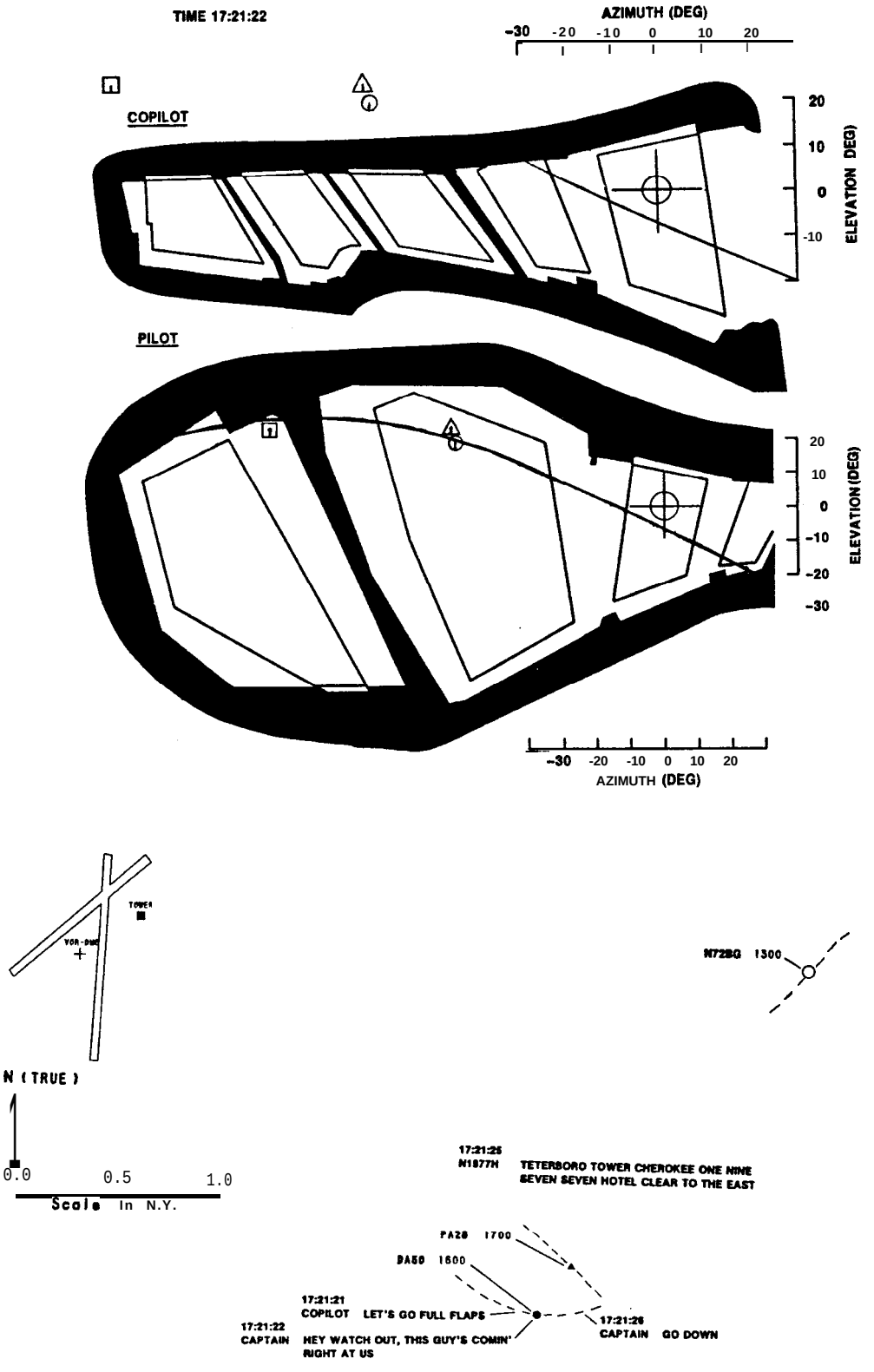


Figure 23.-Cockpit radar positions and cockpit visibility plot of aircraft at 1721:22.

The local controller probably reported the PA28 as "westbound" and failed to mention that it was a transiting airplane because he was busy and the radio frequency was congested. He was working several airplanes and he had admitted to being busy. At 1718:39, when the PA28 pilot reported ". . .one mile to the west" he asked the pilot to ". . .report clear of the airport traffic area to the west" when he should have said east. The Safety Board believes that the local controller inadvertently mistated the location of the PA28. Since he was not corrected by the PA28 pilot in his acknowledgment, the controller had no reason to believe thereafter that the mistatement was incorrect. Therefore, he repeated the mistake on two subsequent instances. Furthermore, he did not provide the DA50 flightcrew with the type identification for N1959T nor for the PA28, as prescribed by ATC procedure. This information could have been helpful to the DA50 flightcrew in identifying the traffic. However, the Safety Board believes that the most significant error on the part of the local controller was not reporting that the additional traffic was an eastbound overflight. This type of human error is indicative of a pronounced workload condition.

Since there were several airplanes in the traffic pattern at the time of the collision and since it is not completely clear which airplane the flightcrew considered to be the "westbound" reported traffic, the Safety Board identified and analyzed three accident hypotheses that could have evolved from the conditions and circumstances presented to the DA50 crew and the local controller. These hypotheses are based on the belief that the DA50 flightcrew were not aware that the local controller had sequenced N1959T between them and the Twin Cessna.

First Hypothesis.- The first hypothesis assumes the DA50 flightcrew identified N1959T as being the number two airplane to land and they would be number three. In this case, they would have had to choose between the PA28 and N72BG as being the additional traffic reported to be *'westbound." At 1719:45, the captain then was referring to N1959T when he said, "Better slow it up Alan, we're following that guy." This airplane, as well as N72BG, was a light twin engine airplane. Furthermore, because it was closer in his 12 to 1 o'clock position at 1,500 feet and it was a light single engine airplane, it is postulated that the captain was referring to the PA28 as the "westbound" traffic. At 1720:18, when he commented, "You're eat'em up" he then was referring to the PA28 indicating that they were rapidly converging. This comment prompted the right turn made immediately by the first officer for separation. Also, the flightcrew would not have been surprised when they passed the PA28 and they would have assumed that it would no longer be a factor. Twenty-one seconds later, at 1720:39, the captain referred to another aircraft down low and the CVR recorded an unintelligible response from the first officer. The captain replied, "Beneath him," and the first officer stated, "I see him." It can only be presumed that the traffic sighted by both pilots in this instance was the same airplane, N72BG, which was below the PA28. Therefore, at 1720:41, when the controller asked the question ". . .you have the traffic, sir?" the captain acknowledged sighting the PA28 believed to be traveling westbound.

However, the Safety Board does not believe the evidence supports this hypothesis because of the initial positions of the other three airplanes relative to the DA50 and the indication that the flightcrew still believed they were following a Twin Cessna at 1721. In addition, the controller admitted he did not know to which airplane the crew was referring - he stated it could have been the Twin Cessna, N1959T, or the PA28. If the DA50 crew believed the PA28 was westbound, they would have expected the traffic to pass them quickly, which did not take place. Furthermore, the captain's comment, "You're eat 'em up," more likely implies the perception of an overtake situation rather than convergence. Also, the belief that they were overtaking the PA28 would have been

reinforced if they heard the local controller tell the pilot of the PA28 that he was being overtaken by the DA50. In this hypothesis, the flightcrew would have likely been confused sooner as to which airplane was the additional traffic and which airplane they were to follow on the downwind leg with the presence of N72BG, and they would not have taken an interval on the PA28—at this point the DA50 was about 4.5 miles behind N1959T.

Second Hypothesis.-This hypothesis assumes that the captain believed that the PA28 was the aircraft assigned as number two to land, that they were number three to follow, and that they had to space themselves with the PA28. However, it is assumed that the "westbound" report was not significant because the flightcrew did not comment about head-on traffic at the same altitude, and the captain's comment, "You're eat 'em up," implied the perception of an overtake situation. Therefore, the flightcrew discounted the two "westbound" reports made by the controller as a mistake. Although this hypothesis would account for the first officer's comment at 1721:00, "What kind of Cessna is that?" the Safety Board believes the hypothesis also does not fully account for the confusion that would have arisen with the appearance of N72BG relative to the PA28. The Safety Board believes that at least from 1720:26 to 1721:22 the DA50 crew would have believed there was additional traffic because both airplanes remained in view. When the first officer began the downwind turn, the relative positions of the PA28 and N72BG again would have made it difficult for the flightcrew to determine which airplane was number two to land.

Third Hypothesis.—The Safety Board believes that a third and more likely hypothesis is supported by the available evidence. Because of the relative positions of the airplanes when the DA50 flightcrew first established communications with the local controller, it assumes that the flightcrew believed that the PA28 was number two to land behind N1959T and they were number three based on the captain's comment at 1719:45. At this time, the DA50 was just completing a left turn to intercept a 305°-radial of the VOR/DME approach; the PA28 was on a heading of 122° just south of the VOR. Because physical evidence indicated that the position lights may not have been on, it could have been extremely difficult for the DA50 crew to recognize that the airplane they were behind was a small airplane, let alone a PA28. Therefore, it would be logical for the flightcrew to assume that an airplane on the same track over the airport would be the traffic they were following into the pattern, the Twin Cessna. Again, they did not know the controller had cleared N1959T between them and the Twin Cessna. To further reinforce this thought, the DA50 crew was told at 1720:05 "Okay, plan number three following traffic turning downwind abeam the tower. . . ." At this time, three aircraft were within the crew's view and both N1959T and the PA28 could have been perceived as being abeam the tower. However, N1959T was more than 20° to the left of the PA28 and therefore it would have appeared to have been the first airplane in the pattern for landing and with the PA28 following as the second airplane in the pattern. Furthermore, the only other airplane that was inconsistent with the flow of traffic in the pattern at that time, and within the flightcrew's view was N72BG.

Therefore, it is believed that the DA50 flightcrew may have mistaken N72BG for the additional traffic reported to be "westbound." Having observed the PA28 for more than 20 seconds, the crew was aware of its easterly heading and would, therefore, have had no reason to suspect it was the subject of the "westbound traffic" advisory. Their response, "We're looking," is understandable, given the number of airplanes in their view. The Twin Cessna they may have thought they were following was well ahead of the other airplanes and about to turn onto the base leg at this time and was not considered a factor.

This hypothesis takes into account the belief that the captain perceived an overtaking situation with the PA28 and is consistant with the right turn for separation. Thinking that the PA28 was the Twin Cessna they were following, they established an interval on that airplane by making the right turn and were anticipating that the PA28 would make a left turn for the downwind leg. As a result, the flightcrew became preoccupied in obtaining separation with the PA28 they thought was number two to land and was unaware they were 3 to 4 miles southeast of the airport and outside the traffic pattern. This hypothesis also accounts for the first officer's question, "What kind of Cessna is that?" because they thought they were following a Twin Cessna and the PA28 was the closest airplane from which an identification might have been made. It should be pointed out that the Safety Board also recognizes the possibility that the first officer could have raised the question because of the PA28's relatively slow speed verses that which would be anticipated from a Twin Cessna and perhaps this was the reason. However, because of the congestion on the radio frequency, the captain did not get a chance to ask the controller to resolve the ambiguity. In the Safety Board's opinion, the local controller's failure to report the additional traffic as an eastbound overflight is significant because it is not likely that the flightcrew would have made the left downwind turn into traffic they were told was eastbound at the same altitude. In addition to providing the eastbound overflight information, had the DA50 crew been given the identification of N1959T, the airplane they were supposed to follow, they would have been confronted with a different situation and it would have caused them to question the presence of the PA28. The Safety Board believes that this additional, but critical information, would have resulted in a different course of action by the crew which could have prevented the accident.

2.3 Pilot Actions

The manner in which the DA50 was flown was not in accordance with company training procedures regarding speed control and landing configuration sequence with respect to the approach being flown. The crew did not reduce their speed to 180 KIAS in a timely fashion as requested by the departure controller. Although the speed was decreasing, it was faster than it should have been under the circumstances regardless of what was permitted by regulation. The DA50 was about 163 KIAS over the airport and the speed was not down to about 140 KIAS until the DA50 passed the PA28. The increased speed resulted not only in a rapid closure rate with the PA28, but it also caused a late configuration of the DA50 for landing and caused it to proceed further away from the airport and outside the normal limits of the traffic pattern. The Safety Board noted that the captain cautioned the first officer to slow down on two occasions, at 1719:45 and at 1720:18. This indicates that the first officer may have been having difficulty managing airspeed and airplane configuration during the approach. This difficulty would have distracted the captain from devoting more attention to the traffic situation. The Safety Board believes that although the flightcrew were told they were following a Twin Cessna by the departure controller, they should not have assumed this could be the case in the traffic pattern because VFR aircraft are mixed with IFR traffic for landing sequence by the local controller at TEB. This apparent assumption would have influenced their expectation of the traffic sequence in the pattern. Furthermore, the Safety Board believes that the excessive speed and the flightcrew's preoccupation with the PA28 resulted in their losing awareness of the position of the DA50 with respect to the airport and the normal limits of the traffic pattern. Had the captain recognized that his airplane was well outside the limits of the traffic pattern when the first officer was obtaining separation from the PA28, the captain should have known that the PA28 was not in the traffic pattern and, therefore, was not the airplane that the local controller had identified as number two to land.

Consequently, the Safety Board concludes that the flightcrew lost "situational awareness" because of a preoccupation in flying the airplane, they had a preconceived idea that they would be following a Twin Cessna in the traffic pattern, they received misleading and inadequate information from the local controller, they were misled by the position of the airplanes they observed in the traffic pattern, and they failed to relate the position of their airplane to the airport. These factors led to their misidentification of the PA28 as the airplane ahead of them in the landing sequence and led to the improper assumption that the PA28 would make a left turn onto a downwind leg for runway 19 both of which established the condition for the collision course with the PA28. Therefore, the Safety Board conlcudes that the flightcrew's loss of situational awareness was a significant factor in the accident.

CLIFO is only a mandatory reporting point on the instrument approach to TEB when an aircraft is not in radar contact with ATC. Since radar service was not terminated by the departure controller, the flightcrew was not required to make a position report at CLIFO based on radar status alone. The departure controller instructed the DA50 to contact the tower at CLIFO. However, the radio frequency congestion prevented a timely position report to the local controller. The clearing turn to the right was the proper maneuver in an overtaking situation. It also would have been the proper turn to make in a converging situation. The CVR record otherwise disclosed that the flightcrew was active in sighting traffic and followed their prescribed procedures.

The manner in which the PA28's flight was conducted was considered routine. Airplanes were frequently given permission by the control tower to transit the airport traffic area in order to reach the Hudson River. The pilot's decision to transit that night at 1,500 feet was risky because of the overhead approach in operation at TEB and the potential conflict with turbojet traffic. Even though he had the VOR/DME-A frequency tuned in, he may not have known the approach was in use at the time. It is suspected that he chose 1,500 feet in order to remain below the floor of the TCA and above the small aircraft traffic pattern. His decision not to contact the TRACON and obtain radar service was evidently governed by his opinion of radar service in the area and the time he had available to make the flight with the expectation of being given a circuitous route to the Hudson River had he done so. The fact that he made a mistake in his position report west of the airport would have been significant only if the local controller had known about the DA50 earlier. Furthermore, had the pilot corrected the local controller's mistake when he asked the PA28 to "report clear of the airport traffic area to the west," the pilot may have stopped the controller's "mindset." Besides, the pilot should have been concerned about the controller3 knowledge of his flightpath in order to obtain timely and accurate traffic advisories. However, it is possible that radio frequency congestion might have precluded the PA28 pilot from correcting the local controller.

Since the DA50 was behind the PA28 initially, it is doubtful the PA28 pilot ever saw the airplane. He also had the right-of-way in this case. When the local controller tried to caution the pilot about the DA50 at 1720:26, the response of the PA28 pilot was believed blocked by another radio transmission. Also, if he heard that the DA50 crew had his airplane in sight, he probably felt no need to take any action. The DA50 passed the PA28 on its right and made a right turn away from the airplane. Therefore, until moments before the collision, the pilot would have had difficulty sighting the airplane, particularly with a passenger in the right seat who would have obscured some of his vision. Five seconds before the collision, the pilot was telling the controller that he was clear of the area to the east as requested. Therefore, it is believed that he did not see the airplane until it was too late to avoid the collision.

In view of the traffic situation and the environmental and physiological limitations that were present, it is evident that the pilots would have had difficulty detecting the traffic and discerning their flightpaths. Under these conditions it takes longer for a pilot to detect conflicting traffic, make a decision, and take evasive action. The FAA's estimate of 12.5 seconds for such action to take place does not take into account the extended time required at night. When the captain said, "Hey, watch out. This guy's coming right at us," it probably took longer than 6 seconds to detect the PA28 and perceive a collision course. Four seconds later, he decided on an evasive maneuver and told the first officer to "go down." However, as the airplanes came closer, 2 seconds later he must have realized that his initial decision was not the best escape maneuver and told the first officer, "Naw, go up." At this last command, there was probably 1.6 seconds remaining before the collision. With the first officer flying, overall response time would have been further delayed because of the additional time required for him to react. Also, given the airplane's response time, there was no time to escape.. The' angle of bank to the right, as indicated by the physical evidence was likely the result of the pilots' instinctive reaction to turn away from the PA28. Why the captain did not take control of the airplane when he perceived the collision threat is not known.

2.4 Air Traffic Management

Because of the location of the TEB airport with respect to LaGuardia and Newark International Airports, the design of the TCA, and the air traffic congestion in the area, pilots flying general aviation airplanes for pleasure under VFR are inclined to overfly TEB in order to take the shortest route to the Hudson River for a scenic flight. In fact, under the present design the Hudson River VFR corridor is frequently used by these pilots as a major transition to remain clear of controlled airspace and there are no rules specific to operations through the corridor. No permission is needed to fly in the corridor and radio contact with a controlling agency is not required. Furthermore, because of the heavy IFR traffic demands on ATC in the New York area, pilots flying under VFR are no doubt unsuccessful in obtaining radar traffic advisory services in the area at every request. Such a situation creates a critical need for clear a critical need for clear and concise communications, ATC coordination, and the necessity for pilots to exercise vigilant "see and avoid" practices when landing and departing the TEB airport. The importance of these factors are demonstrated in this accident.

A breakdown in communications occurred within the TEB control tower. This breakdown underscores the fact that, in spite of the redundancies designed into the system of ATC, deviations from standard operating procedures and practices can result in accidents. Several factors led to the breakdown in communications. In view of the testimony from FAA personnel, it was evident that they did not place much emphasis on the importance of the flight progress strip in this particular accident involving a VFR tower. They essentially admitted that it had its importance, but in this accident they believed that the progress report from the TRACON was more important. Since the operation of a VFR control tower does not handle flight strips as a primary duty in the FAA's view, the importance of the strip was diminished. Furthermore, controllers probably became accustomed to handling traffic from the TRACON without first receiving a flight strip. This situation was common and would have preconditioned the controllers to operate accordingly without concern. The fact that the FAA has taken action to emphasize the use of flight strips at TEB is indicative of a preexisting problem that was not resolved by local FAA management before this accident.

Additionally, the failure of the controllers to follow the prescribed procedures of preparing a flight strip, to conduct a full and proper relief briefing, and to insure proper coordination between controllers was indicative of an informal atmosphere in the

control tower operation and of inadequate supervision. Recognizing that it is not feasible for a duty supervisor to monitor all controller positions simultaneously, he is still expected to be aware of the tempo of operations and of the strength and weaknesses of his controllers to ascertain that all prescribed procedures are followed and that air traffic can be managed effectively. It is recognized that his duty is to provide general supervision and he must rely to a large extent on the knowledge and performance of the controller's to bring irregularities to his attention. Although the Safety Board believes that his actions or inactions in the tower cab did not directly contribute to the accident, his lack of attentiveness to the developing traffic conditions could have been a factor in failing to prevent the accident. The Safety Board believes that the traffic conditions at the time of the accident may have warranted establishing an outer control position. Insofar as it takes several minutes to establish an outer control position, the supervisor should have been monitoring closely the control tower operation in order to anticipate the need for implementing such a procedure. The decision to do so would also be based on the supervisor's experience, judgment, and familiarity with the operation at TEB. Since the supervisor on duty at the time of the accident started working at TEB in 1961, the Safety Board believes that he should have had the knowledge and experience to have anticipated the increase in traffic and thereby, prevent potential traffic conflicts.

Since the TEB traffic area is essentially compressed under the confines of the New York TCA, the policy of permitting the local controller to make on-the-spot decisions about transiting aircraft under these circumstances is questionable. The policy places a great deal of importance on the controller's performance under varying working conditions. As evident in this accident, the local controller was very busy. However, because he was not made aware of the DA50 progress report, the Safety Board believes that his decision to approve the overflight was in accordance with standard practice at TEB. Had he been given a timely progress report, the Safety Board believes that the local controller would have been alerted to a potential conflict between the DA50 and the PA28 and probably could have taken action to prevent the accident. Additionally, the Safety Board believes that the practice of giving this on-the-spot approval should have been based on a sound policy and a procedure that took into consideration traffic volume and complexity. The responsibility of formulating this policy and procedure was that of supervisory personnel and the tower manager.

However, the Safety Board must also point out that the local controller had other options available from which to safely control the flow of traffic at TEB. By not permitting arrival VFR aircraft to enter the traffic pattern and by holding departing aircraft on the ground, he could have reduced the flow of traffic in and out of the pattern and reduced the radio frequency congestion. The Safety Board believes that the local controller should have been more aggressive in controlling the traffic instead of attempting to accommodate all of the traffic on request.

Furthermore, the Safety Board believes that had the control tower been equipped with a BRITE IV radar display enhanced with alpha-numeric capability, the local controller could have detected the arrival of the DA50 in advance and taken action to provide timely advisories without the use of a flight strip. Such enhancement of the BRITE display at TEB would further improve the situation found as the result of a previous midair collision near TEB. 7/ In addition, the TEB control tower is limited to providing VFR service only because the controllers are not radar qualified and

7/ For more detailed informaton read, Aircraft Accident Report—"Ronson Aviation, Bell 206B, N27670 and Seminola Air Charter, Piper PA-34-200T, N8110R, Midair Collision, East Rutherford, New Jersey, September 23, 1981" (NTSB-AAR-82-6).

cannot provide positive separation and the tower is not designed to provide this service. Reliance on the "see and avoid" concept as a sole means of providing air traffic separation is questionable, in view of the compressed airspace situation and the mix of aircraft types with significant performance differences in airspeeds and maneuvering capabilities.

The Safety Board concludes that the ATC system designed to provide traffic advisories to aircraft operating within the TEB terminal area broke down. Because of the airspace structure and the cumulative deficiencies that were occurring at TEB, the Safety Board believes that the tower manager as well as regional ATC management should have recognized the need for corrective action before this accident occurred. Failure on their part to identify and correct these problems suggests a system failure at TEB which created the environment for the multiple individual failures that led to the accident and that reflect poorly on the overall managerial policy and practices at the control tower. Consequently, the Safety Board believes that the lack of aggressive preventive measures by the FAA ATC directly contributed to the cause of the accident.

3. CONCLUSIONS

3.1 Findings

1. The pilots in both airplanes were qualified for their respective flights and were familiar with the operations at TEB. There were no apparent medical factors affecting their performance.

2. The controllers were qualified as full performance level controllers. There were no apparent medical factors affecting their performance.

3. The pilot of the PA28 elected to transit the airport traffic area at 1,500 feet which was in potential conflict with turbojet traffic pattern.

4. The DA50 flightcrew did not comply with a speed reduction to 180 knots for several minutes following the request from ATC and were 15 to 20 knots faster than what would have been prudent for an airspeed in the traffic pattern at TEB.

5. The TRACON departure controller coordinated properly the flight of the DA50 IFR traffic with the TEB control tower.

6. The TEB control tower coordinator failed to follow prescribed procedures when he did not advise the local controller of the inbound DA50 traffic.

7. The clearance delivery controller failed to follow prescribed procedures when she did not advise the local controller of the DA50.

8. There were several airplanes operating at the airport and the radio frequency was congested.

9. The local controller was busy handling several airplanes and was surprised when the DA50 reported over the airport.

10. The local controller gave misleading traffic advisories concerning the direction of the transiting PA28.

11. The DA50 flightcrew loss "situational awareness" and probably misidentified the PA28 as the airplane they were to follow in the pattern for landing.

12. The PA28 pilot probably did not see the DA50 until a moment before the collision.

13. The radio frequency congestion interfered with the DA50 pilot-controller communication at a critical time in the sequence of events.

14. The limitations to vision at night contributed to the DA50 captain's difficulty in resolving the collision course geometry in time to take appropriate action to avoid a collision.

15. There was no clear policy concerning VFR aircraft transiting the TEB airport traffic area.

16. There was ineffective management and supervision over the TEB control tower controllers resulting in a failure to resolve operational problems.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was a breakdown in air traffic control coordination which resulted in an air traffic conflict and the inability of the DA50 flightcrew to "see and avoid" the other aircraft due to (1) an erroneous and inadequate traffic advisory and (2) the physiological limitations of human vision and reaction time at night. Air traffic control management contributed to the accident by failing to insure that controllers were following prescribed procedures and by failing to recognize and correct operational deficiencies.

4. RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety. Board made the following recommendations:

-to the Federal Aviation Administration:

Issue a General Notice (GENOT) to all facilities to require that every controller is briefed on the importance of conducting a complete position relief briefing prior to assuming duties in accordance with the air traffic controller's handbook 7110.65d, appendix D and FAA Handbook 7210.38, Section 2, Paragraph 222. (Class II, Priority Action) (A-87-46)

Issue a General Notice (GENOT) to all facilities to require that every controller is briefed on the application and provisions for terminating radar service to aircraft in accordance with the air traffic controller's handbook 7110.65d, Section 5, Paragraph 5-13. (Class II, Priority Action) (A-87-47)

Issue a General Notice (GENOT)to all air traffic control facilities requiring the establishment of preferred routes for VFR aircraft that request to transit the airport traffic area. These routings should take into account traffic pattern altitudes, instrument departure and arrival routes and altitudes, prominent landmarks, and other operational considerations unique to that facility." (Class II, Priority Action) (A-87-48)

Upgrade BRITE radar systems with alpha-numeric, minimum safe altitude warning (MSAW), and conflict alert capabilities at Level II VFR terminal facilities having limited BRITE radar information with significant traffic density and complexity problems. (Class II, Priority Action) (A-87-49)

Implement the necessary procedures to expand and initiate appropriate training that would qualify the Teterboro Airport for an upgrade to a limited radar approach control. (Class II, Priority Action) (A-87-50)

Initiate a staff-study in accordance with Federal Aviation Administration% Handbook 7400.2C to determine the feasibility of implementing an airport radar service area (ARSA) at the Teterboro Airport. (Class II, Priority Action) (A-87-51)

4.1 **Midair** and **Near Midair Collisions Safety Recommendation History**

Since 1967 the Safety Board has issued 116 recommendations as a result of investigations of midair or near midair collisions and special studies/investigations *of* midair accidents. Due to the shear number *of* recommendations on this subject, the recommendation data based was initially reduced to include only cases involving air carrier aircraft. Those recommendations not selected were then reviewed to determine whether they addressed issues that were appropriate to the recent midair collision investigations. Accidents in this group involved midair collisions or near midair collisions between general aviation aircraft and military aircraft, general aviation aircraft and corporate aircraft, general aviation aircraft and air taxi/commuter aircraft, and only general aviation aircraft. Additionally, recommendations that resulted from accidents involving air carrier aircraft but which addressed unique or cite specific issues were not included in the data base for this summary. This review resulted in identifying 55 recommendations from 15 accidents over a 19-year-period that are pertinent to the accident at TEB and other recent midair collisions.

Following the Safety Board's investigation of a midair collision at St. Louis, Missouri, on March 27, 1968, between a Ozark Airlines DC-9 and a Cessna 150, Safety Recommendation A-68-12 was issued to the FAA:

A. That daylight radar display equipment be installed in the lamberfield tower cab at the earliest possible date.

B. That greater utilization of the facility radar be made so as to provide radar sequencing, monitoring, and advisory service on a full time basis until Phase II of the National Terminal Radar Service Program can be implemented at St. Louis.

> C. That VFR patterns (entry points, tracks, and altitudes) be established for the Lambert Field control zone to be utilized by those aircraft not participating in a radar program.
>
> D. That all of the above recommended actions be considered for their applicability to other locations similar to St. Louis.

On June 28, 1986, the FAA responded that it had installed bright tube radar displays at St. Louis, included St. Louis in Stage II of the National Radar Program, established VFR entry and departure routes for Lambert Field, and identified and was taking action to correct airports which had problem similar to St. Louis's Lambert Field. The Safety Board monitored the FAA's efforts to comply with this recommendation and on January 1, 1985 classified Safety Recommendation A-68-12 as "Closed--Acceptable Action."

On July 19, 1967, at Piedmont Airlines 727 and a Cessna 310 were involved in a midair collision near Hendersonville, North Carolina. Following completion of its investigation the Safety Board issued Safety Recommendation A-68-26 to the FAA on September 20, 1968:

> The Board recommended that the FAA-l. Improve ATC communication methods and procedures for IFR in nonradar environment. 2. Expedite increases in ATC radar coverage. 3. Establish more stringent requirements for pilots using IFR system. 4. Require an annual proficiency flight check for all IFR pilots.

In response to the first two parts of this recommendation, the FAA responded that it would make improvements to the ATC system and expand radar facilities as budgetary limits provided. On March 18, 1971, the FAA informed the Safety Board that it had started rulemaking action which would require experience and qualification requirements for pilots serving as second-in-command and annual proficiency checks for pilots-in-command for aircraft certificated for more than one pilot. The Safety Board found this action to be acceptable and on May 7, 1971, this recommendation was classified as "Closed--Acceptable Action."

Following a midair collision at Shelbyville, Indiana, on September 9, 1969, the Safety Board issued Safety Recommendation A-69-18, to the FAA:

> (1) Undertake an educational program to make both pilots and controllers more aware of the midair collision problem, and to make pilots aware that most collisions occur at or near airports in clear weather and in daylight hours. (2) Establish a continuing program to assure indoctrination and continuing awareness on the part of all pilots to the midair collision potential and avoidance techniques (i.e., "see and be seen" concept, descent, turn, and climb maneuvering techniques, etc.). (3) Examine more stringently all pilot applicants for their external cockpit vigilance, with particular attention to pilots who are tested for flight instructor ratings. (4) Provide special warning and guidance to pilots who are required by the nature of their operations to fly in pairs. (5) Inform all certificated flight instructors of the high statistical significance of their involvement in midair collisions.

(6) Encourage all instructor pilots to notify the control tower operator, at airports where a tower is manned, regarding first solo flights, and require the tower operator to advise other traffic in the pattern about such flights. (7) Conduct detailed traffic flow studies for all high-volume general aviation controlled airports with a view to improving the VFR traffic flow techniques of the ATC personnel. (8) Designate climb and descent corridors for high performance aircraft at high-density airports. (9) Irrespective of the provisions contained in Part 91 of the Federal Aviation regulations, establish standard entry, departure, and go around procedures for each uncontrolled airport. (10) In cooperation with Environmental Science Services Administration (ESSA), develop and produce VFR approach and departure charts for selected airports with a high volume of traffic. (11) In addition to the requirements of Section 91.89 of Part 91 of the Federal Aviation regulations, develop a requirement for the installation of surface pattern indicators (for day and night) at smaller airports which would define specific patterns, particularly the base leg and the final approach. (12) Reevaluate visual conspicuity standards for all civil aircraft. (13) Consider the establishment of requirements for the installation and day and night operation of high-intensity white flashing lights on all civil aircraft, (14) Support the expeditious development of low-cost collision avoidance systems for all civil aircraft.

On October 23, 1969, the FAA wrote the Safety Board stating that the subject of midair collisions required more attention than could be addressed by this recommendation. The Safety Board agreed and decided to hold a public hearing in order to identify areas where immediate action was needed. Safety Recommendation A-69-18 was subsequently classified as "Closed—Reconsidered."

On November 4, 1969, the Safety Board convened a public hearing on the subject of prevention of midair collisions. The following safety recommendations resulted from that hearing and were issued to the FAA on January 30, 1970:

A-70-6

Convene a government/industry meeting to specifically examine the factors involved in establishing the need for standard traffic patterns.

A-70-7

Review the Chicago terminal area notice in Part 3 of the airman's information manual with a view to the expedited development of similar charts for other terminal areas wherever the mix of aircraft warranted.

A-7 O-8

Require pilots be given ground training scanning patterns to optimize aircraft detection and thus make more productive the pilot time spent when looking outside the cockpit. The Board further recommended that detection training equipment be developed on a priority basis and made available for private pilots also, as their need for such training was as equally important as that of commercial pilots.

In its letter of February 9, 1970, the FAA informed the Safety Board that it was in the process of developing and distributing copies of terminal area charts for 22 large airports and selected medium airports where there was a considerable mixture of traffic. Based upon this action Safety Recommendation A-70-7 was classified as "Closed--Acceptable Action."

On January 21, 1972, the FAA informed the Safety Board that it did not plan to require that pilots be given ground training in visual scanning patterns as training devices for such training were not readily available. However, the FAA did plan to work with flight schools in encouraging them to incorporate visual scanning in their programs. The Safety Board upheld its position that the FAA should require such training and subsequently classified Safety Recommendation A-70-8 as "Closed-Unacceptable Action."

In February 1975 the FAA provided the Safety Board with a copy of Advisory Circular 90-66 which recommended standard traffic patterns. The Safety Board found this action to be satisfactory and classified Safety Recommendation A-70-6 as "Closed—Acceptable Action" on October 1, 1975.

On February 22, 1971, the Safety Board issued an additional 11 recommendations to the FAA as a result of a public hearing held on November 4, 1969, on the cause and prevention of midair collisions. These recommendations are as follows:

A-7 l-5

Evaluate the pilot qualifications and minimum airborne equipment necessary for safe operations into high-density terminal areas with a view toward increasing the minimum standards for each.

A-7 l-6

Accelerate the program to provide separation between high- and low-performance aircraft in high-density terminal areas.

A-71-7

Encourage the expeditious development of a collision avoidance system for installation in air carrier aircraft and larger general aviation aircraft.

A-71-8

Make funds available for the ground equipment which may be necessary for support of CAS systems.

A-71-9

Sponsor developmental contracts for pilot warning indicator (PWI) systems utilizing various technological methods in order to evaluate the practicality of each.

A-71-10

Develop regulations to require the installation of CAS and PWI systems when they become available from the activities of 3 and 5 supra.

A-71-11

Consider convening a special government/industry meeting for the purpose of discussing the factors involved in establishing standard traffic patterns and initiating action leading to their creation.

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-71-13

Require suitable training aids be used to augment the syllabus when such aids are developed.

A-7 1-14

Promulgate regulations to require the installation of white anticollision lights on all aircraft as soon as possible.

A-71-15

Accelerate its efforts in developing certification, procedural, and rulemaking processes involved in implementing a full area navigation (RNAV) system for utilization throughout the U.S. National Airspace System.

In response to recommendations A-71-5 and -6, the FAA informed the Safety Board that the requirements for group I and II terminal control areas would increase pilot qualifications, airborne equipment, and aircraft separation. The Safety Board agreed with the FAA's actions and these two recommendation were classified as "Closed—Acceptable Action."

In response to Safety Recommendations A-71-7 through -10, the FAA informed the Safety Board that it had established an industry/government cooperative program to develop and flight test pilot warning indicators and collision avoidance systems. Funding for these efforts were included in the FAA's lo-year plan. The FAA informed the Safety Board that as the necessary equipment and installation requirements matured, regulations would be developed to require the installation of these systems. Safety Recommendations A-71-7 through -10 were classified as "Closed-Acceptable Action."

With regard to Safety Recommendation A-71-11, the FAA had held several meetings with user groups to discuss establishing standard traffic patterns. The Safety Board found this action to be satisfactory and subsequently this recommendation was classified as "Closed—Acceptable Action."

In response to recommendations A-71-12 and -13, the FAA stated that it had issued a Notice of Proposed Rulemaking on this subject, and that the comments received either opposed the proposed rule or requested that additional research and development be accomplished before further action being taken. In its evaluation, the Safety Board noted that these recommendations were similar in intent to recommendation A-71-8 and, therefore, Safety Recommendations A-71-12 and -13 were classified as "Closed—Acceptable Action."

In response to Safety Recommendation A-71-14, the FAA issued a new rule requiring the installation of anticollision lights and a minimum intensity level for anticollision lights on new aircraft. Based upon this action, Safety Recommendation A-71-14 was classified as "Closed—Acceptable Action."

In its letter of March 25, 1971, the FAA informed the Safety Board that it had revised 14 CFR Parts 71 and 75 concerning the designation of area low and area high navigation routes and that approximately 150 routes had been developed. The Safety Board accepted the FAA action as responsive to the intent of recommendation A-70-15 and therefore, classified the recommendation as "Closed-Acceptable Action."

Upon completion of its investigation of a midair collision near Fairland, Indiana, on September 9, 1969, involving a McDonnell-Douglas DC-9 and a Piper PA-28, the Safety Board issued Safety Recommendation A-709 to the FAA:

> Recommend that Parts 21 and 23 of the FAR be modified to require all aircraft under 12,500 lbs., manufactured after some appropriate date, to possess a radar cross section suitable for primary target detection; the Board was now of the view that a more appropriate regulatory approach would be to amend Part 91 of the FAR's to require all aircraft operating in radar service environments to have a minimum level of radar cross section, such action should make it possible for some operators, never intending to operate in radar environments, to avoid the necessity of reflective augmentation.

The FAA response to this recommendation was that effective June 25, 1970, transponders were required on all airplanes operating within group terminal control areas (TCA). While the Safety Board agreed that the requirement to have transponders was commendable, it did not satisfy the intent of this recommendation that radar target detection be improved in all radar environments and not just the TCAs. On January 11, 1974, the Safety Board classified this recommendation as "Closed—Unacceptable Action."

Following the Safety Board's investigation of a midair collision involving an Eastern Airlines DC-9 and a Cessna 206 at Raleigh-Durham, North Carolina, on December 4, 1971, the Safety Board issued the following two recommendations to the FAA:

A-72-27

Require the pilots of all aircraft equipped with an operable transponder to have the transponder turned "ON" and adjusted to reply on the appropriate mode A/3 code whenever VFR operations are conducted into, or in proximity to, an airport serviced by a radar approach control facility.

A-7 2-28

Require an exchange of pertinent traffic information between the control tower and the associated radar approach control facility whenever a pilot who is operating in accordance with VFR has requested a service or stated his intended flight operations. Such exchanges of information should be accomplished on a lower priority basis than that accorded to the transmission of control clearances.

On April 12, 1972, the FAA responded that the airman's information manual already contained information on the use of transponders in VFR operations. Additionally, the FAA issued a rule which required the use of a transponder with mode C capability at 21 of the busiest terminal areas and at 42 additional locations improved transponders would be required. In this same letter, the FAA stated that procedures were instituted which improved the coordination of traffic within an airport traffic area. On December 14, 1973, the FAA informed the Safety Board that 14 CFR Part 91 had been revised with respect to transponder requirements. Safety Recommendations A-72-27 and -28 were classified as "Closed--Acceptable Action."

In June 1972 the Safety Board completed a special accident prevention study which analyzed the commonality of midair collisions and which updated the Safety Board's previous study on this topic. The following recommendations were issued to the FAA as a result of this study:

A-72-156

Take additional steps through their accident prevention specialists to alert the general aviation community of the increasing potential of the midair collision hazard in the vicinity of airports.

A-72-l 57

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.

A-72-158

Require general aviation aircraft, when equipped, to utilize at all times both landing lights and anticollision lights during the approach and takeoff phases of operation and while operating in terminal or other high-density areas.

A-72-159

After a designated date, require the daytime use of high-density white lights on all air carrier aircraft.

A-72-160

Expedite the implementation of standard traffic pattern altitudes at all airports.

A-72-161

Review and reconsider the feasibility of requiring radar reflections on all civil aircraft.

A-72-162

Expedite the planned implementation of terminal control area and terminal radar separation of VFR and IFR traffic and examine the potential benefits of high-speed climb and descent corridor access and egress therefrom.

A-72-163

Designate high-speed climb and descent corridors between the top of the TCA (terminal control areas) and the floor of the PCA (positive control areas) for high density traffic areas.

A-72-164

Study the feasibility of providing funding support and implementation of small mobile control facilities for periods of high-density traffic operation at uncontrolled airports to reduce collision hazard.

A-72-165

Develop a system to evaluate the effectiveness of improvement and developments in midair collision avoidance systems, to assess, measure, and analyze hazard trends.

On October 2, 1972, the FAA responded to these recommendations. The actions taken by the FAA included:

Creation of a media campaign to alert the general aviation community of the need to be more alert for traffic in the vicinity of airports.

Development of a system approach for the collision avoidance system and the pilot warning indicator.

Continued research and evaluation of aircraft lighting.

Development of standardized traffic patterns at uncontrolled airports.

Continued funding of a program to evaluate passive radar enhancement for small aircraft.

The FAA expedited stage II of the national terminal radar program, and the establishment of terminal control areas and modified ATC procedures to ensure better separation of aircraft.

The respective floor and ceiling of the positive control area and the TCA were lowered and raised in heavy traffic areas to provide total positive control.

The FAA established a mobile air traffic control navigational air communication and power system.

The FAA's incident reporting system was improved.

Based upon these actions recommendations A-72-156, -157, -158, -161, and -164 were classified as "Closed—Acceptable Action." Safety Recommendations A-72-160, -162, and -163 were classified as "Closed—Acceptable Alternate Action." The Safety Board did not agree with the actions taken by the FAA with respect to recommendations A-72-159, -161, and -165. These recommendations were classified as "Closed—Unacceptable Action."

As a result of its investigation of an accident involving a North Central Airlines Convair 340/440 and an Air Wisconsin DHC-6 over Lake Winnebago near Appleton, Wisconsin, on June 29, 1972, the Safety Board issued the following recommendations to the FAA:

A-73-27

Develop and publish standards for visual search techniques to be used by instructors and check pilots on all training, certification, and proficiency check flights when pilots are operating in VMC.

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-73-29

Require that all pilots and flightcrew members training, certification, and proficiency check forms contain a specific item on scanning and time sharing.

A-73-30

Require that all pilots and flightcrew members be graded in scanning and time sharing techniques when training, certification, and proficiency check flights are conducted under UMC.

A-73-31

Advise the Board of the status of the FAA's evaluation project of April 7, 1972, on aircraft conspicuity research and, if that project has not been completed, take action to complete the project on a priority basis.

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.

On June 3, 1974, the Safety Board classified Safety Recommendations A-73-27 and -28 as 'Closed-Unacceptable Action" since the FAA had chosen not to develop the standards and requirements for visual scanning training as intended by the Safety Board.

In response to recommendations A-73-29 and -30, the FAA informed the Safety Board in its letter of June 26, 1973 that the enroute inspection forms include specific items associated with scanning and cockpit vigilance. The Safety Board agreed that the enroute inspection forms complied with the intent of these recommendations and classified them as "Closed—Acceptable Alternate Action."

In its letter of June 26, 1973, the FAA informed the Safety Board of the status of the FAA's aircraft conspicuity research project. This action complied with the intent of Safety Recommendation A-73-31, and it was subsequently classified as "Closed—Acceptable Action."

In response to recommendation A-73-32, the FAA informed the Safety Board that all technical approaches having the potential for providing collision avoidance were being investigated. However, the FAA decided not to formulate or issue any standards for collision avoidance systems as the FAA's main effort was toward the development of the discrete address beacon system (DABS). In its evaluation dated June 3, 1974, the Safety Board found the FAA's efforts to develop DABS to be an acceptable approach and classified Safety Recommendation A-73-32 as "Closed—Acceptable Alternate Action."

As a result of the Safety Board's investigation of a midair collision involving a Pacific Southwest Boeing 727 and a Cessna 172 over San Diego, California, on September 25, 1978, the Safety Board issued the following recommendations to the FAA:

A-78-77

Implement a terminal radar service area (TRSA) at Lindbergh Airport, San Diego, California.

A-78-78

Review procedures at all airports which are used regularly by air carrier and general aviation aircraft to determine which other areas require either a terminal control area or a terminal radar service area, and establish the appropriate one.

A-78-82

Use visual separation in terminal control areas and terminal radar service areas only when a pilot requests it, except for sequencing on the final approach with radar monitoring.

A-78-83

Reevaluate its policy with regard to the use of visual separation in other terminal areas.

A-79-73

Prescribe an appropriate method to do so and require all air carrier companies and commercial operators to test pilots recurrently on ATC radar procedures, radar services, pilot/controller relationships, and ATC clearances.

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 clearances as appropriate to their operations.

In its response to Safety Recommendation A-78-77, the FAA informed the Safety Board that it had established a terminal radar service area at Lindbergh Airport and that several improvements had been made to the airport traffic control equipment. Based upon these actions Safety Recommendation A-78-77 was classified as Vlosed-Acceptable Action."

In its letter of April 17, 1981, the FAA stated that following its evaluation of traffic at major airports, the FAA had established 48 additional TRSAs, bringing the total number to 137 with 26 other locations still under consideration, and that 2 new TCAs were added with another 31 locations still being considered. The Safety Board found these actions to be satisfactory and classified Safety Recommendation A-78-78 as Vlosed-Acceptable Action."

The FAA disagreed with the Safety Board's Safety Recommendations A-78-82 and -83, stating that it believed that the use of visual separation in TCAs and TRSAs is a viable concept and that complying with the Safety Board's recommendation would have an adverse effect on the efficient use of airspace and increase delays in the TRSAs. In its evaluation of August 20, 1896, the Safety Board stated that it did not agree with the FAA's assessment. Safety Recommendations A-78-82 and -83 were classified as Vlosed-Unacceptable Action."

In response to recommendation A-79-73, the FAA issued a change to order 8430.17, Air Carrier Operations Bulletin, which outlined procedures to be followed by the POIs to ensure that pilots were tested recurrently on ATC procedures. Safety Recommendation A-79-73 was classified as "Closed—Acceptable Alternate Action."

In response to recommendation A-79-73, the FAA developed a slide and tape presentation that advises pilot of proper procedures for operating in TCAs and TRSAs. Safety Recommendation A-79-74 was classified "Closed--Acceptable Action" on June 8, 1981.

On the May 18, 1978, an investigation as a result of a midair collision between a Cessna 150 and a Falcon Fan Jet about 3.5 miles west of Memphis International Airport, Memphis, Tennessee, the Safety Board recommended the following:

A-78-80

> Evaluate operational data for each TRSA location and establish two categories of TRSA's. Those locations handling the largest volume of traffic with automated ATC equipment available should be designated TRSA I locations, the remaining areas should be designated TRSA II locations.

A-78-81

> Require Mode "C" transponder equipment for operations within a TRSA I and Group II TCA and require that a pilot of a VFR flight traversing a TRSA I establish radio contact with the appropriate ATC facility before entering the designated airspace.

The FAA disagreed with the Safety Board's recommendation that two levels of TRSAs should be created as that such a requirement would add considerable confusion to the TCA/TRSA concept. In response, the FAA stated that its efforts to increase the number of TCAs and TRSAs would provide a similar level of safety. The Safety Board agreed with the FAA's assessment and Safety Recommendation A-78-80 was classified as "Closed--Acceptable Alternate Action."

In response to Safety Recommendation A-78-81, the FAA had issued a NPRM which contained provisions for upgraded transponder equipment. However, after reviewing the comments received, the FAA decided that the increased number of group II TCAs which require the use of transponder equipment would comply with the Safety Board's intent. The Safety Board agreed and classified Safety Recommendation A-78-81 as "Closed--Acceptable Alternate Action."

As a result of the Safety Board's investigation of a midair collision involving a Ronson Aviation Bell 206B helicopter and a Seminole Air Charter Piper PA34 airplane about 2 miles south of the Teterboro, New Jersey, airport on September 23, 1981, the following three recommendations were issued to the FAA:

A-82-58

> Through pilot training and examination programs, emphasize to pilots the importance of accurate position reporting in communications with air traffic control facilities.

A-82-59

> Revise the helicopter routes contained in the Teterboro Letter to Airmen 81-2 to provide improved separation and thereby minimize the potential for conflicts between helicopters and fixed-wing aircraft traffic.

A-82-60

> Provide all pertinent personnel working traffic at BRITE-equipped, non-radar control towers with the proper training and certification regarding the use of that equipment.

In its letter of September 28, 1982, the FAA informed the Safety Board that it would stress the need for accurate position reporting to inspectors, pilot examinees, and flight instructors through operating bulletins and to pilots and industry through the FAA accident prevention program and general aviation news publication. The Safety Board found this response to be acceptable and subsequently classified Safety Recommendation A-82-58 as "Closed—Acceptable Action."

In response to Safety Recommendation A-82-59 on June 6, 1983, the FAA informed the Safety Board that it believed the existing helicopter routes contained in the Teterboro Letter to Airmen 81-2, minimized the exposure of helicopters to fixed-wing aircraft and that the FAA planned no revisions to the letter or routes. In its evaluation letter of September 7, 1983, the Safety Board disagreed with the FAA position, and classified Safety Recommendation A-82-59 as "Closed—Unacceptable Action."

Also, in its letter of June 6, 1983, the FAA informed the Safety Board that it had sent a memorandum to all regional directors which stressed the importance of facility managers ensuring that their personnel, as appropriate, receive required training on the BRITE radar display. In its evaluation letter of September 7, 1983, the Safety Board requested to be informed of the number of persons trained on the BRITE radar display and a description of the placement of these personnel. This information had not been received as of December 1, 1986, therefore, the Safety Board wrote the FAA requesting an additional response. Safety Recommendation A-82-60 is classified as "Open—Acceptable Action."

Additionally, Safety Recommendation A-82-61 was issued to the Aircraft Owners and Pilots Association (AOPA), the National Association of Flight Instructors (NAFI), the Regional Airline Association (RAA), the Helicopter Association International (HAI), and the National Business Aircraft Association (NBAA).

> Through appropriate educational programs and communications, emphasize to pilots the importance of accurate position reporting in communications with air traffic control facilities.

The AOPA, HAI, and NBAA have informed the Safety Board separately that they have taken appropriate action to inform their members of the need to provide accurate position reporting to ATC facilities. The NAFI has recently informed the Safety Board that it plans to include information on this topic to its members in an article to be published soon. The RAA has not yet responded to this recommendation.

The Safety Board's investigation of a midair collision of two general aviation aircraft, a North American Rockwell Aero Commander Model 560E and a Cessna Model 182Q, over Livingston, New Jersey, on November 20, 1982 resulted in the following recommendations:

A-83-54

Consolidate information of 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.

A-83-55

Include questions regarding visual scanning techniques for airborne targets in written examinations for pilot licenses.

In response to Safety Recommendation A-83-54, the FAA developed an item, "Collision Avoidance (Scanning for Other Aircraft), for inclusion in the Airmen's Information Manual, and published several articles with consolidated information on visual scanning techniques. Safety Recommendation A-83-54 was classified as "Closed—Acceptable Action" on July 22, 1985.

In its letter of November 11, 1985, the FAA informed the Safety that it had included questions on visual scanning techniques in the private pilot tests, and that the commercial pilot, flight instructor, and ground instructor tests would have questions on visual scanning techniques included at the next publishing cycle. Based upon this action, Safety Recommendation A-83-55 was classified as "Closed—Acceptable Action."

As a result of the Safety Board's investigation of a midair collision at San Luis Obispo, California on August 24, 1984, involving a Beechcraft model C99 and a Rockwell Aero Commander 112TC, 13 recommendations were issued to the FAA. Two of these recommendations pertain to recent midair collision accidents.

A-85-64

Expedite the development, operational evaluation, and final certification of the traffic alert and collision avoidance system (TCAS) for installation and use in certificated air carrier aircraft.

A-85-65

Amend 14 CFR Parts 121 and 135 to require the installation and use of traffic alert and collision avoidance system (TCAS) equipment in certificated air carrier aircraft when it becomes available for operational use.

The Safety Board is currently reviewing the responses.

As a result, of the Safety Board's investigation of a near midair collision which occurred on December 20, 1984, near New Orleans, Louisiana, involving a Lufthansa Boeing 747 and a single engine general aviation airplane, the following recommendations were issued to the FAA:

A-85-112

Revise the localizer backcourse runway 19 instrument approach procedure or the terminal control area at the New Orleans International Airport to provide a vertical buffer between aircraft following the runway 19 instrument approach procedure and uncontrolled visual flight rules (VFR) aircraft operating below the floor of the terminal control area.

A-85-113

Review instrument approach procedures at airports designated as the primary airport within a terminal control area (TCA) or airport radar service areas (ARSA) to identify potential conflicts involving an aircraft following a published instrument procedure at the floor of the TCA or ARSA and aircraft operating just below the floor of the TCA or ARSA and, if indicated, modify the instrument approach procedure and/or the TCA/ARSA boundaries to provide for positive vertical separation between the aircraft.

A-85-l 14

Institute measures, including appropriate changes to FAA Handbook 7400.2C and FAA Order 8260.19A, to improve coordination between personnel involved in the design of the terminal control area and airport radar service area airspace and those involved in the design of the instrument approach procedures to prevent the creation of potential hazards to the users of the air traffic system.

These three recommendations are currently classified as "Open—Unacceptable Action."

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JIM BURNETT
Chairman

/s/ PATRICIA A. GOLDMAN
Vice Chairman

/s/ JOHN K. LAUBER
Member

/s/ JOSEPH T. NALL
Member

May 4, 1987

5. APPENDIXES

APPENDIX A
INVESTIGATION AND HEARING

Investigation

The Safety Board was notified of the accident at 1800 on November 10, 1985. A team of investigators was dispatched from Washington, D.C., to the scene the next morning. Investigative groups were established for operations, air traffic control, structures, systems, powerplants, survival factors, and human performance.

The parties to the investigation were the Federal Aviation Administration, Nabisco Brands, Inc., Air Pegasus Corporation, Dassault International (USA) Inc., Piper Aircraft Corporation, Garrett Turbine Engine Company, National Business Aircraft Association, and the Aircraft Owners and Pilots Association.

Public Hearing

A 2-day public hearing was held in Hasbrouck Heights, New Jersey, beginning February 24. Parties represented at the hearing were the Federal Aviation Administration, Nabisco Brands, Inc., Air Pegasus Corporation, National Business Aircraft Association, and the Aircraft Owners and Pilots Association.

APPENDIX B

PERSONNEL INFORMATION

Nabisco Brands, Inc.

Captain Gregory L. Miller, 37, was employed by Nabisco Brands, Inc., on September 9, 1980. He held Airline Transport Pilot Certificate No. 2132462 with an airplane multiengine land rating and type ratings in the Learjet DA20 and DA50. He also held commercial privileges for airplane single-engine land and sea. He held a Flight Instructor Certificate No. 2132462 for airplane single, multiengine, and instruments which expired on August 31, 1981. His first class medical certificate was issued on March 1, 1985. He obtained a Statement of Demonstrated Ability, No. 10DD7425, from the FAA December 23, 1974 which stated, "Must wear corrective lenses - defective distant vision 20/200 corrected to 20/20 bilaterally."

Captain Miller initially qualified in the DA20 in December 1981 through March 1982. His last proficiency check in the DA50 was completed on January 17, 1985. He also received a Learjet 35/35A and 36/36A proficiency check on December 9, 1984, and pilot-in-command differences training for the Learjet 30/50 series in August 1985. He had logged a total of about 8,265 flight hours at the time of the accident, 817 of which were logged in the DA50.

First Officer Alan K. Stitt, 31, was employed by Nabisco Brands, Inc., on May 31, 1985. He held an Airline Transport Pilot Certificate No. 26448125 with an airplane multiengine land rating and a type rating in the Learjet. He also held commercial privileges with an airplane single-engine land rating.. His first class medical certificate was issued on October 25, 1985, with no limitations.

First officer Stitt completed his DA50 training on June 7, 1985. He completed a Learjet 30/50 differences training course on June 28, 1985, and an initial training course on the Learjet 55 on August 20, 1985. He had logged a total of about 4,500 flight hours at the time of the accident, 143 of which were logged in the DA50.

Piper Archer

Pilot Marlon J. Moss, 26, held a Private Pilot Certificate No. 127520177 with airplane single-engine land rating issued on July 30, 1981. His third class medical certificate was issued February 25, 1985, with the limitation that "Holder shall wear correcting lenses while exercising the privileges of his airman certificate." He had successfully completed a written examination for an instrument rating on June 22, 1985, but failed the flight test on September 30, 1985. The portion where he received unsatisfactory performance involved VOR and ILS "tracking" during instrument approach procedures. He had obtained additional instruction and was approved by his flight instructor on October 6, 1985, for re-examination. He had logged a total of about 269 flight hours at the time of the accident, 92 of which were logged in the PA28, and 76 hours were flown at night.

Air Traffic Control Personnel

Full Performance Level Controller Steven Kelley (Departure Controller), 32, was hired by the FAA on the New York TRACON in January 1982 as an ATC specialist.

He obtained his initial training at the FAA Academy in Oklahoma City, Oklahoma. He achieved his full performance level status in November 1982 in the Newark radar sector. He was medically qualified for duty.

Full Performance Level Controller Lenard Greenberg (Coordinator), 30, was hired by the FAA in November 1981 as an ATC specialist at the New York ARTCC. He obtained his initial training at the FAA Academy. He transferred to the TEB control tower in October 1984. He achieved full performance level status in May 1985. He was medically qualified for duty.

Full Performance Level Controller Barbara Bryan (Flight Data/Clearance Delivery Controller), 27, was hired by the FAA in October 1981 as an ATC specialist at TEB. She obtained her initial controller experience as a militarv controller for 4 years. She did not attend the FAA Academy. She achieved her full performance level status in June 1982. She was medically qualified for duty.

Full Performance Level Controller Barry Smith (Ground Controller), 34, was hired by the FAA in January 1982 as an ATC specialist at Philadelphia control tower. He obtained his initial training-at the FAA Academy. He was reassign&d to TEB in June 1984. He achieved full performance level status in January 1985. He was medically qualified for duty.

Full Performance Level Controller Kenneth Millan (Local Controller), 29, was hired by the FAA in November 1982 at the New York TRACON as a flight data specialist. He obtained his initial training at the FAA Academy. He later became a developmental ATC specialist at the New York TRACON before he was reassigned to TEB in February 1985. He achieved his full performance level status in May 1985. He holds a Commercial Pilot Certificate with single and multiengine land ratings. He held a Flight Instructor Certificate and an Instrument Ground Instructor Certificate. He was medically qualified for duty.

Full Performance Level Controller Joseph J. Paparazzo (Area Supervisor), 55, was hired by the FAA in 1958 at the New York ARTCC as an assistant ATC. He obtained his initial training at the FAA Academy. He was reassigned to Teterboro in December 1961 and achieved full performance level status in 1961. He was medically qualified for duty.

Controller Training

All of the controllers at Teterboro Control Tower received training in four phases: Phase VI - Flight Data; Phase VII - Clearance Delivery; Phase VIII - Ground Control; and Phase IX - Local Control. These phases included both classroom and on-the-job instruction; they include a pass/fail requirement. Each specialist is required to attain certification on all operating positions before attaining the full performance level status. The area supervisor is responsible for closely monitoring the specialist's progress in order to detect deficiencies and initiate remedial action. These phases are also applied to qualified specialists who are not operationally current or who have transferred from another facility.

Classroom training includes instructional presentations or self-study units administered away from the operating positions. When staffing conditions permit, instructional presentations are provided to augment the self-study program. On-the-job training is conducted under actual air traffic conditions and monitored by a qualified controller until the specialist achieves certification.

APPENDIX C

COCKPIT VOICE RECORDER TRANSCRIPT

TRANSCRIPT OF A SUNDSTRAND AV577-C COCKPIT VOICE RECORDER, S/N 9650, REMOVED FROM THE FALCON 50 WHICH WAS INVOLVED IN A MIDAIR COLLISION NEAR THE TETERBORO AIRPORT ON NOVEMBER 10, 1385

LEGEND

CAM	Cockpit area microphone voice or sound source
RDO	Radio transmission from accident aircraft
-1	Voice identified as Captain
-2	Voice identified as First Officer
-?	Voice unidentified
MTWR	Morristown New Jersey Local Control (Tower)
TRACON	New York Terminal Radar Approach Control (TRACON)
TWR	Teterboro New Jersey Local Control (Tover)
N1959T	Aircraft November one nine five nine Tango
N02V	Aircraft November zero two Victor
N1977H	Aircraft November one nine seven seven Hotel
N72BG	Aircraft November seven two Bravo Golf
N6746J	Aircraft November six seven four six Juliet
N68734	Aircraft November six eight seven three four
N915	Aircraft November nine one Sierra
N164	Aircraft November one six four
P163	Aircraft People one sixty three
UNK	Unknown
*	Unintelligible word
#	Nonpertinent word
%	Break in continuity
( )	Questionable text
(( ))	Editorial Insertion
---	Pause

Note: All times are expressed in eastern standard time.

INTRA-COCKPIT

TIME & SOURCE	CONTENT
17:10:42 CAM-1	We'll be lookin'
17:10:45 CAM-2	Anti collision light
CAM-I	All
CAM-2	Landing lights
CAM-1	On
17:10:50 CAN-2 ,	And ah igniters and radar
CAM-I	Igniters are on, radar standin' by
CM-2	Okay transpouder, okay we got ---

AIR-GROUND COMMUNICATIONS

TIME b SOURCE	CONTENT
17:10:33 RDO-2	Ah Tower Falcon seven eight bravo with ya
17: 10:37 MTWR	Falcon seven eight four bravo Morristown Tower runway two three cleared for takeoff, wind two three zero at seven, use caution, there's some deer on the tight side of the runway just about mid field
17:10:44 RDO-2	Eight four bravo roger, cleared for takeoff

INTRA-COCKPIT

TIME & SOURCE	CONTENT
CAM-l	Tranepondete on and F.A.T.S
17: 10:58 cm-2	Flaps and slats set twenty --- air brakes are stowed and lights are out --- trims are one two three and speeds are ninety four, one ten one twenty five one seventy we're lookin' for ninety nine on the power
17:11:13 CAM-l	All right you got it
CAM-l	Ready
CAM-2	Yup
CAM-1	You got it
CAM-l	Here we go
17:11:20 CM	((Sound of increasing engine speed))
17: 11:28 CAM-l	Power's set
17:11:30 CAM-1	Air speed
17: 11:35 CAM-1	Vee one

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT

INTRA-COCKPIT

TIME 6 SOURCE	CONTENT
17:11:38 CAM"1	And rotate
17:11:42 CAM-1	Positive rate
CAM-2	Gear up
17:11:45 CAM-2	Igniters lights and yaw damper
17:11:49 CAM-2	Flaps up
17:12:06 CAM	((Sound of altitude alert)
17:12:07 CAM-2	Slats up

AIR-GROUND COMMUNICATIONS

TIME b SOURCE	CONTENT
17:11:51 MTWR	Falcon eight four bravo contact departure good day
17:11:53 RDO-1	Good day
17:11:58 RDO-1	Departure seven eight four bravo's with you off Morristown climbing to two thousand
17:12:02 TRACON	Falcon seven eight four brave New York ident maintain two

INTRA-COCKPIT

TIME b SOURCE	CONTENT
17:12:24 CAM-2	Might as well do a after takeoff check here to
CAM-l	Yeah I will
17:12:30 CAM-1	Left turn zero eight zero two thousand
CAM-2	Roger
17:12:48 CAM-1	Okay landing gear
CAM-2	UP
CAM-1	Yaw damper
CAM-2	It's ah on

AtR-GROUNDCOMMUNICATIONS

TIME b SOURCE	CONTENT
17:12:09 TRACON	Seven eight four bravo is radar contact two south of Morristown start a left turn now heading zero eight zero
17:12:15 RDO-1	Left turn zero eight and ah we're only getting you about two by two
17:12:18 TRACON	Okay it should get a little better when you get some altitude there

N

INTRA-COCKPIT

TIME & SOURCE	CONTENT
17:13:12	
CAM-1	Landing gear
CAM-2	It's up
CAM-1	Yaw damper
CAM-2	It's on
17:13:55	
CAM-1	Stats and flaps
CAM-2	Are clean
CAM-1	Anti-ice
CAM-2	It's off
17:13:58	
CM-1	Igniters
CAM-2	They're off

AIR-GROUND COMMUNICATIONS

TIME b SOURCE	CONTENT
17:12:52	
RADAR	Falcon seven four bravo you are on vectors for a VOR DME alpha approach Teterboro and ah good visibility ah correctton good VFR visibility two zero winds are two four zero at eight VOR DME alpha approach overhead the airport left traffic for runway one niner
17:13:08	
RDO-2	Eighty four bravo understand

INTRA-COCKPIT

TIME b SOURCE	CONTENT
CAM-1	Landing 'er taxi light, no smoke
CAM-2	They're off
17:13:21	
CAM-1	Pressurization
CAM-2	Set
CAM-1	Okay at t imeters
CAM-2	Thirty ---
17:13:25	
CAM-1	I'll get you the ATIS
17:13:27	
CAM-1	Oxygen
CAM-2	Set
17:13:29	
CAM-1	Landing lights
CAN-2	They're on
17:13:31	
CAM-1	Seatbelt sign
CAM-2,	Not required
CAM-1	All right --- entrance curtain
CAM-2	Open

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT

DI

INTRA-COCKPIT		AIR-GROUNDCOMMUNICATIONS	
TIME b SOURCE	CONTENT	TIME b SOURCE	CONTENT
17:13:35			
CAM-1	Attitude controller		
CAM-2	Okay net ---		
CAM-1	Set for Teterboro nine		
17:13:39			
CAM-I	Ant i-icing		
CAM-2	Is ah off		
17:13:43			
CAM-1	And seatbett stgn --- cahtn		
CAM-2	Seatbelt sign is not required and cabin checked		
		17:13:52 P163	Approach People one sixty three is passing eight hundred for twenty five hundred
17:13:48 CAM-1	Okay you're up to the approach check		
17:13:55			
CAM-1	You got the center for a minute		
CAM-2	Yeah		
		17:13:56 TRACON	People one sixty three New York departure control ident

INTRA-COCKPIT		AtR-GROUND COMMUNICATIONS	
TIME b SOURCE	CONTENT	TIME b SOURCE	CONTENT
		17:13:58 ATIS	Runway one niner NOTAM runway two four is closed for landings only one thouaand foot markers runway one niner missing taxiway hotel --- taxiway bravo, center lights out of service, advise on initial contact that you have Information Delta --- Teterboro Airport Information Delta two two zero zero Greenwich weather, sky condition ten thousand scattered, two five thoueand thtn scattered visibility two zero, temperature six five, dew point four niner, wind two two zero at niner, altimeter three zero at one eight, VOR/DME alpha approach in use, landing and departing runway one niner NOTAM
		17:14:10 TRACON	People one sixy three is radar contact climb and maintain nix thousand at one thousand eight hundred feet, turn right direct * ((simultaneous with above))
		17:14:15 P162	Okay goin' up to six thousand out of eighteen hundred direct (Spire) ((simultaneous with above))
		17:14:40 ATIS	((ATIS communications ends))
17:14:41 CAM-1	All right nineteen's the runway VOR alpha to nineteen		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-2	Okay		
17:14:44 CAM-1	Three zero one eight on the altimeter --- they're ten thousand scattered, twenty miles sixty five degrees winds are two twenty at nine		
CAM-2	*		
		17:14:53 TRACON	Falcon seven eight four bravo turn left heading zero one zero
		17:14:58 RDO-1	Zero one zero seven eight four bravo
		17:15:00 TRACON	Seven eight four bravo and ah you can start your speed back if you would sir to ah one eight zero you'll be following a Twin Cessna to Teterboro I'm gonna turn you on just outside Clifo
		17:15:08 RDO-1	Slowing to one eighty eight four bravo
17:15:21 CM	((Sound of trim in motion))		
17:15:23 CM	((Sound of trim in motion))		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
17:15:25 CAM	((Sound of trim in motion))		
17:15:29 CAM-1	One sixteen for Vee ref		
17:15:35 CAM	((Sound of whistle))		
		17:15:40 TRACON	Falcon seven eight four bravo traffic twelve o'clock four miles westbound ah known VFR we're working him he's at two thousand five hundred Cessna one seventy two have additional VFR traffic eleven thirty and two miles eastbound shows one thousand eight hundred unverified
		17:15:56	
..RDO-1	Oh we got a couple of em out there thank		you much eight four bravo
17:15:59 CAM-1	Got one out then left to right low	17:15:59 TRACON	Roger
CAM-2	Yeah --- I got him		
17:16:03 CAM-1	And ya got ---		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
		17:16:04 TRACON	And seven eight four bravo the one I'm primarily concerned about is twelve o'clock about a mile now headed eastbound he's showing one thousand niner hundred now in the Mode C
		17:16:10 RDO-1	He's in sight ah eighty four bravo
		17:16:12 TRACON	Thanks very much
17:16:29 CAM-1	There's the twenty five hundred foot traf Eic --- and there's the nineteen hundred foot traffic		
17:16:32 cAn-2	They're all over the place today		
CAM-l	Yeah, yeah nice day everybody's out		
CAM-2	Yeah		
17:16:37 CAM-l	Another one down low up ahead here		
17:16:42 CM-1	It's the ones below the horizon that are bard to see		
CAM-2	Yeah		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME b SOURCE	CONTENT	TIME b SOURCE	CONTENT
17:16:45 CAM-1	They can get you to		
17:16:51 CAM-1	Ah thirty thirty two is ah		
		17:16:55 TRACON	Falcon seven eight four bravo is three miles west of Clifo turn right headfng zero niner zero two thousand until on the Teterboro three zero five radial cleared VOR DME alpha approach
		17:17:04 RDO-1	Zero nine zero intercept we're cleared the VOR DME alpha seven eight four bravo
17:17:14 CAM-1	Two thousand till you're on the radial --- when you're on the radial then you can go down to sixteen if you're inside Wanes which is ten point eight out		
17:17:29 CAM-1	They're every where --- now do you remember the frequency thirty two nothing for ah Falcon jet		
17:17:35 CAM-2	Ah I don't know Falcon jet ah --- f got the clip board it there ---		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME b SOURCE	CONTENT
		17:17:41 TRACON	And Falcon seven eight four bravo that was obviously not the best turn sir continue right one four zero to pick it up
		17:17:47 RDO-1	We'll figure this out eight four bravo thank you much
		17:17:50 TRACON	Guess I need all the help I can get
		17:17:52 TRACON	People one sixty three climb and maintain eight thousand
17:17:53 CM-2	Got a guy over here		
17:17:54 CAM-1	Yeah		
		17:17:55 P163	People one sixty three's goin' up to eight
		17:17:58 TRACON	Falcon ah seven eight four bravo traffic as you turn back around twelve o'clock less than a mile one thousand seven hundred unverified westbound

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
		17:18:05 RDO-1	In sight eight four bravo
		17:18:06 TRACON	Thank you sir
17:18:06 CAM-1	Geez's		
		17:18:12 TRACON	Falcon eight four bravo thank you sir your traffic you're following just overhead Teterboro this time contact the tower one one niner point five so long
		17:18:19 RDO-I	Nineteen five good night
		17:18:24 N1959T	Teterboro tower --- Twin Bonanza five niner tango uh two miles northwest of airport
17:18:29 CAM-I	Clifo is mandatory at sixteen hundred	17:18:29 TWR	Five niner tango Teterboro tower --- continue overhead --- report overhead the field --- zero two victor turn right at hotel, contact ground point niner
CAM-2	Yeah ---		
		17:18:37 N02V	Zero two victor

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
		17:18:39 N1977H	Teterboro tower, Cherokee one nine seven seven hotel one mile to the west
		17:18:42 TWR	One niner seven seven hotel flash your landing light
		17:18:46 TWR	One niner seven seven hotel is in sight report clear of the airport traffic area to the west
17:18:48 CAM	((Sound of altitude alert))		
		17:18:50 N1977H	Seven hotel
17:18:53 CAM-2	Slats please		
17:18:55 CAN-1	Comin'		
		17:18:56 TWR	Seven two bravo golf, cleared for takeoff
		17:18:57 N72BG	Bravo golf rolling
		TWR	Seven three four cleared to land, wind two two zero at six

INTRA-COCKPIT

TIME & SOURCE	CONTENT

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
17:18:59 N6746J	Teterboro tower this is Cherokee six seven four juliet holding short of ah one nine on bravo for takeoff ah Lincoln Park destination ((simultaneous with above))
17:19:08 TWR	Holding short of nineteen I stepped on you, say again
17:19:11 N6746J	Uh, six seven four six juliet, uh, I'd like a right turn out if possible to Lincoln Park
17:19:17 TWR	Six seven four six juliet taxi into position and hold runway one niner, right turn will be approved
17:19:22 N6746J	Uh roger, four six juliet
17:19:24 RDO-1	Falcon seven eight four bravo inside Wanes ah inside Clifo ah airports in sight
17:19:31 N72BG	Bravo golf's requesting left downwind departure

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
		17:19:33 TWR	Four eix juliet's clear for takeoff runway one niner
		17:19:35 N6746J	Roger Eour six jay is rolling
		17:19:38 TWR	Bravo golf remain east of the Hackensack River
		17:19:39 N72BG	Bravo gol E
		17:19:41 N1959T	Five niner tango overhead
17:19:45 CAM-1	Better slow it up Alan, we're following that guy ---	17:19:45 TWR	Five niner tango number two following traffic on left base over route eighty
CAR-2	Okay		
17:19:48 CAM-2	Flaps *		
		17:19:49 N1959T	Five niner tango in sight
		17:19:51 TWR	Seven three four cleared to land

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME b SOURCE	CONTENT
		17:19:53 N687 34	Seven three four
		17:19:54 TWR	Inside Clifo say again call sign
		17:19:56 RDO- 1	Falcon seven eight four bravo's coming up overhead with the traffic in sight
		17:20:01 TWR	Eight Eour bravo, understand you're overhead the field sir
		17:20:04 RDO-1	Ye8 sir
		17:20:05 TWR	Okay, plan number three following traffic turning downwind abeam the tower additional traffic is at your one o'clock westbound at one point five
		17:20:13 RDO-1	We're lookin' eight four bravo
17:20:14 CAM-2	Flaps twenty gear down before landing checklist	17:20:14 TWR	Okay air, you're closing on him, he's uh light aircraft at uh your one to twelve o'clock westbound
17:20:18 CM-1	You're eat 'em up		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
17:20:19 CM	'((Sound of landing Rear warning horn starts))		
		17:20:21 N91S	Teterboro tower, nine one sierra is ready to go
		17:20:26 TWR	Seven seven hotel traffic is a Falcon jet overtaking you from your ah six o'clock ah loo-
17:20:28 CM	((Sound of landing gear warning horn stops))		
		17:20:35 N164	Uh roger sir ABC towers
17:20:39 CM-1	Another one down low		
CAM-2	*		
17:20:41 CAM-1	Beneath him	17:20:41 TWR	Eight four bravo, you have the traffic str
CAM-2	I ace him		
		17:20:43 RDO-I	Affirmative

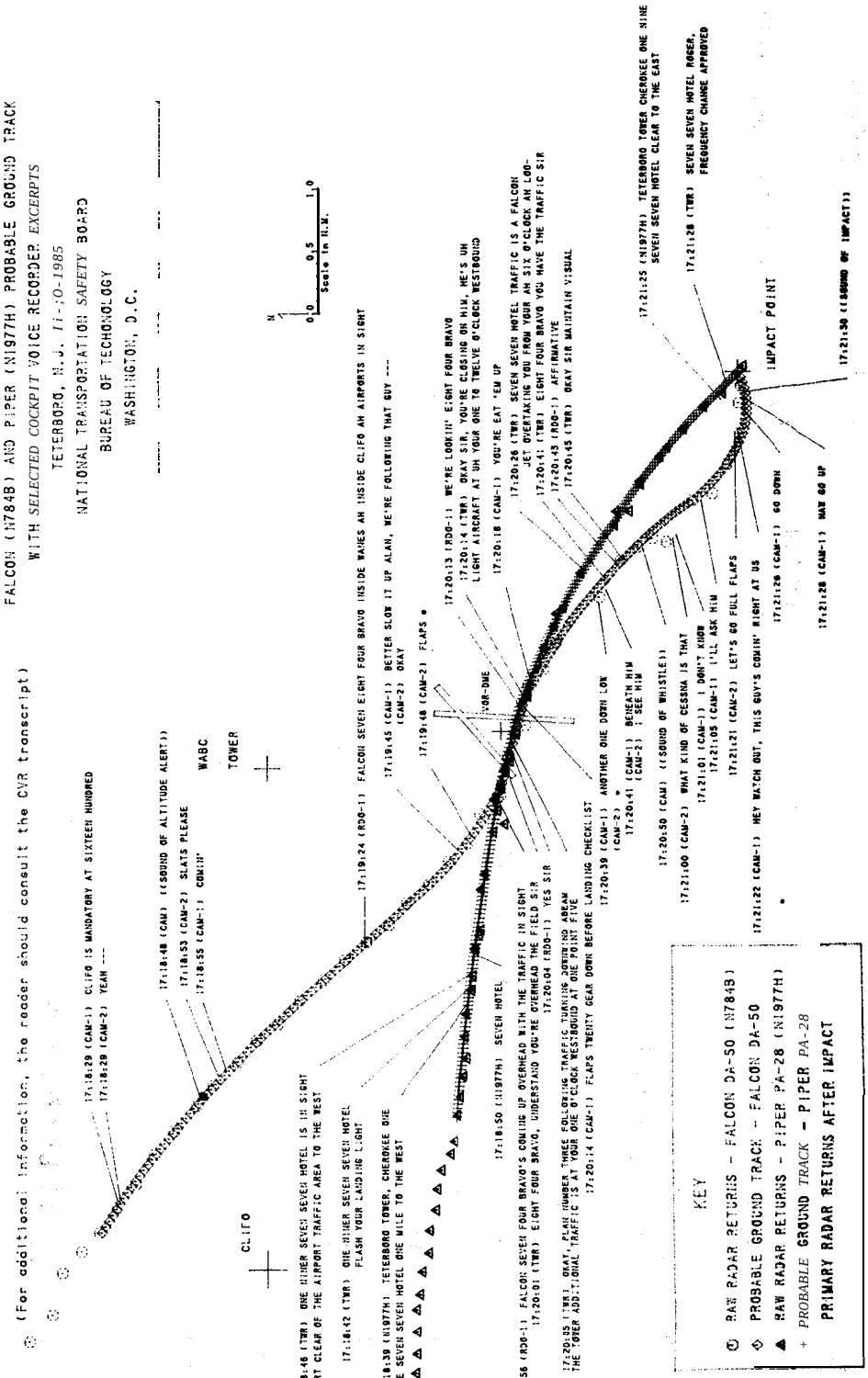
INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
		17:20:45 TWR	Okay sir maintain visual
		17:20:46 N6746J	Four six juliet is beginning a right crosswind
17:20:50 CM	((Sound of whistle))	17:20:50 TWR	Four six Juliet ah understand you beginning a right crosswind sir?
		17:20:54 N6746J	Roger, understand I'm cleared for a right turn out
		17:20:56 TWR	Yes sir, a right turn out has been approved sir, remain south of the Teterboro three zero Eive radial
17:21:00 CAM-2	What kind of Ceesna is that		
17:21:01 CM-1	I don't know		
		17:21:02 N6746J	Ah roger, will do, thank you very much
		17:21:04 N91S	Nine one sierra to number one for one niner

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
17:21:05 CAM-1	I'll ask him		
		17:21:07 TWR	Ready for runway one nfner, hold short
		17:21:09 N91S	Nine one sierra
		17:21:11 N164	Roger sir, I just crossed the ARC towers
		17:21:16 TWR	Five niner tango cleared to land, make short approach runway one niner
		17:21:19 N1959T	Five niner tango
17:21:21 CAM-2	Let's go full flaps		
17:21:22 CAM-1	Hey watch out, this guy's comin' right at us		
		17:21:25 N1977H	Teterboro tower Cherokee one nine seven seven hotel clear to the east
17:21:26 CAM-I	Co down		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
17:21:28 CAM-1	Naw go up	17:21:28 TWR	Seven seven hotel roger, frequency change approved
17:21:30 CAM	((Sound of impact))		
17:21:31 CAM-2	Ah #		
CAM-1	* * ((simultaneous with above))		
17:21:34 CAM-1	##		
17:21:35 CAM-1	# #		
17:21:37 CAM-1	#		
17:21:39 CM-2	* *		
CAM-1	#		
17:21:41	((End of Recording))		

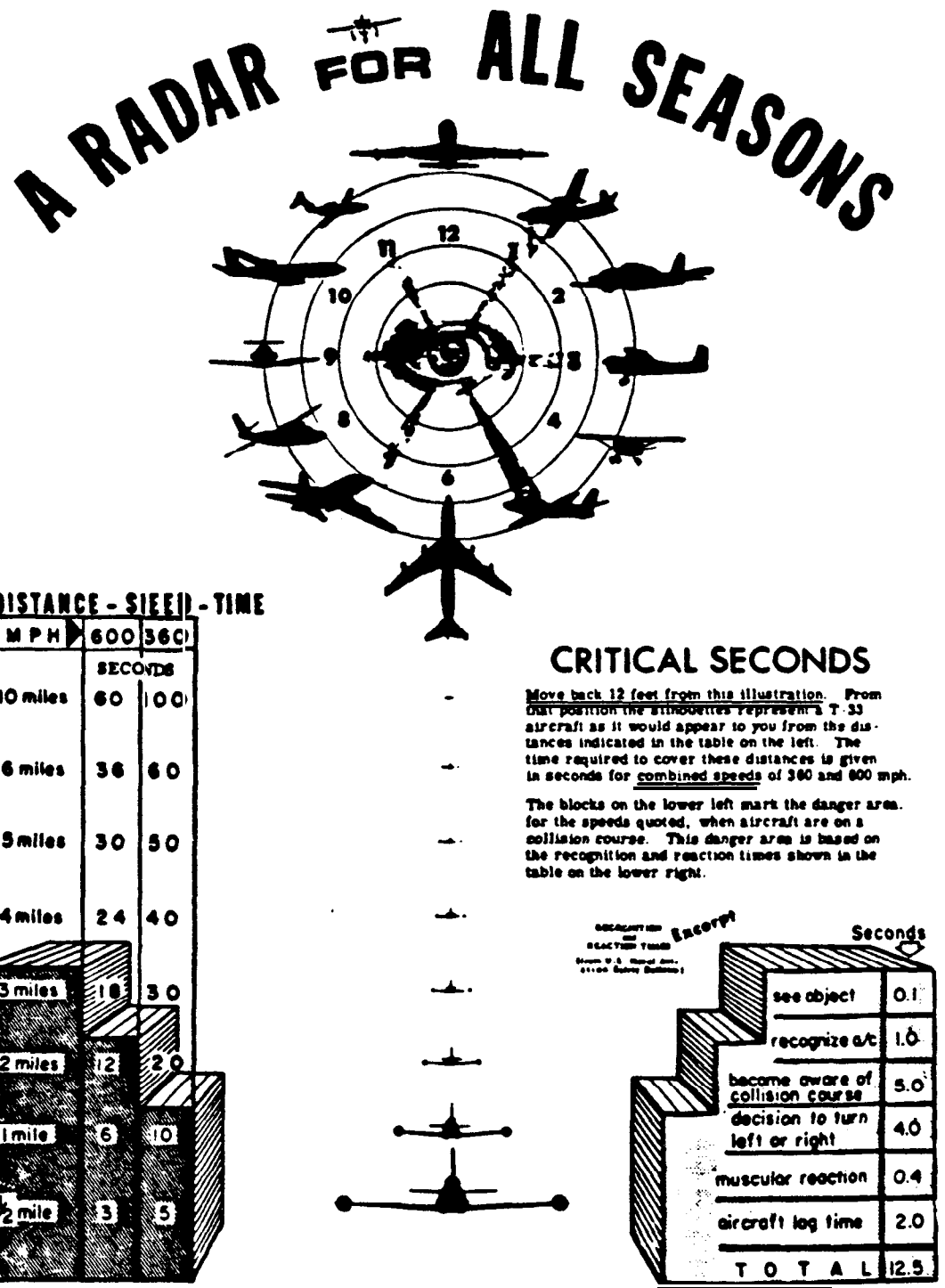
APPENDIX D

RADAR GROUND TRACK PLOT



APPENDIX E

ADVISORY CIRCULAR 90-48C
DISTANCE - SPEED - TIME CHART



*U.S. G.P.O. 1987-181-101:60004